University of Kragujevac
Faculty of Technical Sciences Čačak

TIE 2022

Proceedings TIE 2022

9th International scientific conference

Technics and Informatics in Education

Čačak, Serbia,16-18 September 2022

University of Kragujevac
Faculty of Technical Sciences Čačak

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Preface

Ninth international scientific conference Technics and Informatics in Education – TIE 2022 aims to promote and support research in education of new generations in technical and technological fields at all levels of education and contribute to technology development and education improvement.

After double-blind reviewing, 72 papers were accepted for the current edition of Proceedings in the form of plenary lectures and original scientific papers, within various fields of technical, IT and technology- supported education at all educational levels – primary, secondary, higher education and education for adults. Two more papers were accepted to be published in Appendix A of the Proceedings (on Serbian language) for the Symposium "Technics and Informatics in Education: School Teachers for Teachers" that is organized within TIE 2022.

Authors are responsible for any spelling, grammar and stylistic errors in their work.

Articles in the *Proceedings TIE 2022* are organized by the following topics:

- Technics, Technology and Informatics in Education;
- Educational Technology;
- Engineering Education and Practice;
- IT Education and Practice;
- Professional Development and General Education Topics;
- ESP and Technics and Informatics: Challenges and Perspectives;
- Digital and Psychological Resilience.

Special activities within the Conference are the following:

- Tribute to Professor Dragan Golubović – founder of conference and creator of Technics and Informatics education in Serbia;
- Round Table: Digital and psychological resilience support by networking and peer problem solving;
- Open discussion: Education of technics and technology teachers – university–school cooperation.

Within the TIE 2022 conference, a special thematic segment is dedicated to the current ERASMUS+ cooperation partnerships in higher education project "Enhancing digital and psychological resilience through peer networking in the online environment in times of crises – DigiPsyRes" (2021-1-RS01- KA220-HED000032204). This multidisciplinary project deals with the problem of the growing need for psycho-social support in times of crises by enhancing digital and psychological resilience through peer networking in the online environment. The main goal of the project is to build capacities, readiness and procedures to empower students to enhance their digital and psychological resilience. The project is coordinated by the University of Kragujevac (2021-2024) and partner institutions are University in Foggia, Italy, and Kazimierz Wielki University in Bydgoszcz, Poland.

The Scientific and Organizing Committee wishes to express gratitude to all the professionals from various fields who contributed to the Conference.

We would like to thank Partner Institutions which participated as co-organizers of the Conference.

We express special thanks to the Ministry of Education, Science and Technological Development of the Republic of Serbia for financial contribution to this scientific gathering.

Ivan Milićević
Editor

Presidents' Foreword

Faculty of Technical Sciences Čačak, University of Kragujevac, has the honour to organize the ninth international scientific conference "Technics and Informatics in Education – TIE 2022".

The Conference follows the tradition of gathering teachers, researchers and professionals engaged in various levels of technical, technological and IT education. Over the past 50 years, these gatherings have been organized in numerous forms (conferences, seminars, consultations, etc.) in Serbia and the region. From 2006 to 2016 the conference Technics and Informatics in Education – TIE was organised biennially at the Faculty of Technical Sciences as a national conference with international participation. As of 2018 TIE has a form of an international conference. Eight conferences titled Technics and Informatics in Education were held from 2006 to 2020. The TIE conferences have had a huge impact on the development of IT, technical and scientific subjects in both primary and secondary education. The significant impact has also been perceived in diverse fields related to technical and IT education at university level. However, the new circumstances necessitate organising scientific assemblies in the field of technics and the related technologies.

The TIE 2022 conference aims to improve the exchange of knowledge and experience between experts, professionals, researchers and teachers from Serbia and the region. The conference is expected to provide an analytical review of technical, technological and IT education, focusing on teacher training, terminology in the related fields, as well as the achievements regarding teaching aids, student books, educational assistive technology, technology supporting the enhancement of mental health and well-being, etc.

The Conference involves all the levels of technical, technological and IT education: from preschool institutions, primary and secondary schools over higher and university education, to various forms of lifelong learning.

Furthermore, the special emphasis is given to the importance and role of informatics and computer science in technical education, as well as the correlation between technical education and other natural, social and education sciences. The thematic field of ESP, encompassing foreign/second and professional languages in the realm of technics, technology and informatics, is the new aspect of the Conference.

Within the TIE 2022 conference, a special thematic segment will be dedicated to the current ERASMUS+ project which is realized under the section strategic partnerships in higher education and is run by the University of Kragujevac (2021-2024). Project activities within the conference propose a round table, a symposium, and a workshop addressing the issue of the psychological and social resilience of students in times of crisis.

The results of the conference are anticipated to contribute to planning the development of education in the fields of technics, technology, engineering, IT and computer sciences. The results are also expected to support the exchange of educational patterns and the alignment with regional, EU and global trends in fields in the focus.

We hope that experience gained at the Conference will be very useful both for the participants and for the development of technical-technological education field.

Presidents of the Scientific Committee and Organizing Committee

Organization

The 9th International Scientific Conference Technics and Informatics in Education - TIE 2022 is organized by the Faculty of Technical Sciences Čačak, University of Kragujevac, Serbia.
The Conference is held under the patronage of:

- Ministry of Education, Science and Technological Development of Republic of Serbia
- University of Kragujevac, Faculty of Technical Sciences Čačak, Serbia

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Tribute to Professor Dragan Golubović – the founder of the Conference and creator of Technics and Informatics education in Serbia

Today's international scientific conference „Technics and Informatics in Education – TIE2022", which was established as the national conference „Technical Education in Serbia/Tehničko obrazovanje u Srbiji – TOS2006", is one of the most important professional results of a very diverse and rich professional and scientific career of Prof. dr Dragan Golubović.

Prof. dr Dragan M. Golubović
(1947–2021)

Prof. dr Dragan Golubović was born on 21st May 1947 in Lopaš (Požega Municipality). After attending primary school in Prilipac, near his village, he finished Technical High School in Užice in 1966. In 1971 he graduated from the Faculty of Mechanical Engineering at the University of Belgrade. His master's thesis „Considerations of the possibilities for using the equivalents of the chip for optimising the metal treatment by drilling" was defended in 1975, while his PhD thesis „Addition to optimising the stability of vehicle control" was defended in 1980 at the Faculty of Mechanical Engineering, the University of Kragujevac.

He started his professional career at Technical High School in Čačak in 1970, and in 1975 he was registered as the first employee at the newly founded Pedagogical Technical Faculty in Čačak. He was appointed an assistant professor in 1980, associate professor in 1985, and in 1992 he obtained the academic title of full professor for the narrow scientific field of Technical Mechanics.

His scientific and research work was very fruitful. He presented at numerous international and national scientific and professional conferences and he published a great number of papers in international and domestic journals. Professor Dragan Golubović's list of references includes over 250 titles. He was the author of six monographs, six university textbooks and over fifty other publications.

He was the leader or participant of the research teams for the implementation of more than 20 projects supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia or the Economy of Serbia. He was the author of several technical solutions.

Dragan Golubović was the mentor of six defended doctoral dissertations, 29 master's theses, and over 150 graduation theses. He participated in the work of committees for the selection of all associate and teaching positions at the Faculty of Technical Sciences in Čačak, but also at other faculties, such as the Faculty of Engineering Sciences in Kragujevac and the Faculty of Mechanical and Civil Engineering in Kraljevo.

He was the creator of two innovative study programmes: Mechatronics, which was first introduced in Serbia at the Technical Faculty in Čačak, back in 1990, and Technology and Informatics, a study programme where the largest number of technical education professors who were employed in the education system in Serbia obtained their diploma.

He was also the founder of the laboratory for mechanical tests, which from the very beginning significantly contributed to the development of cooperation between the Faculty and the economy. He performed important professional and leadership duties at the Faculty of Technical Sciences in Čačak. Professor Golubović was the head of the Department of Mechanics and Mechanical Constructions twice, from 1980 to 1982 and from 2001 until his retirement in 2012. He performed the duties of the Vice Dean for Teaching from 1986 to 1988 while he was the Dean of the Faculty from 1988 to 1992. At the University of Kragujevac, he was the Vice Chancellor for Finance and Development from 1994 to 1996, a member of the Council for Technical Sciences and a member of the University Council.

He attended professional trainings in well-known institutes and universities throughout the country and abroad: University of Krakow, MADI - Moscow, ČVUT - Prague, Technical University - Dresden, Technical University - Timisoara, University - Lancaster and others. Above all, professor Golubović made a special contribution to the improvement of the education and training system, particularly in the technical culture domain.

Professor Golubović was a member of numerous national entities in the field of education as well as working groups of the Ministry of Education. He was a member of the Education Council of Serbia from 1982 to 1986, a president of the Association of Organizations for Scientific and Technical Creativity of the Serbian Youth (1982-1984), a president of the Commission for Technical Education from 1980 to 1990, a head of the Center for Improvement of Technical Education and Training (1981-1986), a member of the Commission of the Institute for the Improvement of Education and Training (2001-2008), a chairman of the License Commission for Technical and IT Education of the Ministry of Education of the Republic of Serbia (2006-2011). He was a member of the Society of Engineers and Technicians of Serbia (1972-2012), as well as the Society for Engines and Motor Vehicles of Serbia (1980-2012).

Professor Golubović devoted his 42 years long career to research in technology and education. He made a special contribution to the improvement of education in the field of technology and informatics on various educational levels, ranging from primary to higher education. He laid the foundations of technical and IT education in Serbia and for more than 30 years he wholeheartedly promoted the improvement of the teacher education.

The professor paid particular attention to the careers and professional development of his former students. He was the author of several accredited professional training programs for teachers in the field of technology and informatics, which were attended by over 1,000 teachers throughout Serbia from 2007 to 2015. More than 20 generations of primary school students studied the subject of Technical Education, which was later renamed Technical and IT Education. Even nowadays, the school subject Technics and Technology is taught from the textbooks signed by Professor Golubović.

He was a gatherer of numerous rewards and one of the most important was the December Prize of Čačak Municipality which he gathered in the same year when he retired.

Professor Golubović started this conference with the idea to improve and support the education and professional development of the teachers and researchers in the technical-technological field, as well as their mutual collaboration.

Within the 9th International Scientific Conference "Technics and Informatics in Education - TIE2022", we bring back our memories of the Conference founder and the university teacher who was outstanding in the field of technology and informatics education. The round table will be open for fellow teachers and researchers, the professor's students of all the levels of studies, as well as the professionals to whom he was a model for their professional and personal improvement and development.

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Online Resources as a Support for Teaching STEM Courses in Secondary Vocational Schools and in Faculties

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Abstract: *The paper provides a systematic review of a plethora of online resources that can be used as a support for teaching various STEM courses that are usually taught in secondary vocational schools or in faculties. These resources have been utilized by the author of this paper on a regular basis, especially during the pandemic and post-pandemic period. The majority of the resources are related to the field of power engineering, but they also comprise other examples from Physics and other related disciplines.*

Keywords: *online resources; technical courses; secondary vocational schools; faculties*

1. INTRODUCTION

In the last few years, online teaching has been necessary and for many months the only possible way of delivering instruction in schools and colleges. As every cloud has a silver lining, the digital competence of teachers and professors has significantly increased in a short period of time, which was due to the sudden necessity that the teachers get familiar with new software packages and programs for online communication. Unfortunately, most of the teachers had neither any training nor a systematic approach to learning new tools.

In the last two years, a significant number of scientific and professional papers have been published that analyzed online teaching during the COVID19 pandemic [1, 2, 3]. Those studies analyzed the teaching methods applied, the platforms used, the achieved effects, as well as advantages and disadvantages of the instruction.

The distribution of online activity is given in [1]:

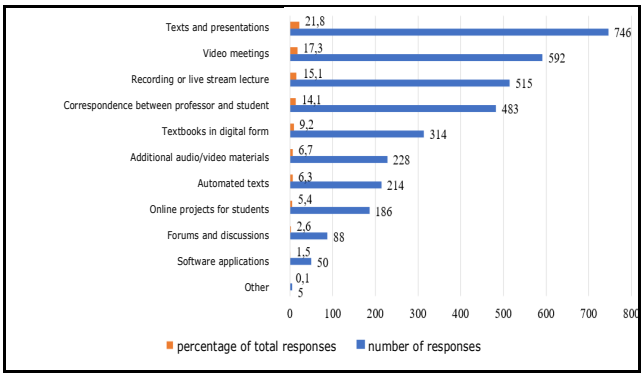


Figure 1. *Distribution of online activities [1]*

The findings of the research (Figure 1) imply that there was an extremely low percentage of the use of additional audio and video materials (6.7%) and software applications (1.5%). For that reason, in this paper special attention is paid to these apparently underused online resources. Thus, the paper is an attempt to systematize those computer resources.

Since the author of the paper is a professor of power engineering, most of the listed examples come from the electric machines and electromotive drives scientific field. Of course, with a little additional interest and effort, one could easily also find adequate content from most other technical disciplines.

The goal of this paper is to introduce teachers and professors of STEM subjects to the easy accessible online resources, so that they start using them in their teaching activities.

2. ADVANTAGES AND DISADVANTAGES OF ONLINE TEACHING

After the abrupt transition to online teaching, without the preparation and training for both students and teachers, distance learning has shown all its downsides and upsides.

The advantages of online classes are as follows:

- increase in digital literacy of both students and teachers,
- saves time and money,
- delivered from homes, in a more relaxed atmosphere,
- allows the use of new resources that have not been used much before.

The downsides of online classes are as follows:

- lack of socialization and networking,
- there is no closeness, no exchange of emotions, alienation occurs,
- not everyone has equal conditions or opportunities,
- families with several children studying online at the same time are a special problem,
- there are big differences from city to city, from school to school, and even from class to class. In some schools, students are required to be online during every lesson, while in others they are free for several days,
- physical activity is worsened or neglected,
- far greater engagement of teachers, of course of those who seriously and responsibly undertook the preparation of online classes.

3. LITERATURE AVAILABLE ON THE INTERNET

There is an abundance of technical literature available online - from the explanation of elementary laws of physics to the explanation of the latest technical achievements. There are also many sites that specialize in certain scientific fields with excellently presented content. The only possible limitation can be of the linguistic nature since most of the displayed content is presented in English. In the following part of the paper, some of those contents have been selected and presented that can be used in teaching activities.

The following list provides an overview of several excellent websites (classified by the paper author) that specialize in certain scientific fields:

• **SCRIBD** [4]

Scribd is a vast digital library filled with ebooks, audiobooks, podcasts, magazines & news articles, sheet music, documents, and more. For a low monthly fee, subscribers gain access to the SCRIBD library.

• **TECHNICAL BOOKS PDF 1** [5]

Technical Books PDF provides Free Download PDF Books, PDF Manuals and Notes for students, related to Engineering, Science, Mathematics and other.

• **TECHNICAL BOOKS PDF 2** [6]

This site lists free online computer science, engineering and programming books, textbooks and lecture notes, all of which are legally and freely available on the Internet.

• **TECHNICAL BOOKS PDF 3** [7]

Freebookcentre.net contains links to thousands of free online technical books. The book collection is either downloadable or can be viewed online. Their collections include core Computer Science, Electronics, Science, Medical and many more. You are welcome to follow the following links for the free books tour.

Something special, but not from the scientific field:
- http://www.digitalna.nb.rs/ Treasury of medieval written monuments. Old printed books.
- https://www.rastko.rs/ The Library of Serbian Culture.

You should be very careful when using Internet resources since not all available content is legal, i.e. they were posted without the knowledge and approval of the authors. In other words, their use is not approved. In this paper, only two of the widely used sites will be listed, of course without the links given.

Illegal sites:

- **Sci-hub,** search and download pdf files, and scientific articles with DOI number.
- **LibraryGenesis**, download PDF books.

4. TUTORIALS, LESSONS, TESTS

There are numerous specialized sites on the Internet with prepared lessons from certain STEM disciplines. In the abundance of the available material, the biggest problem is to find the one that best suits students in terms of the content and complexity of the presented material.

It used to be more difficult to find high-quality professional literature. Nowadays the problem is to choose the best quality from the abundance of materials. Of course, most of the available content is related to learning programming languages and specialized software (because the Internet and online classes are based on them) or general education subjects, e.g. physics.

The following list gives an insight into some of them:

• **On-line tutorials** [8]

JavaTpoint is a Delhi/NCR-based leading IT Company established in 2011. The development of JavaTpoint began with a motto to spread technical knowledge and help students learn efficiently. Today, JavaTpoint is a global platform that provides remote and free access to learning to students. JavaTpoint has over 150 million users.

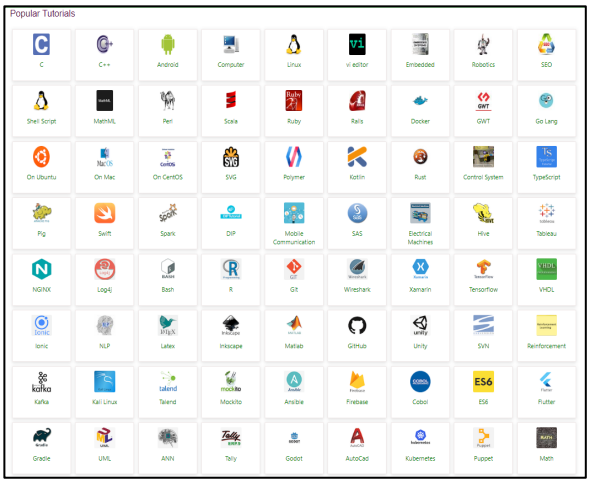


Figure 2. *Showing part of the icons of the software packages whose tutorials are offered*

• **On-line matlab** [9]

This tutorial has been prepared for the beginners to help them understand basic to advanced functionality of MATLAB. After completing this tutorial you will have a moderate level of expertise in using MATLAB from which you can proceed to the next levels.

• **On-line physics lessons** [10]

HyperPhysics is an exploration environment for concepts in physics which employs concept maps and other linking strategies to facilitate smooth navigation. For the most part, it is laid out in small segments or "cards", true to its original development in HyperCard. The entire environment is interconnected with thousands of links, reminiscent of a neural network. CD or DVD versions have been sent to 86 countries to date, and translations into German, Italian, Chinese, and Español have been licensed and are underway.

• **Tests**

There are several specialized programs for testing knowledge. One of the most popular is Moodle.

For students who take courses on Electrical machines and Electric motors at FTS Čačak, several moodle tests were created for practice and mid-term exam preparation. Thus, students have access to tests that can best test their knowledge as they can learn from their mistakes. In that way, they can better prepare for the exam preparatory classes in which their test responses are analyzed. The tests are designed in a way that they are more difficult than the questions expected at the mid-term exam.

This method of preparing for mid-term exams which has been used for many years has given excellent results and is especially suitable for ''better'' students, i.e. those who want to achieve a good mid-term result that would exempt them from taking the oral part of the exam.

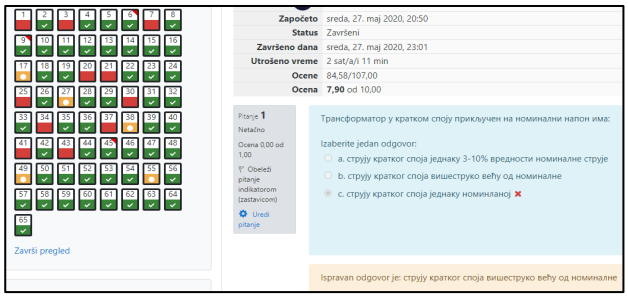


Figure 3. *An example of a test question created in Moodle*

5. ASYNCHRONOUS AND SYNCHRONOUS ONLINE LESSONS

5.1 ASYNCHRONOUS ONLINE LESSONS

In this type of teaching, the teacher communicates with the students DIRECTLY via the Internet, but they are not in direct communication. The teacher uploads his teaching materials, assignments and questions, and the students download the material, learn from it, complete the set tasks and assigments, which they also post/upload on specialized websites.

The most popular and relatively evenly used programs are the following: MICROSOFT TEAMS, ZOOM, MOODLE, GOOGLE CLASSROOM [1].

This type of instruction can be very successful, if the teacher makes an effort to record his material, either as a lesson held in front of the blackboard or as a recorded video with numerous integrated multimedia contents, which the students will be able to review and re-use later. The advantage of this way of teaching is that there is a possibility for the teachers to review their material, and subsequently complement and/or correct it.

On the other hand, many teachers replaced their classes with scanned pages of books or their notebooks and left the students to process them independently. Some of them provided students with additional office hours. This way of "teaching" is the worst, since teachers replace their teaching activity with teaching contents, which are usually abridged versions of textbooks, scripts or other materials, which should already be available to the students.

Examples of good asynchronous online teaching, with a choice of various models for presenting teaching content, are as follows:

• **ONLINE RTS SCHOOL** [11]

After analyzing these materials, one can notice a huge disparity in their quality. Some teachers created a PPT presentation with a few static slides and read the text from the textbook. Some, on the other hand, recorded their class using a whiteboard without computer support. Some of them recorded their lectures with the support of computer resources: presentations, films, and animations. For elementary school students, these contents were broadcasted on the RTS TV channel, daily, in a scheduled time frame.

• **PHYSICS** [12]

This channel contains the complete lectures: Physics I: ClassicalMechanics (autumn 1999), Physics II: ElectricityandMagnetism (spring 2002) and Physics III: VibrationsandWaves (autumn 2004) on MIT.

These lectures are very thoroughly prepared, with integrated physics experiments. They were realized in an amphitheatre in the presence of students and with all the technical support that was used at that time, about 20 years ago. A lot of collaborators participated in the preparation of the lecture and the preparations lasted for days with organized "final rehearsals". All the lectures of these 3 courses were completely recorded and are available on the Internet on the YouTube page of Professor Lewin, who is still active to this day, continuously

posting weekly program assignments. It has over 1,300,000 followers.

Figure 4. *Pictures from Professor Lewin's classes*

• **ELECTRICAL ENGINEERING** [13]

Recorded video lessons by Professor Navaez with an interesting virtual whiteboard display.

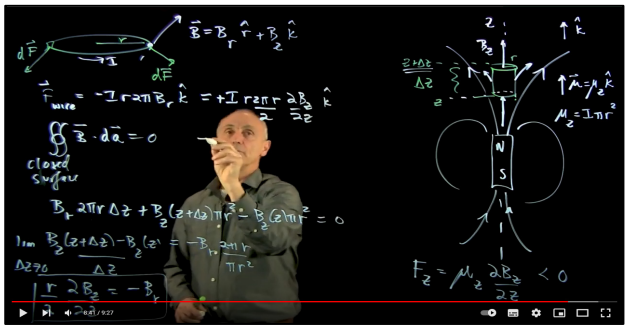


Figure 5. *Appearance of the virtual whiteboard during the lecture*

• **MATHEMATICS** [14]

This is a YouTube channel of professor Voo Sydney that contains over a hundred playlists, each of which has several to several hundred videos of recorded lectures in the field of mathematics.

• **INTRODUCTION TO POWER ELECTRONICS** [15]

Excellent whiteboard lectures by professor Katherine A. Kim, National Taiwan University.

• **SIMLE ELECTRONICS** [16],

Recorded videos of using the SymplyElectronics software package, very useful for simulating electrical and electronic circuits.

Figure 6. *Videos (left) and software (right)*

• **ELECTRICAL MACHINES COURSE** [17]

Video lectures of the course prof. AdelGasti, Department of Electrical Engineering at Qatar University from electrical machines: magnetic circuits (6 video lectures), transformers (8), DC machines (5), Induction machines (5), Synchronous machines (6). Presentations, videos, animations and simulation programs are integrated into the videos.

• **ELECTRIC MACHINE DESIGN** [18]

Lectures from the University of Minnesota. PPT presentations are recorded, where the author can

be seen and heard in the corner of the screen video. Contains 36 video lectures.

• **BASIC ELECTRIC DRIVE** [19], University of Minnesota:

By the same principle as the previous lectures. Contains 14 video lectures.

4.2 SYNCHRONOUS ONLINE LESSONS

This type of teaching implies DIRECT communication with students. It is best if it is achieved by mutual use of a webcam and a microphone. Online communication by exchanging online messages is also possible. It is important that the teacher or student can communicate directly. This type of communication is the most demanding and requires a lot of preparation time. The class is held at the exact time.

It is possible to record the lessons and subsequently reproduce them. The disadvantage is that if the class is recorded, all unwanted situations in the class remain permanently recorded (professor's lapsus, possible mistakes made during performance, technical problems caused by poor quality of the internal connection or inability to display the selected content). Also, the possibility of misuse of the recorded video cannot be ignored. For this reason, many professors avoided this type of teaching, some of them not wanting to be filmed while teaching. For this reason, there is a ban on carrying mobile phones in classes in many schools.

One of the compromise solutions, which the author of this paper used in his lectures, was to use a mobile phone aimed at the desk instead of a web camera, which has a lower resolution. In doing so, the IP Webcam program was used on a mobile phone.

Figure 7 shows a screen view from a mobile phone (right) with the ability to adjust image parameters: resolution, cropping, orientation etc. (left).

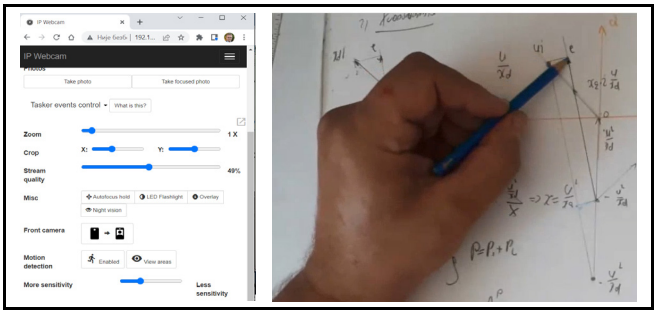


Figure 7. *View program IP Webcam.*

In the described way, participants of the online course could listen to the lecturer and follow the content he wrote on his desk. Of course, the web camera could be turned on at any time, through which the teacher would also be visible.

6. ANIMATION IN CLASS

Graphic animations can be an excellent resource in teaching. It is said that a picture is worth a thousand words. Animated moving images allow a better understanding of physical phenomena, principles of operation, construction and arrangement of components etc. The following list contains a selection of several excellent addresses used (mainly posted via the YOUTUBE platform) that illustrate the power of using animation in teaching.

- **LESICS** [20]

Lesics was founded by Sabin Mathew, an IIT Delhi post graduate in 2012. At Lesics, with aim to provide quality engineering education. The videos are designed to clear misconceptions, create a passion for engineering and explain complicated technologies in a simple way.
Contains 13 playlists. It has over 5 million followers! The number of followers confirms the fact that it is one of the best YOUTUBE channels with animations in the field of technology.

The excellent quality of the animations, the expertise with which the content was carefully selected and explained, the topicality of new video animations make this site exceptional. Within a few hours of the publication of new content, tens of thousands of views are achieved.

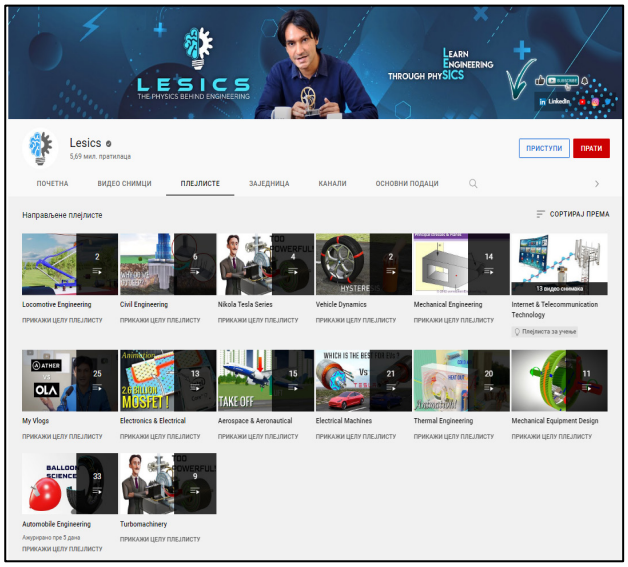


Figure 8. *Playlists of youtube channels LESICS (former name Learn Engineering)*

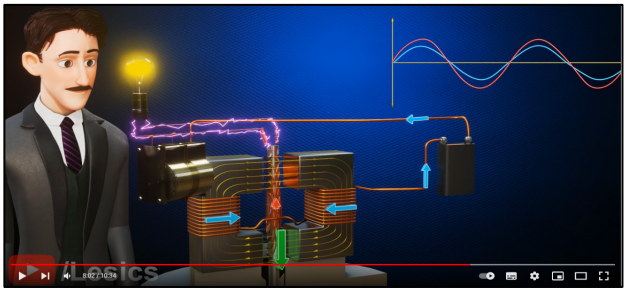


Figure 9. *One slide animation about Nikola Tesla*

- **THE ENGINEERING MINDSET** [21]

The Engineering Mindset was started in 2015 by its founder, Paul Evans. The mission was to help students, engineers and like-minded people learn technical engineering topics through short, simplified tutorials. Number of playlists 16, number of followers over 2 million.

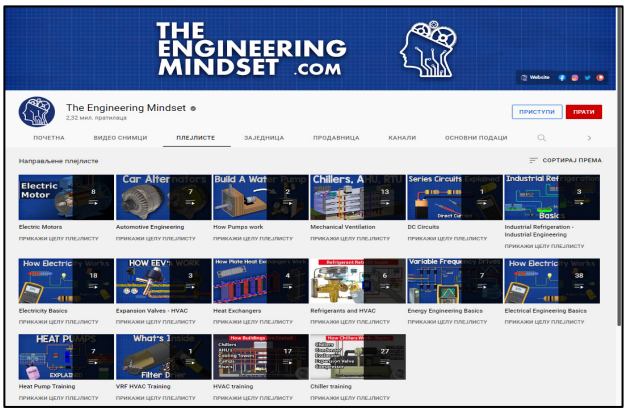


Figure 10. *Playlists of youtube channels The Engineering mindset*

- **PHYSICS** [22]

Physics YouTube channel made and run by Eugene Khutoryansky.
Most of the video animations are from electronics, where it is effectively used to illustrate the different potentials of network nodes with different heights. Very illustrative and easy to understand phenomena in electrical engineering. The analogy used successfully visualized and explained the basic electrical parameters: resistor, capacitor, coil, transistor, voltage and current source etc.

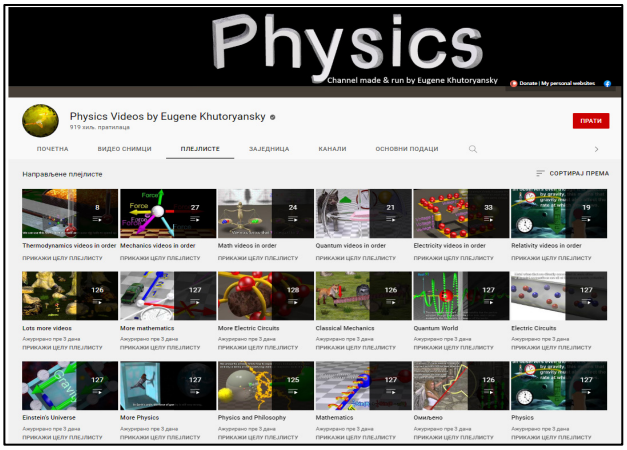


Figure 11. *Playlists of youtube channels Physics*

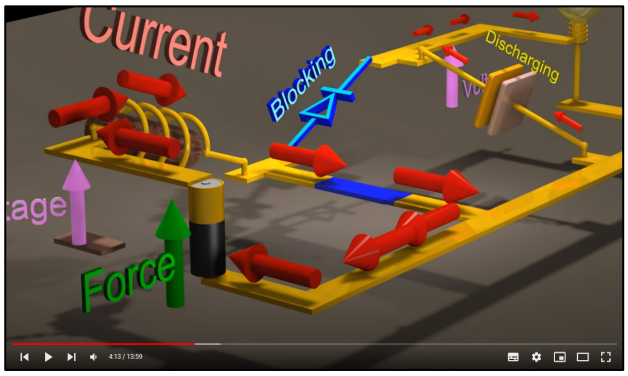


Figure 12. *Screenshot from an animation explaining an electronic circuit using analog quantities*

- **LEARNCHANNEL** [23]

Electrical Engineers Tutorial Video Channel: Topics covered: Automation, Electric engineering, Robotics, Hydraulics, Pneumatics, Electric motors, Closed-loop controls. Great animations with great explanations. As an illustration of the extraordinary animations, the image below shows a part of the video from the electrical machines.

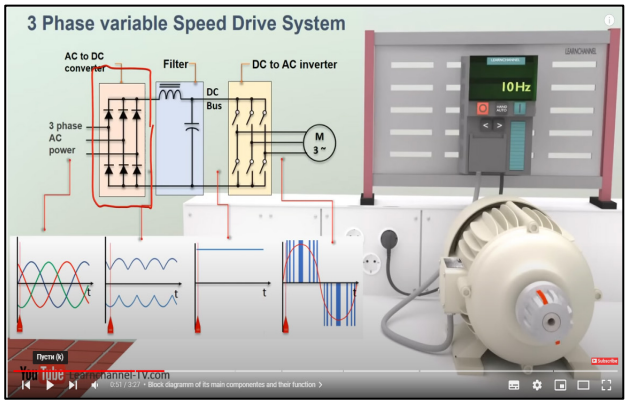


Figure 13. *With an explanation of the operating principle of the frequency converter*

- **HOW TO MECHATRONICS** [24]

Mechatronic systems: Arduino Projects and Tutorials, DIY Projects, How It Works, Electronics, Robotics, CNC, 3D Printers, Tips & Tricks, Arduino Source Codes, Circuit Schematics, Download files and much more can be found at this site.

7. TV SHOWS, DOCUMENTARY AND FEATURE SERIES IN THE FIELD OF TECHNOLOGY

On the Internet (YOUTUBE) you can watch many TV shows in the field of technology. From the abundance of that content, only a few were selected, according to the author of a very popular and watched series on the Discovery channel:

- **SCIENCECHANNEL** [25]

From the 58 playlists, only a few very popular shows were selected:

- ***How it was made***: 287 videos of very popular scientific and educational shows. (in 15 days of following these contents, the number of videos increased by 30)
- ***How the* Universe *Works***: 120 videos
- **MythBusters**: 44 videos
- ***Street Science***: 30 videos
- **Imposible *Engineering***: 42 videos

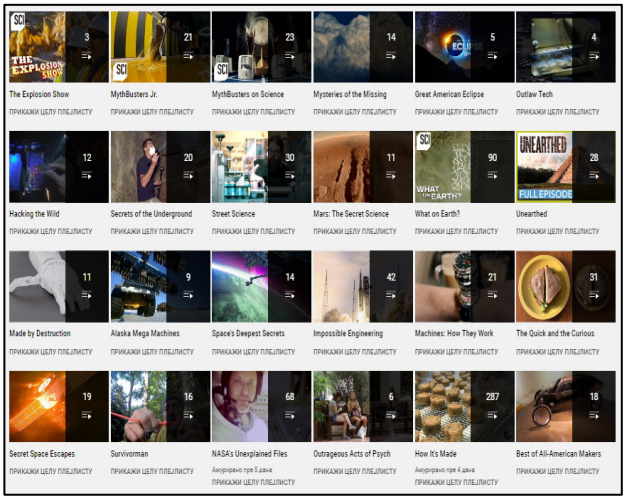


Figure 14. *Playlists of youtube channels SCIENCECHANNEL*

- **HOW IS MADE, DISCOVERY UK** [26]

121 videos from the TV Discovery channel.

8. LABORATORIES FOR ELECTRICAL MACHINES, DRIVES AND AUTOMATICS (EMPA) YOUTUBE CHANNEL

In the laboratory for electrical machines, drives and automatics at the FTN in Čačak, many laboratory setups have been designed and implemented for decades, which follow the teaching content of several subjects in the bachelor, master and doctoral studies in the field of power engineering. Since the recording of video contents became available using mobile phones, an effort has been made to record more interesting laboratory experiments and make them available to all interested parties. One of the reasons for recording video content is that the number of performed laboratory exercises far exceeded the possibilities of performing them with students within the limited fund of working hours in the laboratory.

In this way, a larger number of performed experiments are shown in classes, and interested students can perform them outside of the regular hours of work in the laboratory.

Currently, the YOUTUBE channel contains 48 lists with over 600 selected videos uploaded. The videos have been collected over the years and are sorted by fields. Videos by other authors are specially marked, sorted by topic, and especially videos recorded in the laboratory, whose playlists start with the label EMDA lab etc.

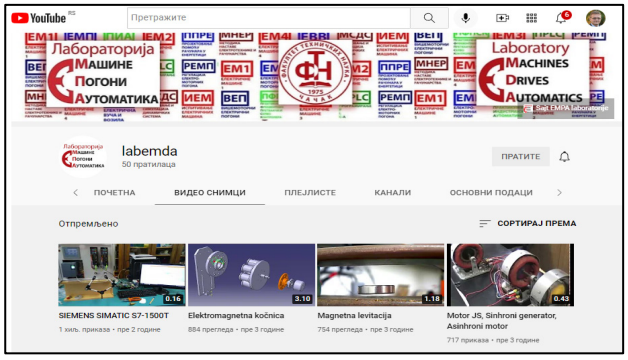


Figure 15. *Home screen of the EMDA laboratory youtube channel*

8.1 Standard electrical machines, electronics, automation:

The following playlists of standard electric machines have been created:

- Transforamtors
- Electromechanical energy conversion
- DC machines
- Induction machines
- Synhronous machines
- Electric drives
- Power electronics
- Automatics

8.2 Special electrical machines:

Special electrical machines are studied in the courset Electrical Machines 4, whose playlists are given in the following list:

- Single-phase asynchronous motors
- Universal motors
- Step motors
- BLDC motors
- Servo motors
- Csynhronous reluctance motors
- Axial motors
- Electric vehicles
- Linear motors
- Torque motors
- Special electric machines

8.3 Other

- Basic terms
- The simplest electric motors
- Autoelectrics
- Does Korkoch's second law apply?
- FEMM
- Electrical machine laboratories
- History of electrical engineering and electrical machines
- Nikola Tesla – animations
- Experiments in magnetism by Professor Lewin
- Sensors and actuators

From the Nikola Tesla series, sequences in which laboratory experiments are performed have been selected. They were performed on replicas identical to the original equipment that Tesla worked with: EMDA lab. parts of tv series Nikola Tesla.

9. RECORDED VIDEO EXPERIMENTS

9.1 EMDA laboratory video experiments:

Sixteen playlists have been created in EMDA laboratory, with over 100 videos:

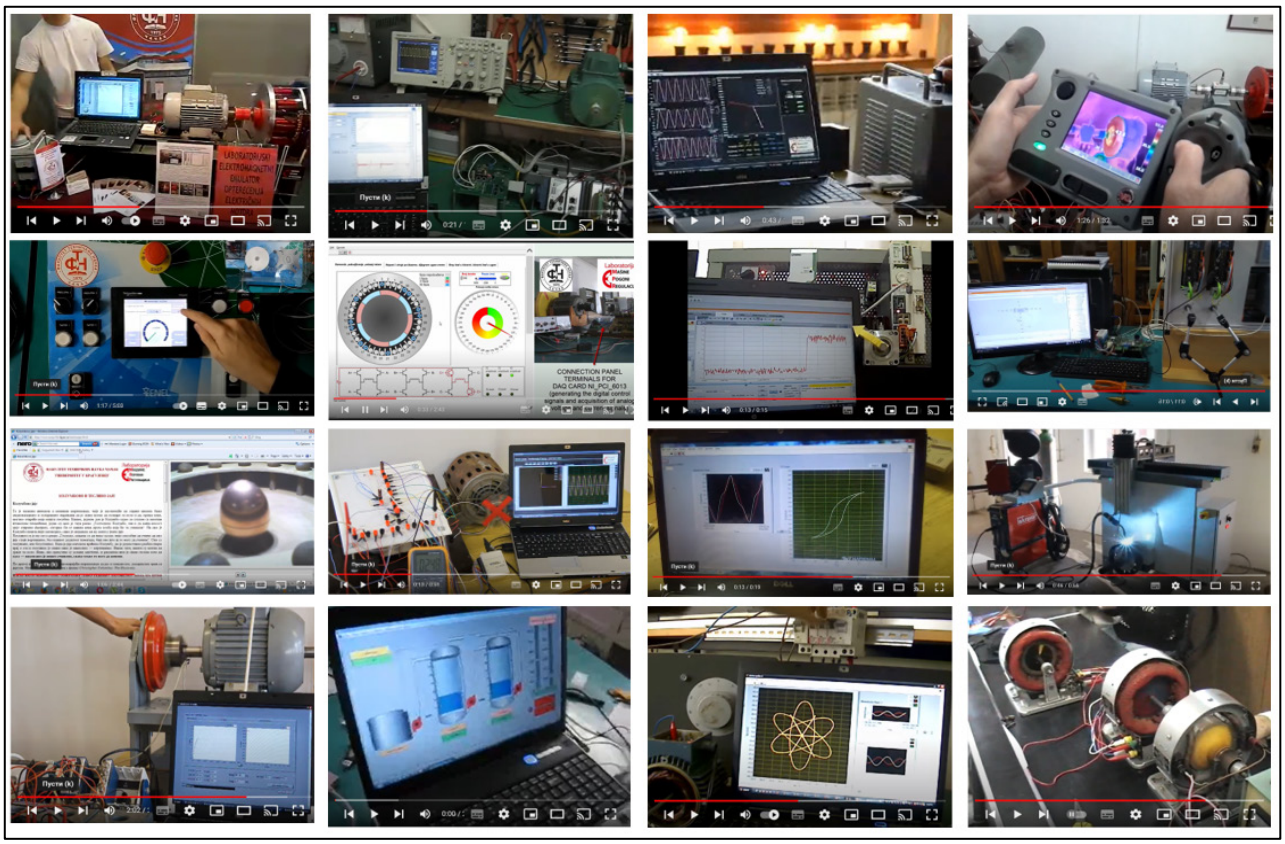


Figure 16. *Screenshots of several recorded videos from the EMDA lab*

1. EMDA lab. Demonstration laboratory experiments
2. EMDA lab. Magnetic circuit, transformers
3. EMDA lab. Electromechanical energy conversion
4. EMDA lab. DC machines
5. EMDA lab. Induction machines
6. EMDA lab. Synhronous machines
7. EMDA lab. Recording the characteristics of electric motors
8. EMDA lab. Winding of electric machines
9. EMDA lab. DC motor inductance winding
10. EMDA lab. Stator winding of a three-phase asynchronous motor
11. EMDA lab. NeReLa remote experiments.
12. EMDA lab. Simulation program of FTS Čačak
13. EMDA lab. Special electric machines
14. EMDA lab. Technical solutions
15. EMDA lab. Videos from the Technical School G. Milanovac
16. EMDA lab. Automation

9.2 Video experiments by other authors

Recently, more and more recorded samples from the laboratory can be found. In the field of electrical machines, drives and regulation, there are dozens of Internet sites where you can view the performed and recorded experiments. Only some of the more interesting ones are given:

- **Electrical Machines Laboratory** [27],

Recorded experiments, Jamshoro, Pakistan Lectures on Different Electrical Engineering Subjects By Engr. Shoaib Ahmed Dayo.

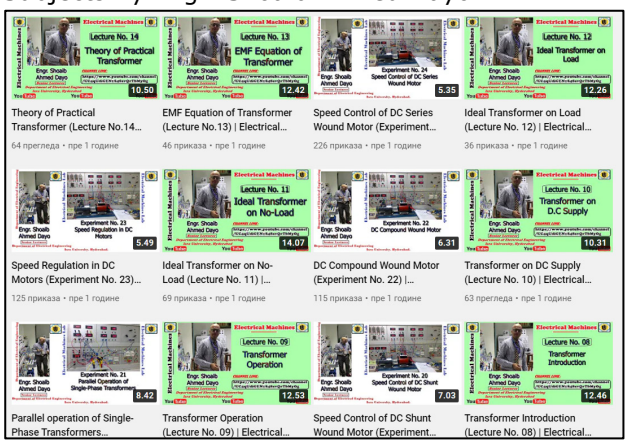
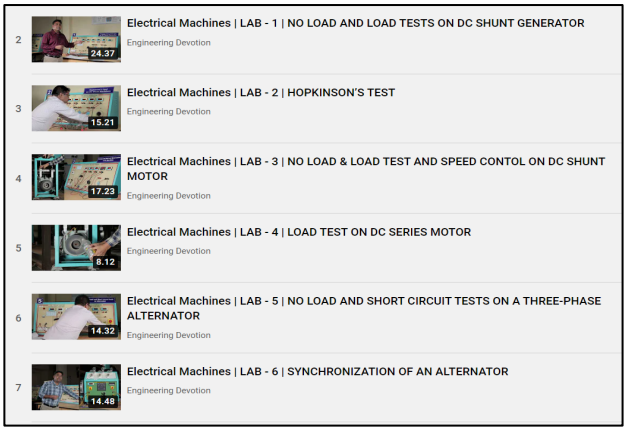


Figure 17. *Playlists of youtube channels Lectures on Different Electrical Engineering Subjects*

- **Recorded 10 settings from electrical machines** [28]

College Secunderabad, India: In addition, there are recorded laboratory settings from the following areas; Electrical & Electronics Engineering Devotion channel: Power Systems, Control Systems, Circuit theory, Power Electronics, etc.



- **Experiments in Physics for 2nd, 3rd and 4th grade of secondary vocational school**

Tomislav Đuran [29], recorded video, Electric machines and drives:

- **Energy electronics** [30],

Machines and Drives, Saša Skoko, Mihailo Pupin High School Novi Sad:

9.3 Youtube technical contents

Since the conference at which this paper is presented is not strictly specialized in the field of electrical machines and drives, in this part of the paper several links to excellent videos in the field of technology - especially electrical engineering - will be provided.

Kathy Loves Physics [31]

Kathy Joseph uses primary sources and talk about real physics and the real, quirky history to tell where our scientific universe came from.

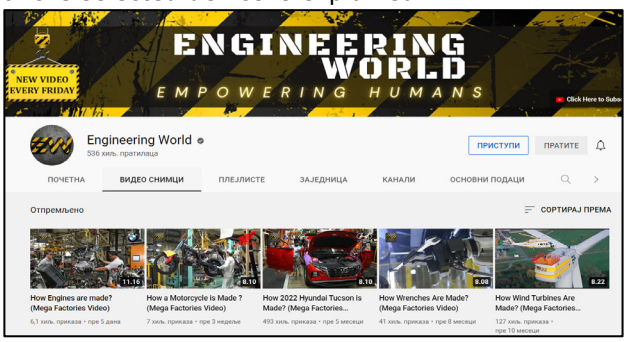
- **ElectroBOOM** [32]

Attractive videos by electrical engineer MehdiSadaghdar with over 5 million followers

- **Engineering World** [33]

The channel features videos so as to be a learning tool for those interested in the engineering field by providing a platform for discussion and sharing ideas.

Every week, a new video is posted, usually from the factory facilities, in which the principle of operation of the selected device is explained.



- **Amazing Technology** [34]

- **CARinfo3d** [35]

Educational channel about the device and the principle of operation of the car, in an easy-to-understand - 3D animation.

10. FRAUD ON THE INTERNET

The Internet is an inexhaustible source of a wide variety of information. The problem used to be the lack of information and how to get it. Today, the problem is how to find the appropriate one from the abundance of information.

Anyone can upload content to the Internet. There are no restrictions, or if there are, they refer to the display of inappropriate content, insults on different renewals, etc. In most cases, there is no restriction based on the criterion of the accuracy of the posted information, especially in the field of technology. This is why the Internet is flooded with content with various types of scams. Of the many, there are very popular sites that offer a way to get the so-called "free energy" i.e. devices and constructions that achieve perpetual mobile.

Since there are a lot of gullible people, these contents are very visited and cause a lot of damage. No matter how hard the professors try to explain that energy cannot be created by itself, there are always those who fall for the scam. Especially if all this is accompanied by videos that "confirm" that such systems have already been built and are working.
As an example, two links will be provided. The first shows a generator that produces free energy, and the second is an excellent video listing and debunking such devices.

- **Example of the Internet fraud** [36]

The video (picture 21) shows, although the author tried to hide it with the angles of the presentation, the shadow of the wire that connects the apparatus to the external source of electricity.

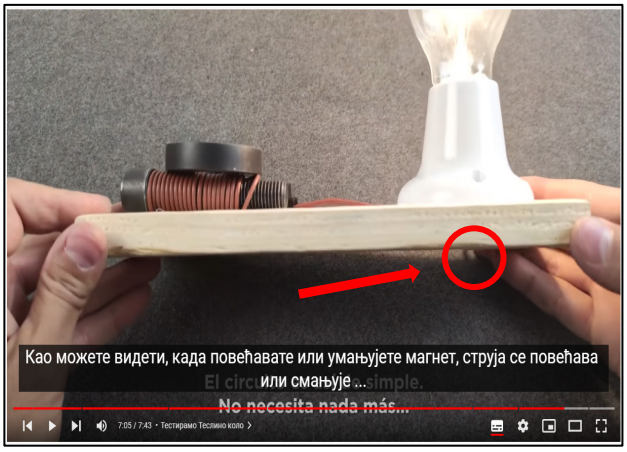


Figure 21. *A part of the video where the fraud is revealed through the carelessness of the author*

- **Examples of free energy [37]**

Description and explanation (from 6 min. 30 sec. the author exposes all the previously shown scams of free energy exchange).

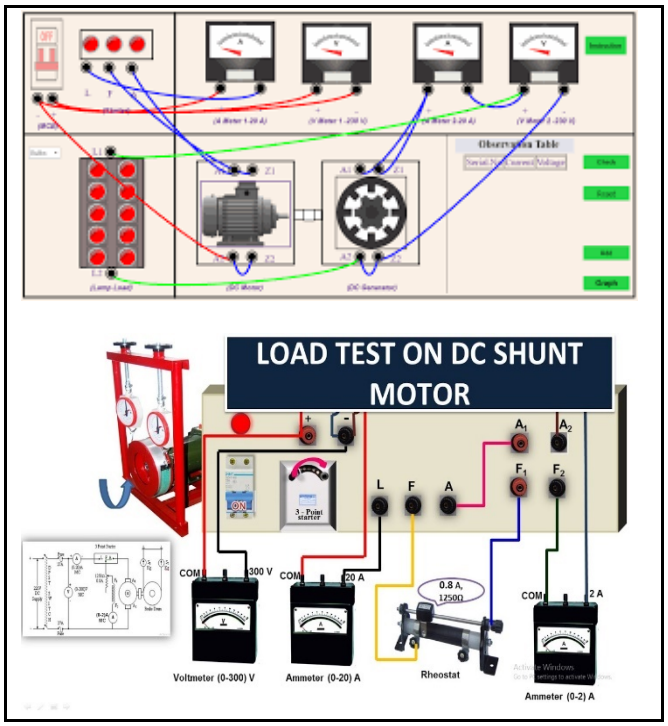
11. VIRTUAL LABORATORIES

Virtual laboratories are an excellent way to prepare students before working in the laboratory itself. By using them, students are trained and equipped to work without fear that any mistakes made will cause damage or danger to the persons who perform them. In addition, virtual laboratories allow students to simulate the phenomena they are examining. Of course, despite the excellent possibilities, virtual reality must not be replaced by concrete, practical work in the laboratory.

In the following list, several virtual laboratories in the field of electrical machines and drives are given.

- **Virtual Laboratory in Electrical Machines**, New Delhi, India [38]:

Virtual Labs project is an initiative of Ministry of Human Resource Development (MHRD), Government of India. Under Virtual Labs project, over 100 Virtual Labs consisting of approximately 700+ web-enabled experiments were designed for remote-operation and viewing. The intended beneficiaries of the projects are: all students and Faculty Members of Science and Engineering Colleges who do not have access to good lab-facilities and/or instruments, high-school students, whose inquisitiveness will be triggered, possibly motivating them to take up higher-studies.



- **Laboratory of Power Electronics and Drives**, Gljivice, Poland [39]

The aim of the project is to increase the teaching potential of the applicant in the field of electrical drives. The results of the project will be as follows: interactive, bilingual teaching materials published through a dedicated web site and create two new laboratory testing sets equipped with modern industrial drive solutions.

12. APLETS

An applet (little application) is a small software program that supports a larger application program. Ten years ago, applets were a widely used way of simulating phenomena and processes. The Internet was full of great little apps integrated into websites. There were especially many programs from the field of physics and those applets had a special name - **Fhyslet**. But, since most of these programs were programmed in the Java programming language, all the problems that accompanied Java applications were reflected on these programs as well. Namely, due to security reasons, some web browsers have disabled the possibility of starting java programs. This prevented the use of thousands and thousands of programs that were excellent teaching material for years.

However, some applets can still be used today. The following, very narrow selection, provides an overview of them:

- **Set of applets from electrical machines** [40]

- **Applets from physics** [41]

Translated into Serbian (translation by Prof. Dr. Zlatan Šoškić, The faculty of Mechanical and Civil Engineering in Kraljevo)

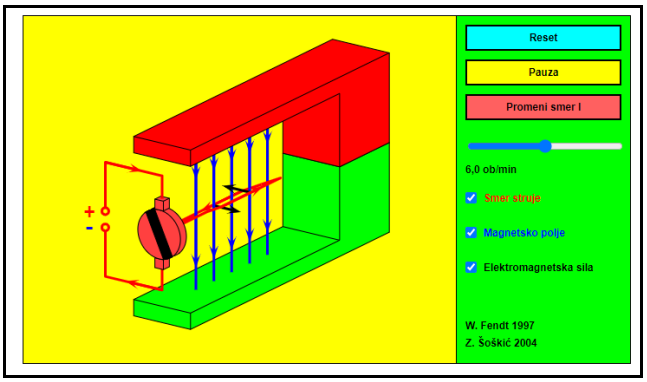
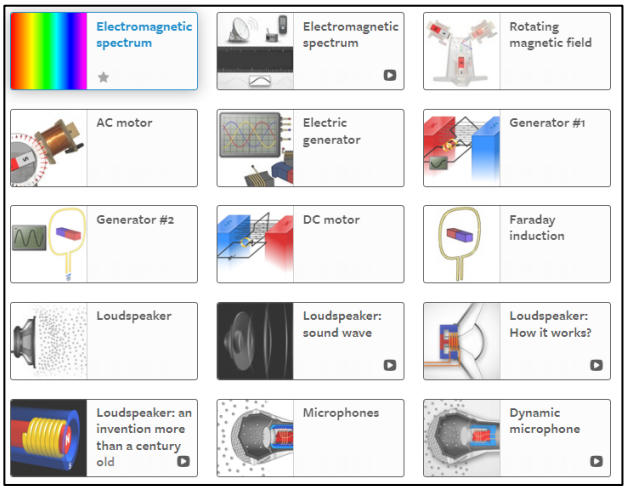


Figure 23. *An applet demonstrating the role of commutators in DC motors*

- **Set of applets from electrical machines** [42]
- **Applets from the field of electromagnetism** [43]

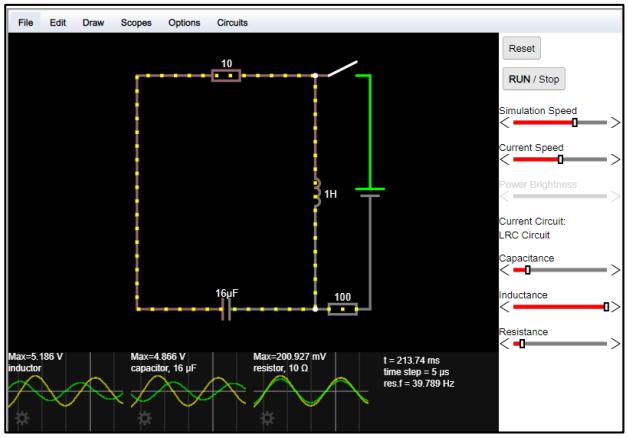


- **Applets from electrical machines**, e.g. Riaz, University of Minnesota [44]:

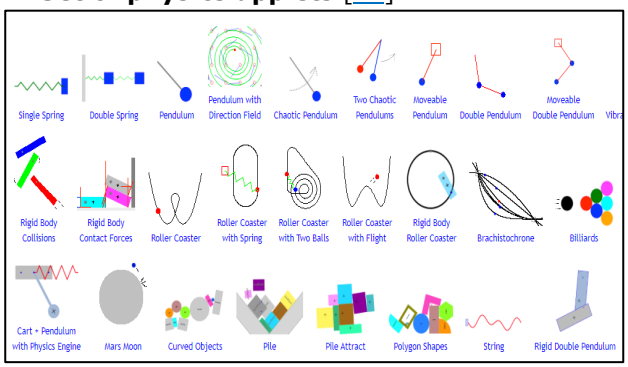
Excellent simulation examples are created in Simulink software packages. Part of the program was translated with the permission of the author and is used in the Master's studies in the course Regulation of Electric Motor Drives at FTS Čačak.

Excellent math and physics applets [45]

- **The electric circuit simulator is from the same author** [46]



- **Set of physics applets** [47]



- **Set of applets in Serbian language** [48]

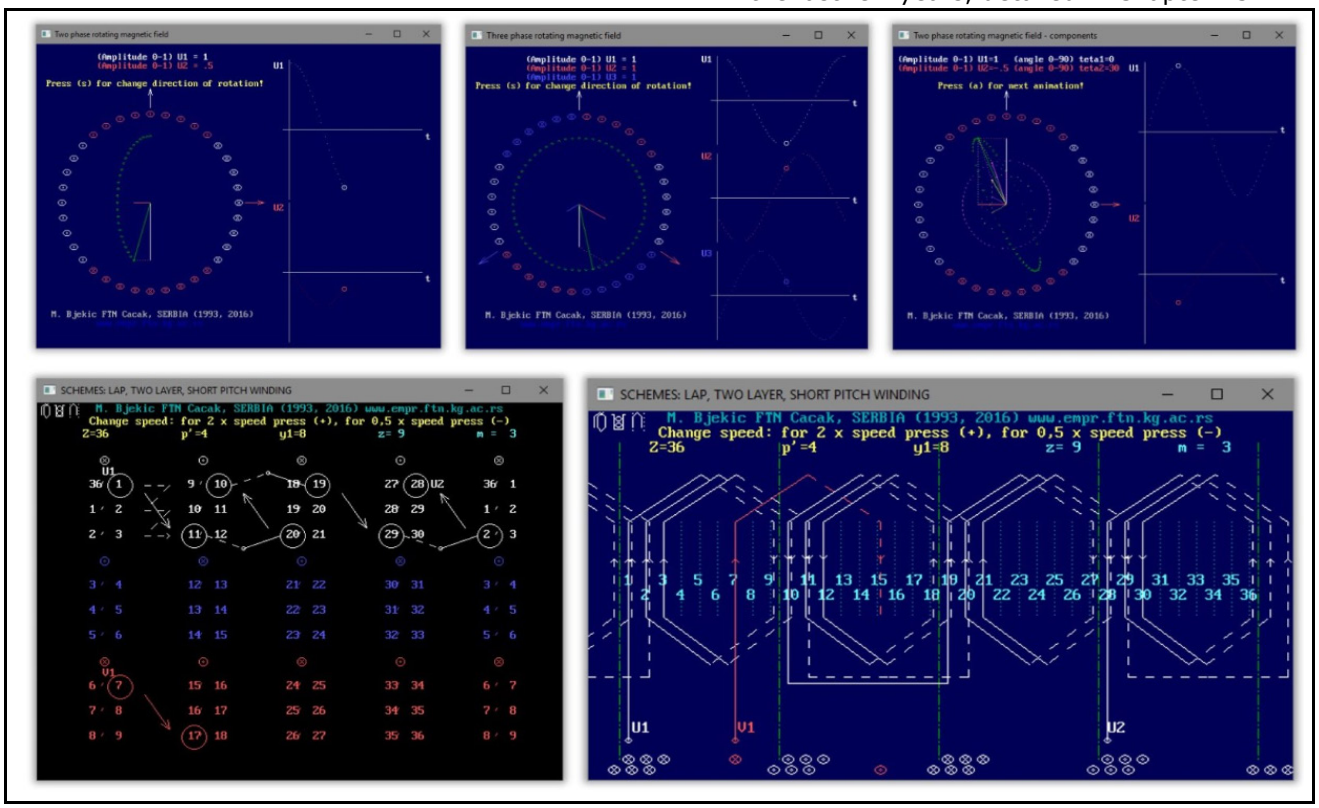
13. SPECIALIZED SIMULATION PROGRAMS

- **Educational software created at FTNS Čačak** [49]

Since 1994, educational software in the field of electrical machines and drives has been created at FTS in Čačak. In accordance with the then available technology, computer characteristics and available programming languages, dozens of educational software were created.

These software can be classified into the following units:

a. Software created in the programming language QBASIC: magnetic fields, windings of single-shift and asynchronous machines, Lissajous figures, created in 1993 and 1994 (Figure 28)
b. Software created in Simulink: Characteristics of electric motors and generators. Translations of programs by prof. Riaz.
c. Software created in the Geogebra software package. Over 30 programs have been created in the last few years, detailed in Chapter 15.



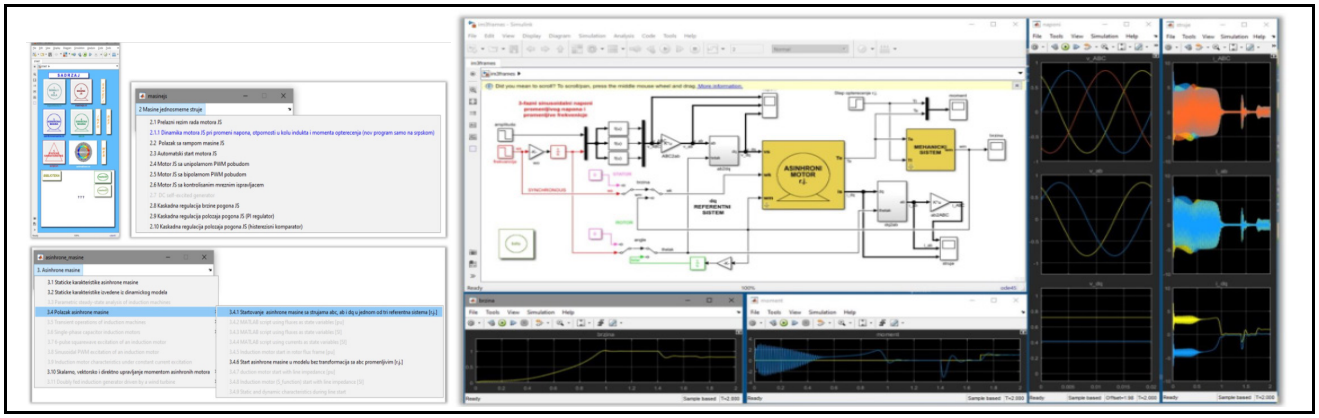


Figure 29. *b) A screenshot of the translated software with a demonstration of one of them*

50].

FEMM is a suite of programs for solving low frequency electromagnetic problems on two-dimensional planar and axisymmetric domains. The program currently addresses linear/nonlinear magnetostatic problems, linear/nonlinear time harmonic magnetic problems, linear electrostatic problems, and steady-state heat flow problems.

FEMM is divided into three parts:

1. **Interactive shell** (**femm.exe**). This program is a Multiple Document Interface pre-processor and a post-processor for the various types of problems solved by FEMM. It contains a CAD-like interface for laying out the geometry of the problem to be solved and for defining material properties and boundary conditions.

2. **triangle.exe**. Triangle breaks down the solution region into a large number of triangles, a vital part of the finite element process.

3. **Solvers** (fkn.exe for magnetics; belasolv.exe for electrostatics); hsolv.exe for heat flow problems; and csolv.exe for current flow problems. Each solver takes a set of data files that describe problem and solves the relevant partial differential equations to obtain values for the desired field throughout the solution domain.

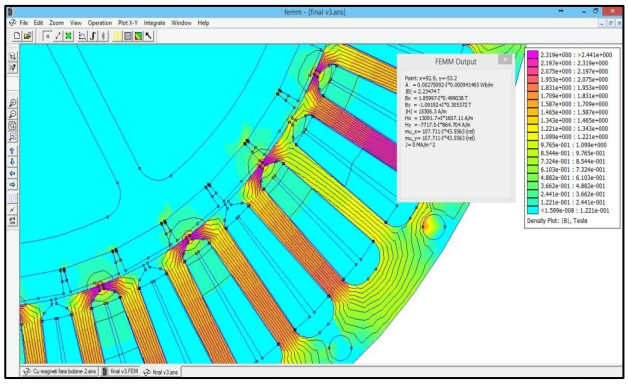


Figure 30. *An example of a FEM analysis of an AC machine stator*

- **Matlab – Simulink** [51].

Matlab is a programming platform designed specifically for engineers and scientists to analyze and design systems and products that transform our world. The heart of MATLAB is the MATLAB language, a matrix-based language allowing the most natural expression of computational mathematics.

Matlab has become one of the most used programming languages in the world in the field of technology. It is intended for engineering calculations. It has a large number of toolboxes, of which Simulink stands out, which enables dynamic, electrical, mechanical simulations thermal, hydraulic and other processes. In particular, a few years ago, the SIMSCAPE block was created, which can combine these processes into one model.

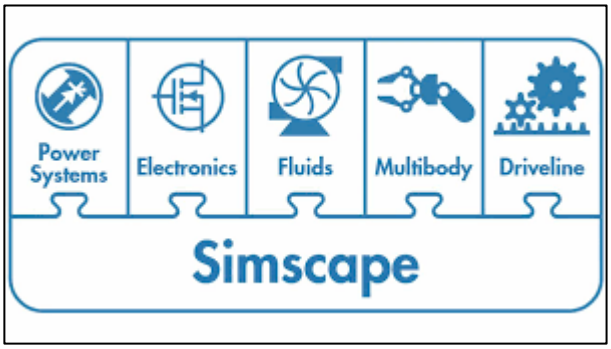


Figure 31. *Simscape components*

- **On-line algorithms and programming** [52]

Flowgorithm features the following: easy to understand output, graphical variable watch window, interactively generate code (for 16+ languages), Safe recursion, loops, arrays, and flexible expressions, multilingual support etc.

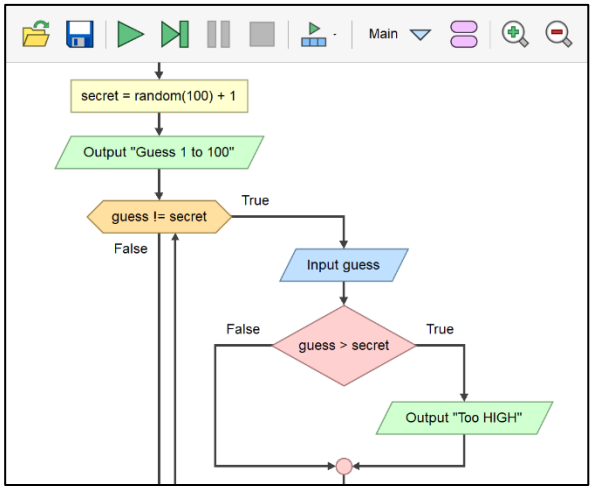


Figure 32. *Flowgorithm program*

14. REMOTE EXPERIMENTS

In the gradation of content applicable in the teaching of technique from the lowest level to the highest, the following order could be defined: images, videos, animations, simulations, remote experiments.

- **Set of remote experiments of 4 universities in Serbia created within the NERELA project** [53]:

LiReX (Library of Remote Experiments) is Web repository of remote experiments developed under Tempus project NeReLa. The Library of Remote Experiments contains set of remote experiments and exercises developed and set up in the labs of four project partner universities in Serbia: University of Kragujevac, University of Belgrade, University of Nis and University of Novi Sad. Each partner university has their own sub-repository with remote experiments developed and installed in their labs.

- **Remote experiments created at FTN Čačak** [54]:

Five remote experiments were created in the EMDA laboratory:

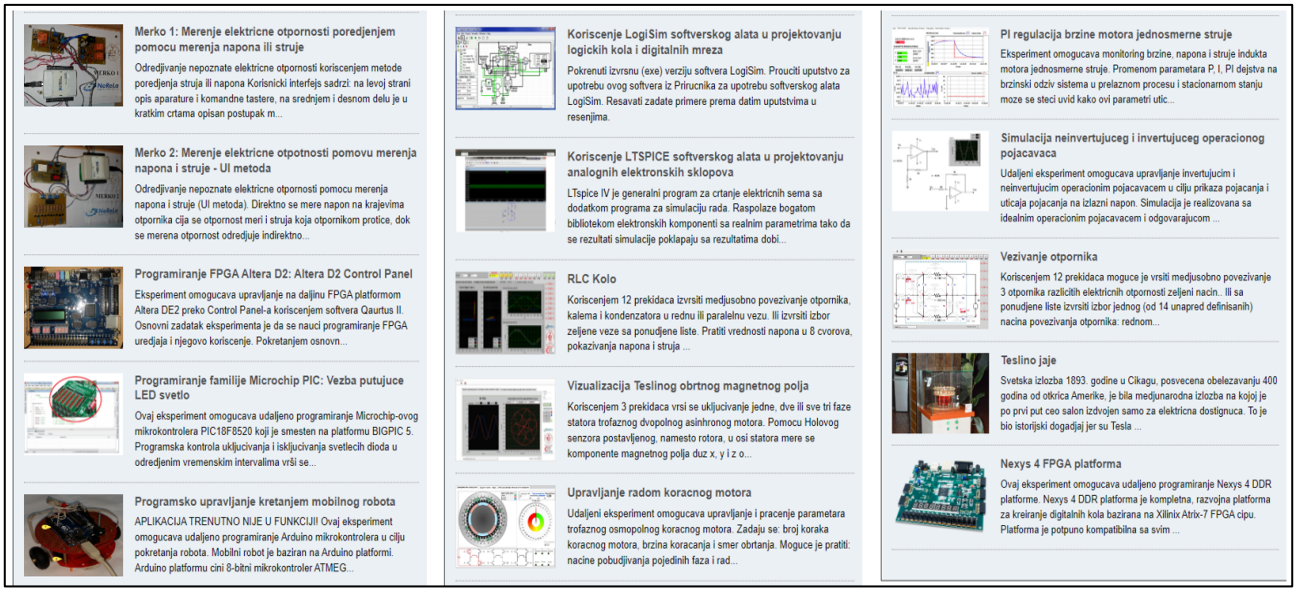


Figure 33. *Remote experiments created at FTS Čačak within the NERELA project*

- **Visualization od Teslas rotating magnetic field** [55]:

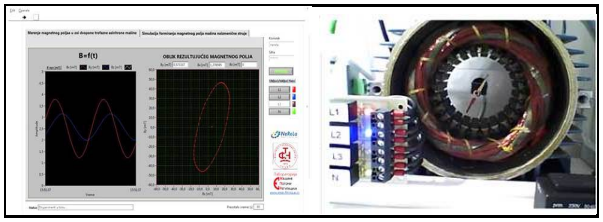


Figure 34. *Screenshot with a webcam image*

- **Resistors connections** [56]:

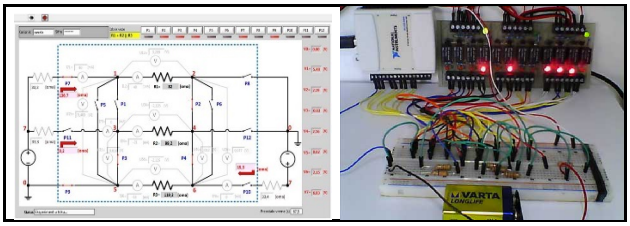


Figure 35. *Screenshot with a webcam image*

- **Series and parallel RLC circuit** [57]

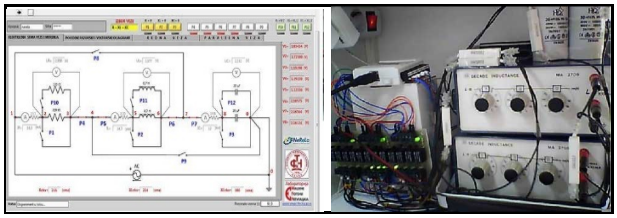


Figure 36. *Screenshot with a webcam image*

- **Controlling a step motor** [58]

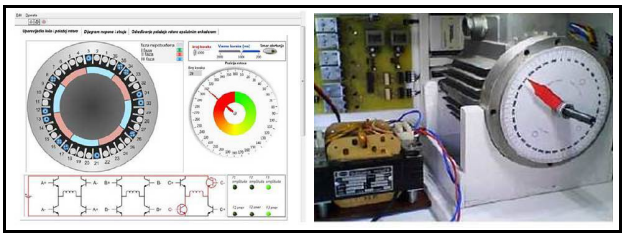


Figure 37. *Screenshot with a webcam image*

15. GEOGEBRA

Although primarily intended as a mathematical tool, it is very useful for displaying 2D and 3D functions, graphically performing characteristics and procedures used in technical disciplines.

Geogebra programs by M. Bjekić [59]:

The author of this paper has created 30 programs for the purposes of teaching several courses at undergraduate and master's studies in electrical engineering.

The many possibilities of the Geogebra program are used: simple drawing of functions with the possibility of easy parameter changes, animations, generic display of graphic performance etc.

Screenshots of some of those programs are given in Figure 38.

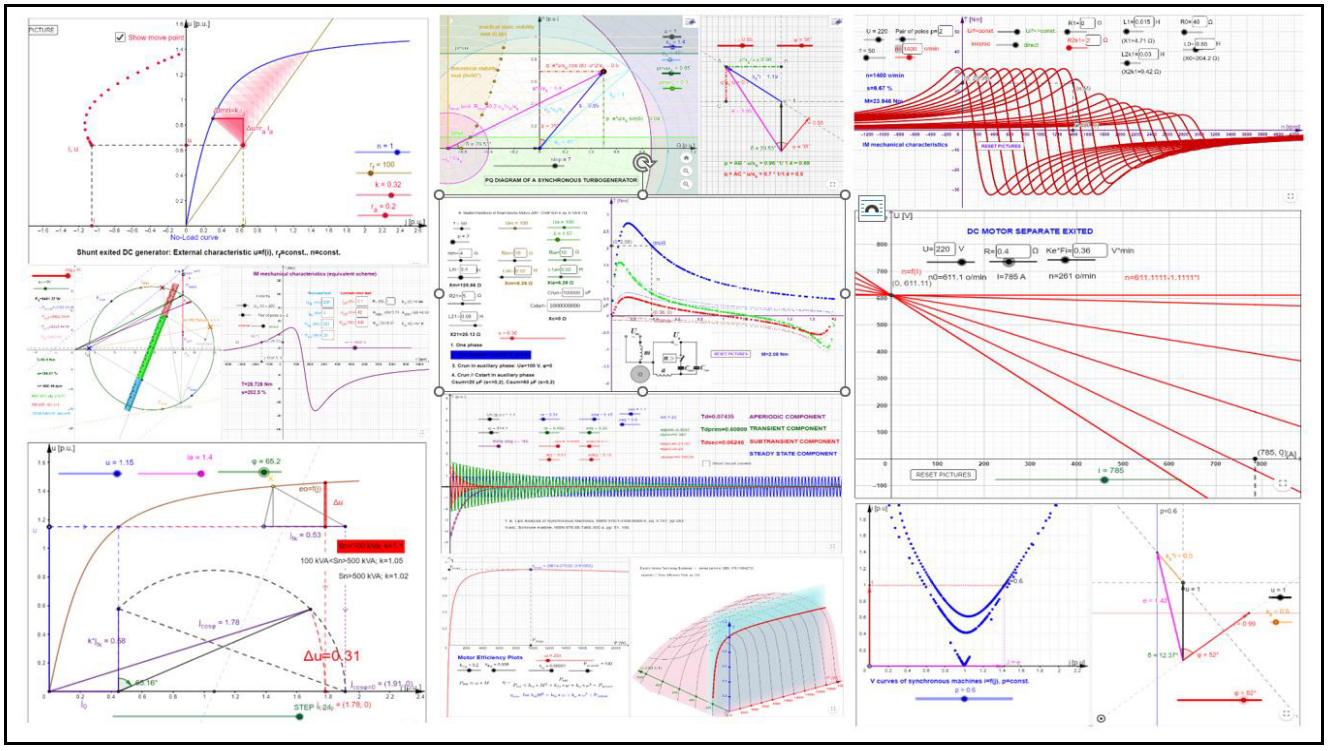


Figure 38. *Part of the Geogebra program in the field of electrical machines and drives, authored by M. Bjekić*

- **Geogebra programs of other authors**:

Searching Geogebra content in the field of Electrical Machines and Drives found 38 authors (data from 2021) with more than 150 programs [60].

- **Geogebra books**:

An example of the possibility of using Geogebra textbooks can be seen in [61]. No geogebra textbook was found in the area of Electrical machines. Once a large base of programs is created the plan of the author of this paper is to create an interactive textbook, that will include first his own programs, but also programs of other authors.

16. EXAMPLE OF AN ONLINE CLASS AT FTS ČACAK RECORDED IN THE TIME OF THE PANDEMIC

At the time of the COVID-19 in the 2020/21 academic year, due to circumstances, online classes were the only means of delivering instruction. This unplanned and unwanted teaching method was a challenge, athough it it was possible and much easier to integrate online content into lectures. The preparation for the online classes took much longer than the preparation of a classical class. A total of 57 online two-hour lectures and exercises were held in 5 courses (Electrical machines 1-4 and Testing of electrical machines). All classes were recorded and are available to current and future generations of students.

As a demonstration of the teaching method, several screenshots from the recorded lessons will be shown, from which you can see which online teaching materials were used.

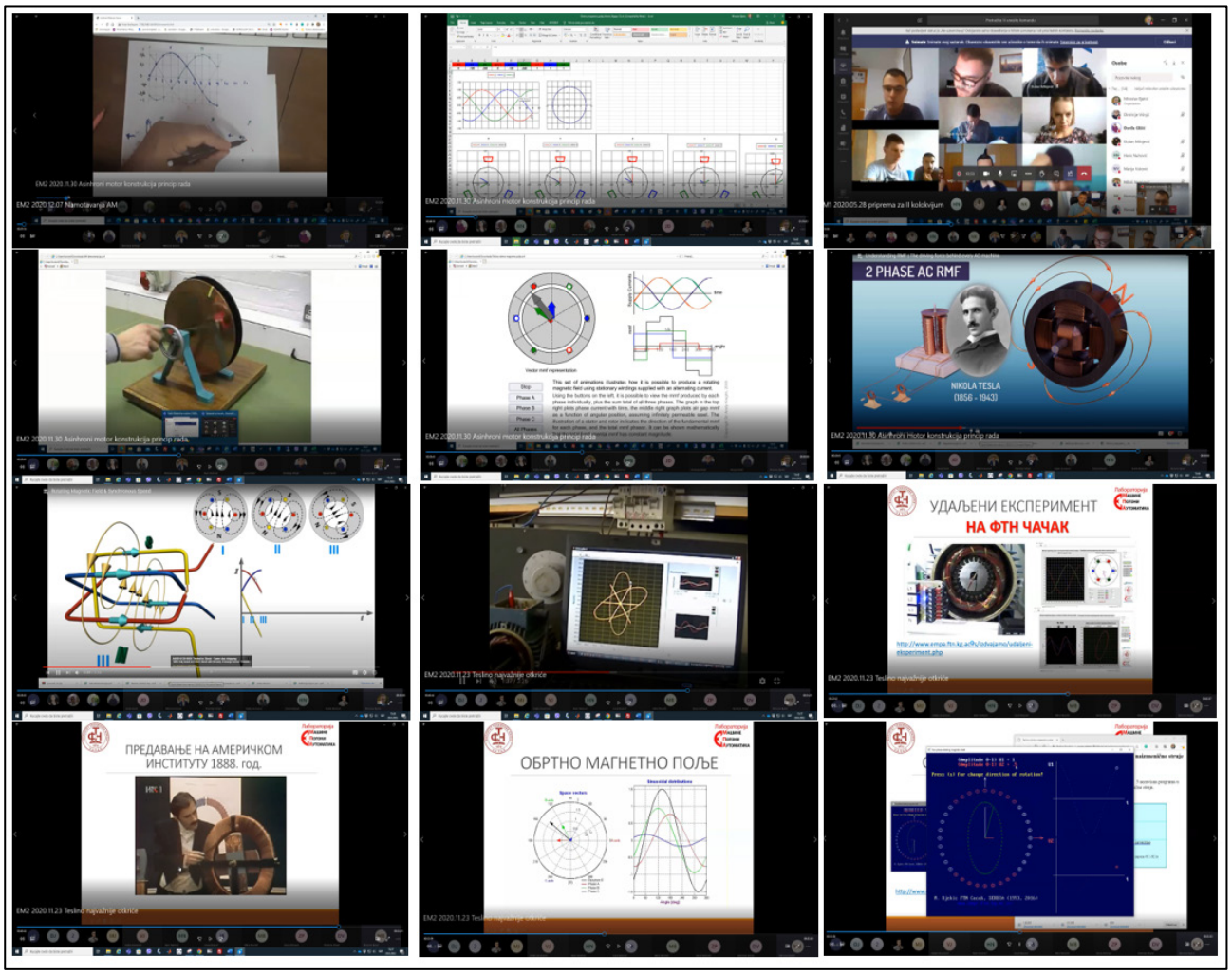


Figure 39. *Screenshots of recorded online classes in the subject Electrical Machines*

A quick recording of a given class can be seen at the following link [62].

17. CONCLUSION

The paper attempts to systematize the online content that can be used in classes. In doing so, the author presented the teaching content that he has used for more than 30 years in the teaching of the subjects Electric machines and Electric motors. Everything is illustrated with videos of several online classes realized and recorded at FTN Čačak in the 2020/21 school year.

ACKNOWLEDGEMENTS

This study was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia. These results are parts of the Grant No. 451-03-68/2022-14/200132 with University of Kragujevac Faculty of Technical Sciences Čačak.

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[17] https://www.youtube.com/playlist?list=PLt7mkiJmDd6azg6E6TkkcxIJlp8xm6IUX

[18] https://www.youtube.com/playlist?list=PLR3pRvvCj_Y_jcg_Ia6ARvzefov05c7vf

[19] https://www.youtube.com/playlist?list=PLR3pRvvCj_Y_sONKEu-kKmrs_qExmTrBm

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Problematic Internet Use: Old problems with a new twist

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Abstract: *The Internet is an integral part of human society and everyday life of most people, and it may be used for satisfying various human needs. The Internet has changed the way we process information, learn, talk, behave, etc. However, when something is used too much, it always brings some consequences with it, one being Problematic Internet Use, which is an umbrella term that encompasses a wide range of repetitive disabling behaviours, such as Internet video gaming, gambling, cyberpornography addiction, compulsive online shopping, social networking problematic use, and so on. In this paper, different views on Internet use in modern society will be considered, from ideas (over)emphasising its harmful effects on users' health, to ideas ignoring these warnings. We will be discussing the advantages of ICT use, as well as characteristics of the Internet, which may ease a compulsive use or preoccupation with online content and activities. We will particularly focus on classification criteria for specific online behaviours into the category of problematic use or Internet addiction, and finally we will point to some of the negative effects of PIU, as well as types of such Internet-related problems.*

Keywords: *Internet*; *problematic Internet use; Internet addiction.*

1. INTRODUCTION

According to the Annual Report of the Statistical Office of the Republic of Serbia [1], 76.7% of households own a computer and Internet access, over 92% of citizens use a mobile phone, and around 10% of them have never used the Internet. Therefore, it is not unusual that ICT and the negative effects of its excessive use are typically taken into account when mental health and quality of life is concerned, both in Serbia and worldwide.

The Internet is an integral part of human society and everyday life of most people, an inevitable tool for communication and interaction with other people, a way of spending leisure time, the main source and a means for quick and relatively easy information search [2]. The Internet has changed the way we process information, learn, talk, behave, while social network profiles have even become an extension of identity for some people, creating an overlap between the real and virtual world, which has led social scientists to term the Internet-age generation as *Homo technodigitalicus* [3]. It may be used for satisfying various needs, from affiliation, entertainment, education, to business[1]. What is particularly important is that the Internet has integrated the best features of other mass media, such as multimedia contents, easy access, and above all, interactivity [2].

However, when something is used too much, it always brings some consequences with it. As the Internet is expanding further into different aspects of everyday life, the academic and clinical circles are assigned a task to establish criteria and provide treatment for problems or disorders caused by its excessive, compulsive, and dysfunctional use [5]. The phenomenon, known under different terms, which we will term the Problematic Internet use (PIU) herein, is of special importance. Although PIU affects a minority of individuals who use the Internet, reports have documented a series of unhealthy lifestyles and medical disturbances that are thought to represent the consequences of severe forms of PIU, especially when it comes to youth [3]. Problematic Internet use is often characterised as impaired control over online activity, increased priority given to Internet behaviour over other activities, occurrence of tolerance and withdrawal symptoms, and continuation of Internet use despite the negative consequences on other important areas of life [6]. This umbrella term encompasses "a wide range of repetitive disabling behaviours that include, but are

[1] One of the taxonomies of *psychological needs*, which are at the core of Internet and gaming addiction, proposes seven groups of motives [4]: fun & entertainment, emotional relief, escape from reality, social needs (affiliation and belonging), achievement & self-actualisation, the need for excitement and challenges, power & control.

not limited to, Internet video gaming, compulsive online sexual behaviours, Internet-related buying, gambling, cyberchondria, social media use, among others" [7].

In this paper, different views on Internet use in modern society will be considered, from ideas (over)emphasising its harmful effects on users' health, to ideas ignoring these warnings; from ideas that place the Internet at the heart of these processes, to those regarding the Internet as a means for managing one's needs, wishes and fears.

2. IS IT A REAL PROBLEM?

It is in human nature not to embrace new ideas and concepts easily. The same was true with the idea that Internet use may be problematic and that it can lead to mental health issues. Yet, once a person becomes aware of danger, they tend to exaggerate and see signs of that danger in everything. This is exactly what happened to Internet use. Thus, various researchers, and particularly media representatives, started competing for warnings against an array of Internet-use-related dangers, frequently overstating percent and degrees of the problem. A study from the beginning of the 21st century reported as many as 40% of the participants who at least partially fulfilled the criteria for Internet addicts [8]. The truth is most commonly somewhere in-between.

Very soon researchers realised that the time criterion, which was initially used as critical, is a changeable category. Due to the development of IT and the fact that it wove its way into every aspect of life, the initial criterion around ten hours per day very soon reached over 40 hours per week online, and then even more [2]. Even nowadays the time spent on the Internet is taken as the main criterion. However, serious authors maintain that it is justified to present Internet addiction (IA) as an extreme case of its excessive use when online activities, content, and their consequences, besides the time criterion, have to be taken into consideration [9]. The key difference between *excessive Internet use* and *Internet addiction* lies in that that addiction is qualitatively different. It is accompanied by lack of control, compulsive behaviour, and connected with negative effects on different spheres of life. We need to accept the fact that people are more and more relying on technology (mobile phones and computers) and Internet in the process of human development. However, that fact is neither a criterion for nor an indicator of addiction.

Similarly, it is the Internet that was frequently characterised as a problem, not the person using it, thereby unnecessarily directing attention solely to Internet features or online content, rather than characteristics of humans. "The Internet is an environment, database, system of activities, and as such, it provides only opportunities; it is only an instrument for the realisation of the existent addictive tendencies, or other forms of psychological difficulties" [5]. Hence the title of this paper. When we talk about problematic Internet use, a person most commonly tries to solve their old problems with a new tool, which is the Internet. In due process, many of them are not actually trying to solve their problems (anxiety, depression, loneliness, family issues), but are simply fulfilling their needs, which are in their own right problematic, even in the "real" world (e.g., gambling, sexual compulsions, aggressive behaviour, bullying, etc.).

However, this "new twist" entails that the said problems take different forms when they are realised via the Internet. It is crucial to extract personal characteristics of users from technical features of media because they together form the media chain. Some features and forms of media either enable or prohibit the fulfilment of personal needs. Therefore, we cannot completely disregard the characteristics of the Internet and cyberspace, which may ease a compulsive use or preoccupation with online content and activities [2]. We will mention just a few:

- availability – with mobile phones, tablets, and other portable electronic devices, nowadays the Internet is available from almost every part of the world, at any moment, which means that a person may have a non-stop access to the gratifying object;
- anonymity – users have an opportunity to do what they want and to present themselves in a desired light, without any fear of other people's reactions;
- there are no temporal nor spatial limitations – we may communicate with people from "the other side of the world", any time we feel like it, at an available price for a growing number of people;
- a huge amount of information and their intensity;
- greater control – a user may choose contents according to their affinities, may freely express their reactions and take actions.

3. INTERNET ADDICTION, EXCESSIVE INTERNET USE, PROBLEMATIC INTERNET USE…?

The polarisation concerning the essence of the concept in question, including its name, started immediately after its first mention in expert literature, and it reflects different approaches in defining the type of mental health problems and clinical features underlining the concept. Is it an addiction, independent disorder or a symptom of some other psychiatric conditions? These are some of the problems and questions that we set to

answer more than two decades ago [5], which we will also mention now.

Work of several researchers in the mid-1990s resulted in a set of proposed diagnostic criteria for IA that resembled those formulated for Pathological Gambling [3]. At the same time, the mentioned ideas started to grow, those making a strict distinction between addictions *on the Internet* (the majority of individuals simply use the Internet as a tool medium to engage in specific types of rewarding behaviour) versus addictions *to the Internet* (individuals that are primarily addicted to content solely generated inside the Internet) [10]. The key problem lies in the fact that researchers attempted to place this disorder under the existing categories of mental health issues, while PIU shows similarities with many of them: addictions (in the first place with behavioural, like gambling disorder), impulse-control disorders (e.g., compulsive sexual behaviour) or obsessive-compulsive disorder.

The next issue relates to *classification criteria* for a form of online behaviour into the category of problematic use or a disorder. As already stated, the first criterion would be the time criterion for Internet use, which is followed by addiction criteria. However, addiction disorders, typically associated with PIU, are not a unitary construct, which makes the classification even more difficult. The main criticism upon classifying this problem as an addiction is that there is no intake of chemicals into the body. Nevertheless, using the Internet gives a feeling of satisfaction, triggered by activation of specific biochemical mechanisms (e.g., release of dopamine) in the CNS, similar to the effect of chemicals[2]. Moreover, psychological dependence is always connected with biochemical reactions in the brain. Findings that support this idea are those revealing that the activation of the sympathetic and parasympathetic autonomic nervous systems in Internet addiction is similar to that in drug addiction [11].

Accordingly, the solution can be found in introducing the category of *behavioural addictions*, in order to classify Internet use disorders, but also other forms of addiction to activities, such as pathological gambling, compulsive shopping, etc. [12]. The DSM-5 introduced the category of "Substance Related and Addictive Disorders", and included Gambling disorder as a behavioural addiction, while Gaming disorder has recently been included in the ICD-11 section on "Disorders Due to Substance Use or Addictive Behaviours" [7]. Although the concept of behavioural addictions is related to the majority of PIU forms, for others, similarities with social anxiety, impulse-control disorders and OCD may be more prominent [7]. For this reason, a consensus is being reached about the fact that each person displaying some form of PIU should undergo an extensive analysis, and assessment on whether it is the case of addiction, anxiety, or OCD, in that particular case, with the aim to direct future treatment in the right direction.

Finally, the term Problematic Internet Use is frequently used in scientific circles, as in this paper, so as to encompass a wider range of problematic behaviours and difficulties that may arise from Internet use, which do not necessarily meet the criteria for Internet addiction. Some of these problems will be given in further text.

4. SYMPTOMS, TYPES AND CONSEQUENCES

Regardless of small percentage of people who truly have some of the form of Internet addiction developed, it is evident that these people *do* exist, and that they report certain symptoms and difficulties due to excessive and dysfunctional Internet use.

4.1. How to recognise the problem?

As mentioned, many authors hold that nowadays we can talk about a spectrum from controlled and adaptive Internet use to uncontrolled and maladaptive, whereas uncontrolled use has been associated with marked functional impairment, including loss of productivity, and mental health issues, including mood and anxiety disorders [7]. Nonetheless, we shall start with the basic criteria that characterise Internet addiction [2-7]:

- Basic criteria for categorising it into a disorder are impaired control (unsuccessful attempts to reduce or cease the behaviour), preoccupation (increasing priority of Internet activities resulting in neglect of other daily activities and social relations), and continued use, despite the occurrence of negative consequences. However, when some of the criteria are not fulfilled, that still does not mean that the person will not have some form of PIU;
- Much rarer, but still present in persons with fully developed Internet addiction, are physiological addiction criteria: tolerance, and withdrawal symptoms (anxiety, hostility, irritability);
- Besides, there are mood swings, emotional sensitivity, conflicts with environment because of neglect of other activities, use of the Internet to escape from "real life" problems, as well as recidivism [9];
- Lastly, in more severe cases, there are physical and psychosomatic symptoms, such as chronic fatigue or insomnia, eyesight, and appetite problems, and so on [13].

[2] More information on the physiological basis of these processes can be found in Fineberg et al. [7]

Although we will not dwell on *predictors of PIU* in this paper, it is important to emphasise that a "number of studies indicated that comorbidities appear to be the norm, rather than an exception for individuals with the problem of IA or PIU", with mood and anxiety disorders appearing to be particularly common in this context [14].

4.2. Consequences

Some of the negative effects of PIU overlap with the stated criteria for or symptoms of PIU or IA, but we will list them at this point as well [2, 7, 15]:

- low academic or educational outcomes, professional failure, neglecting household duties;
- problems in family and social relationships which may result in loneliness or social isolation;
- low physical activity and health-related side effects (back and neck pain, sleep problems, problems with appetite, eyesight problems;
- problems in cognitive processes, loss of focus, problem with concentration, learning, disruption of thought processes, etc.;
- distress, impulsiveness, mood swings, anxiety, restlessness, depression, irritability.

4.3. Types of PIU/IA

PIU can be expressed in various forms. The first two types, already mentioned in this paper, have been acknowledged as independent disorders, i.e., gambling and gaming disorders. We will name some of the most important ones.

Gaming disorder has existed before, but now it can realise its full potential through online mode (Internet-related gaming disorder), where an individual, besides gaming, fun and escape from boredom, can compete and communicate with other players. It refers to "excessive playing of online games, development of loss of control of the gaming behaviour, prioritisation of gaming over other important everyday activities, resulting in significant and substantial impairment in multiple areas of psychosocial or physical functioning" [3].

The next type pertains to persistent or recurrent gambling behaviour that results in impaired control over gambling, continuation, or escalation of gambling, despite the occurrence of negative consequences, leading to significant impairment in other areas of life [15]. Moreover, "the Internet has allowed new types of gambling to be available online, making Internet-related Gambling Disorder one of the most popular and lucrative businesses on the Internet" [3].

The next type is developed when someone is using the Internet to view or interact with pornographic material in an excessive way. Some findings point to around 12% of cyberpornography users that develop recurring and uncontrollable patterns of pornography use, i.e., Cyberpornography addiction [3].

The type that is growingly being brought up, especially with an accelerated development of social networks, is excessive preoccupation with social media use – Social media addiction or Social networking. This dependence on communication in social networks, chats and forums can be focused on a specific social network (hence specified names as Instagram addiction, Facebook addiction, Twitter addiction). Nevertheless, the largest number of these individuals switching networks, as another one gains in popularity, while the others are becoming less popular. This problem can be related to the *fear of missing out* from activities that peers post online. Moreover, it can also include obsessive *preoccupation with ratings* on social networks (e.g., number of followers, friends, or likes, etc.).

A type of PIU that is not very common is Compulsive online shopping – craving for purchasing or e-shopping characterised by irresistible urges to possess consumer goods. "People with a shopping disorder buy more consumer goods than they can afford, need or frequently use" [3].

5. INTERNET USE RELATED PROBLEMS

For some people, problems with Internet problematic use may be a temporary, and thus may be spontaneously resolved. Unfortunately, in some cases, PIU becomes chronic, and turns into IA. Then, it is frequently underscored that the duration of intensive PIU is up to six months, after which it may be the case of IA [5].

However, users may develop some other type of problem while using the Internet, which is not necessarily, or entirely a clinical issue, although it makes difficulties in everyday functioning of a person. One of these problems is *endless Internet surfing*, when Internet users wander around websites, social networks, forums, reading or watching all kind of online content, endlessly following links, etc. [15]. Then, *digital hoarding* (a tendency to excessively collect, store or hoard digital material, including photos, music videos or YouTube videos). In some people, there is the case of excessive digital searching for medical information or *cyberchondria*. Although it is driven by the need to alleviate health-related distress or anxiety, it is ultimately resulting in the worsening of such symptoms and behaviours [3]. There is also *cyberbullying*, or the use of IT to harm, intimidate, or coerce other people online. Similarly, there is a phenomenon of *catfishing*, where people falsely present themselves in the hope of deceiving other users due to personal benefit of for other reasons.

The vital question in bringing the Internet into all spheres of life is a reduced boundary between what is exclusively a characteristic of a real, physical

situation in life and what is a property or part of virtual world. Very frequently, something posted in a virtual world can have the same or even a higher level of importance than something that has happened in physical world or direct communication [2]. On the other hand, Internet users often get relaxed when they start feeling safe with this kind of communication, and thus *online disinhibition* may occur, so they more readily take emotional risks, flirt, start a conversation more easily, give positive and negative comments and express their opinions easily, as well as aggressive impulses [2]. Both of these may lead to more serious problems.

6. CONCLUSION

A lot of online behaviour have the evolutionary function for humans in the era of new technologies. The Internet is a significant type of social activity, and as the most powerful form of the mass media, it is becoming important even for some psychological processes, such as identity formation, or personality development.

As noted in this paper, it is yet vital to draw attention to the alarming signs, which may be indicative of some of the Internet-use-related problems, or even PIU or IA. This takes on added importance since we know that there are still problems with reliable diagnostic criteria and valid assessment tools. Likewise, IA treatment is "not funded by the government across the world, leaving individuals seeking help either for other primary disorders or through private organisations" [14]. Finally, this is still a serious issue for younger generations, who are more attached to ICT, and are more psychologically vulnerable [16]. Age and gender relate importantly to PIU, with younger people typically having problems with gaming, social networks use and media streaming, males with gaming, gambling and cyberpornography, and females with social media and e-buying [9, 16, 17].

Therefore, it is important to discuss these problems, based on scientific and clinical findings, without exaggerations in the media and/or causing unnecessary fears in people of something that is and will be a part of our life.

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The relations between students' perceptions of equipment and attitudes toward teaching technical culture and informatics

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Abstract: *The students' attitude towards teaching is important in order to arouse interest and motivation for the lessons. In addition to the teacher, who plays the most important role, the environment in which instruction takes place can also influence student interest and motivation. Considering the peculiarities of technology and computer science teaching, the equipment of the classroom where the teaching takes place could have an influence. Therefore, the relationship between students' perceptions of workshop/classroom facilities and their attitudes toward teaching technology and computer science was investigated here. The research was conducted in the form of a survey among a sample of 5th-8th grade students (N = 2155) from primary schools in Croatia. The results show a positive correlation between the students' perception of the equipment and the statements that technical culture is important for life, that there should be more teaching in technical culture, that they like hands-on activities, and that they like working with technology. A weak correlation was found between the equipment and the need for more informatics and attitudes towards a career in this area. Therefore, it can be concluded that equipment is important for making students aware of the importance of this teaching, but it is not a decisive predictor of student attitudes.*

Keywords: *informatics; technology teaching; equipment; students' attitudes; technical culture*

1. INTRODUCTION

The structure of any educational institution, including schools, consists of physical and organizational as well as social aspects [1], with classroom organization being an important part of the physical aspect. A rich and stimulating spatial and material environment is considered an indispensable condition for quality learning and full development of students [2]. In other words, the environment in which learning and teaching take place must not only provide opportunities for the implementation of student activities, but should also be stimulating for students. This means that it cannot be considered only as a passive space for carrying out activities, but must be an integral part of learning that helps to shape the personality of each child [3]. For this reason, the technical-technological area of education is particularly demanding and specific. This area goes hand in hand with a very dynamic epistemological (content) foundation, but also with a specific path to knowledge that is not possible without student activity in a meaningful instructional context. Part of this context, which gives meaning and significance to the content that students learn [4], is also a specially equipped space (workshop/ lab/practicum) in which such activities are carried out, as well as the equipment for carrying out the activities. This space, with its aesthetic appearance, can influence students' attitude towards the subject [5], as they feel more comfortable in it and are therefore more motivated for the activities. Teachers also believe that a space suitable for teaching technology, equipped with the necessary classrooms, tools, and other technical resources, plays an important role in achieving the goals of teaching [6]. However, students' attitudes should not be ignored, i.e., their perceptions of classroom/workshop equipment and attitudes towards teaching in this area. Although students' attitudes are their personal perceptions, beliefs, values, judgments, opinions, personal theories, and similar constructs of a particular reality, there is no doubt that they are related to their interest in a particular field [7]. Thus, the main objective of this study was to determine the extent to which students' perceptions of classroom equipment are related to attitudes toward teaching technical culture and informatics. In this way, it was hoped to gain a deeper insight into the ways in which the space in which instruction takes place can indirectly influence attitudes toward that instruction, as well

as students' interest in and motivation for that instruction and field of activity.

2. METHODS

The research was conducted as an anonymous survey of student attitudes, on a stratified sample of students (N = 2155) in 5th through 8th grades. An extended version of the Pupils' Attitudes Toward Technology - Short Questionnaire (PATT-SQ) test was used to collect data, as described by Ardies et al. [8]. This expanded and adapted version of the questionnaire was named PUTTOR (Student preferences towards technique, technology and sustainable development), which was then validated and used to examine broader student preferences [9]. Items were selected for this study, i.e., statements made by students to which they expressed their agreement on a Likert scale ranging from 1 - I strongly disagree to 5 - I strongly agree. Students expressed their assessment of the classroom/workshop facilities (equipment) on a scale from 1 - very poor to 5 - excellent. The selected items of the questionnaire are shown in Table 1. The first variable (OPRE) is treated here as an independent variable, while the other variables are dependent. Data collection was done in cooperation with primary school teachers and in accordance with the Code of Ethics for Research with Children [10].

Table 1. *Selected items from the PUTTOR questionnaire*

No.	Variable – statement
1.	*How would you rate the workshop/classroom facilities in your school? (OPRA)*
2.	*Technical culture is important for life (TKZI)*
3.	*Informatics is important for life (INFZ)*
4.	*I would like to join the club of young technicians (RKMT)*
5.	*There should be more technical culture in school (VITK)*
6.	*There should be more informatics in school (VIIN)*
7.	*I like to repair things at home (UZKU)*
8.	*I like practical exercises in class (SVPV)*
9.	*I will probably choose a profession in technology (VJPO)*
10.	*I like to work with technology (UZTE)*
11.	*I would like to become a technician or engineer (ZETE)*
12.	*I would like to become a programmer or computer scientist (ZEIN)*

After collection, all data were processed using descriptive statistics procedures, and regression analysis was performed to determine the relationship between equipment ratings and student attitudes. In this way, a correlation was established between the students' ratings of the equipment and the distribution of the ratings in relation to the statements of the questionnaire. By determining the value of the correlations, it was also determined with which students' attitudes and in what way their perception of the equipment of the classroom could be related.

3. RESULTS

A total of 2155 primary school students in Croatia participated in the study, of which 1025 (47.56%) were boys and 1130 (52.44%) were girls. Among them, 497 were 5th grade students, 530 were 6th grade students, 559 were 7th grade students, and 569 were 8th grade students.

The descriptive statistics data (Table 2) show that the students rated the equipment of the workshops/classrooms as medium-high (M = 3.822), with the most frequent rating being four (Mod = 4) and the coefficient of variation CV = 25.06%. Although, according to teachers in most primary schools, the equipment of technical culture workshops is not up to the level it should be [11], the equipment of classrooms IT can be considered acceptable. This is because, although resources for computer science (informatics) teaching are weaker than the European Union average [12], [13], the state has repeatedly invested significant resources in this equipment. In contrast to computer science, the equipment of technical culture workshops is mostly left to the schools and the abilities of individual teachers. Therefore, we believe that this way of evaluating the equipment by students can reflect the reality from their point of view.

The mean scores of the ratings as well as the dominant scores are highest for the statements that informatics is important for life (M = 4.371; Mod = 5), that they like practical exercises (M = 4.021; Mod = 5), and that technical culture is important for life (M = 4.016; Mod = 4). This is followed by the mean scores for enjoying working with technology (M = 3.705; Mod = 5) and enjoying repairing things at home (M = 3.478; Mod = 5). For the variables related to the attitude that there should be more technical culture and informatics in school, the mean values of the assessments are relatively low (M = 2.943 and M = 3.297), and the dominant value (Mod = 3) indicates a large number of undecided students on this question. Similarly, the student is likely to choose a career in engineering and technology (M = 2.593; Mod = 3). The lowest mean scores of the ratings, but also worryingly dominant scores, are observed in the statements about their future career development and about the clubs' activities for young technicians. Thus, the mean values of the evaluation for the statement that the student wants to become a technician or engineer are convincingly the lowest (M = 2.423) with a high percentage (33.41%) of students disagreeing with this statement at all. Similarly, the statement that the

student wants to become a programmer or computer scientist (M = 2.695) has 30.02% of students disagreeing with it at all. Surprisingly low is the mean estimate for the statement that the student would like to join the Young Technicians Club (M = 2.661), with which 26.90% of the students disagree at all. This finding for the RKMT variable was not expected, as the students expressed mostly positive attitudes toward technical activities, as evident from the estimates for practical exercises (SVPV), enjoying working with technology (UZTE), and enjoying repairing things at home (UZKU). In addition, for the variable RKMT, a high inconsistency of student ratings (CV = 52.34%) was found, which may indicate either a high polarization of students or a lack of information about such a possibility.

Table 2. *Descriptive statistic data for the selected items.*

Var.	M	M od	F of Mod	Var	SD	CV (%)
OPRA	3.822	4	907	0.917	0.958	25.06
TKZI	4.016	4	850	0.866	0.930	23.16
INFZ	4.371	5	1171	0.673	0.820	18.76
RKMT	2.661	1	638	1.940	1.393	52.34
VITK	2.943	3	677	1.698	1.303	44.28
VIIN	3.297	3	600	1.712	1.308	39.69
UZKU	3.478	5	650	1.794	1.339	38.50
SVPV	4.021	5	960	1.270	1.127	28.03
VJPO	2.593	3	646	1.721	1.312	50.60
UZTE	3.705	5	674	1.367	1.169	31.56
ZETE	2.423	1	720	1.716	1.310	53.93
ZEIN	2.695	1	647	2.060	1.435	53.24

The results of the regression analysis of the relationship between each dependent variable and the independent variable are shown in Table 3. From the results, it can be seen that the values of all variables correlate positively and statistically significantly with the equipment ratings. However, the correlation values show a mostly weak relationship, but also significant differences in the correlations. The values for the statement that students like practical exercises (SVPV) correlate most strongly with the equipment variable (OPRE), whose values tend to be moderately correlated (R = 0.246; F = 138.212; p = 0.000). The correlation can be considered indicative for the statement that technical culture is important for life (R = 0.215; F = 104.669; p = 0.000) and for the student's statement that he would like to join the club of young technicians (R = 210; F = 99.171; p = 0.000). High F-values for the above variables also indicate the possible predictive value of workshop/classroom equipment for the development of such attitudes among students. Slightly lower values, but still significantly higher than the lower ranged, were recorded for the statements that the student likes to work with technology (R = 0.199; F = 88.671; p = 0.000) and that there should be more technical culture in school (R = 0.176; F = 68.809; p = 0.000). The correlation of the student statement that they enjoy repairing things at home with the equipment ratings is weak (R = 0.133; F = 38.826; p = 0.000). The correlation values for students' statements that they are likely to choose a career in engineering and technology (R = 0.114; F = 28.196; p = 0.000), that they would like to become a technician or engineer (R = 105; F = 23.989; 0.000), and that computer science is important in life (R = 0.101; F = 22.364; p = 0.000) are strikingly low. Although these values are also statistically significant and above the reference value (R = 0.10), the relationship between these variables and workshop/classroom equipment is borderline and therefore highly questionable. For the variables related to the statements that there should be more informatics in school (VIIN) and that the student wants to become a programmer or computer scientist (ZEIN), the very low correlation with the workshop/classroom equipment assessments is striking. Namely, the correlation values for these variables are below the reference value, while the F-values indicate a weak predictive value of the equipment for the development of student attitudes from the variables VIIN and ZEIN mentioned above.

Table 3. *Regression analysis of the relationship between dependent variables and the independent variable OPRE.*

Var.	R	R^2	SS	F	p
TKZI	0.215	0.046	86.438	104.669	0.000
INFZ	0.101	0.010	14.897	22.364	0.000
RKMT	0.210	0.044	184.004	99.171	0.000
VITK	0.176	0.031	113.287	68.809	0.000
VIIN	0.056	0.003	11.521	6.748	0.009
UZKU	0.133	0.018	68.443	38.826	0.000
SVPV	0.246	0.060	165.046	138.212	0.000
VJPO	0.114	0.013	47.933	28.196	0.000
UZTE	0.199	0.040	116.465	88.671	0.000
ZETE	0.105	0.011	40.725	23.989	0.000
ZEIN	0.075	0.006	24.971	12.187	0.000

4. DISCUSSION

Although workshop/classroom equipment can be considered from different and highly professional points of view due to the specific equipment used for teaching technical culture and informatics, the

value of students' perceptions of the equipment is of particular importance in this research. Indeed, students' perceptions are often more important than the actual equipment in the classroom, because students should perceive it as such. The distribution of equipment ratings presented here, which at the same time meets the normality criteria (K-S d = 0.24851, $p < 0.01$), can be considered as an authoritative indicator of workshop/classroom equipment.

From the descriptive statistics data, it appears that students perceive technical culture and informatics classes as important for life, and that they like the hands-on (practical) activities that are conducted in these classes, as well as activities with engineering and technology in general. However, when it comes to the question of whether there should be more teaching in these subjects, it is obvious that students express significantly more doubts about these issues. This points to the problem of realization of teaching subjects in this area, which is not the subject of this research. As for the attitude towards joining young technicians' clubs as an extracurricular activity, the assessments on this (Table 2) somewhat clash with the observed correlation from Table 3, which could indicate that students in some elementary schools do not know about this possibility or that the teacher in their school has not organized such activities. Regarding the perception of future career choice and professional activity, it is obvious that the majority of students do not want to assert in technology. However, research points to the problem of insufficient knowledge about the possibilities of such affirmation and the insufficient number of lessons in which students could become aware of this area [14], so positions on these issues should be taken with caution.

Regression analysis shows a positive and statistically significant correlation between workshop/classroom equipment and all dependent variables. However, this correlation is generally weak, which is to be expected. Indeed, the classroom as such is not expected to directly influence student attitudes. Despite the weak correlation, the differences are still noticeable, so it can be said that the equipment of the classroom has some predictive power and is related to the students' attitudes. This relates to students' interest in hands-on (practical) activities, attitudes toward the importance of technical culture in life, and attitudes toward extracurricular activities. In other words, the better equipment of the classroom could produce a more positive attitude among students if the main conditions are also met. By the main conditions, we primarily mean the implementation of appropriate and meaningful activities and the essential quality of teachers as the most important factor for the quality of teaching. At the same time, it can be seen from the analysis that the equipment of the classroom does not have such a great predictive power when it comes to the attitude towards the importance of the informatics for life, nor for the attitude towards the future professional development of students in the engineering and technology. From the results, it appears that workshop/classroom equipment is much more important for teaching technology (technical culture) than for teaching computer science (informatics), and therefore is a more important predictor of the quality of this teaching. Finally, the equipment of the technical culture classroom differs significantly from that of the computer science (informatics) classroom, as indirectly evidenced by the results of this study. Similarly, the equipment of the technical culture workshop is much more complex than the equipment of the classroom IT. Given the high prevalence of computers in everyday life today, low correlations between student perceptions of equipment and attitudes toward computer science instruction are not surprising, as students often do not view computer use through the lens of specific equipment.

Although the analysis of the research results showed a correlation and a positive relationship between the equipment and the attitude of the students, the equipment cannot be the decisive factor in the development of the awareness and the positive attitude of the students. In fact, the equipment and space are still static elements of the environment, which are not able to influence the students directly. For this reason, even such a weak correlation should be considered an important finding that nevertheless indicates some influence of a rich environment on student attitudes toward instruction. This is particularly important in technical education and teaching informatics because such an environment is a necessary condition for instructional success.

5. CONCLUSION

In this research we tried to answer the question if there is a connection between the equipment of the workshop/classroom where technical culture and informatics is taught and the positive attitude of the students towards these subjects and the teaching area and what is this connection.

In the analysis of the research results, it was found that there is a positive and statistically significant correlation between the variable of workshop/classroom equipment and all the variables of expressed attitudes of the students. This correlation is weak, which also indicates a weak relationship. Despite the weak correlation, it was found that the correlation between the equipment of the classroom where the classes are held is significantly higher for students' attitudes towards the importance of technical culture classes for life, for attitudes towards practical exercises in class, for attitudes towards extracurricular

activities in technical culture, for attitudes towards the need for more technical culture classes, and for students' enjoyment of working with technology. The relationship with the teaching of informatics and students' desires for career development in technology and informatics is significantly lower or even negligible. Overall, it can be concluded that the equipment of the classroom can have a positive effect on students' attitudes towards the teaching of technical culture, including informatics. Although this is a weak correlation, it should be noted that the equipment is only one part of the learning environment, so the results presented are meaningful according to the role of the equipment in the teaching process. In other words, the equipment can influence students' attitudes toward teaching, but it cannot be a decisive predictor of the development of students' attitudes and interests.

The research findings have provided a clearer picture of the role of the technical culture and computer science classroom in forming positive student attitudes toward it. Nevertheless, and especially because of the impossibility of real equipment assessment during this research, the role of space for the delivery of technology instruction in the formation of students' attitudes and interests toward this instruction requires additional research. Such research should answer questions about key elements of the environment that may influence the formation of positive student attitudes toward this specific instructional area.

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Self-assessment of Student Digital Competences in Serbia

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Abstract: *The updated Digital Competence Framework, DigComp 2.0, defines five key areas of digital competences that every citizen needs to be able to use ICT in a critical, creative and collaborative manner for business, learning, entertainment, inclusion or social participation. This paper examines digital competences of students in Serbia, and the general aim of the research is to determine how students in Serbia self-assess their digital competences, whether their self-assessment is determined by specific socio-demographic characteristics, such as: university, field of study, year of study, frequency of use of ICT devices in teaching, and everyday activities. Two research instruments were created for the purposes of this research: Questionnaire on Socio-demographic Characteristics, and Digital Competence Assessment Scale, which is based on the European Digital Competence Framework – DigComp 2.0. Students from 22 faculties (N=183) from four administrative districts in Serbia (Moravica, Zlatibor, Južna Bačka and the City of Belgrade District) participated in the research. The research determined that students assess their digital competences as highly developed, both in relation to the scale and its integral subscales, and confirmed that there are significant differences in student self-assessments with regard to independent research variables: university and frequency of use of technical devices (smartphones) in teaching and everyday activities.*

Keywords: *self-assessment; DigComp 2.0; digital competence; higher education; lifelong learning.*

1. INTRODUCTION

In a rapidly changing world which is largely characterized by uncertainty and unpredictability, developing and improving citizens' digital competences is crucial. Digital devices (computers, tablets, smartphones, etc.) are an integral part of everyday life, because they ensure professional, social and entertainment functions to every individual. Everyone, young and old alike, must adapt to the changing world without exception, continuously learn and improve their digital competences in order to successfully accomplish their personal and professional tasks.

The future, competitiveness, and prosperity of every country depend on the readiness of its citizens to successfully tackle the challenges of the fourth industrial revolution in the 21st century, increased technological and scientific development, globalization, health and social crises (e.g. COVID-19 pandemic). In this regard, the readiness of different countries to take advantage of modern information and communication technologies in order to raise the quality of life of their citizens, improve effectiveness and efficiency of business and labor, and economic growth of their society depends on the digital competences of their population [1][2]. Given that the only certainty is unpredictability of changes and society's progress in the future, the higher education system should strive toward building the competences of young people for independent life and work in the 21st century [2]. Digital competences occupy a special place among numerous competences that young people need to master. In this way, higher education should directly contribute to the sustainable development of a society, which is based on knowledge and innovation, technology development and critical thinking.

The use of ICT has grown exponentially in recent years, and experts predict that over 90% of the jobs in the future will require highly developed digital competences [2]. Previous analyses indicate that almost half of the population of the European Union does not possess sufficiently developed digital skills, whereas 1/5 does not possess any digital skills whatsoever. The conclusion is that EU member states must make additional efforts to raise the level of digital skills in the general population, throughout the entire sector of education and professional training. The analysis [3] also focuses on the issue of social and economic inequality that arises due to differences in ICT infrastructure in educational institutions, science, culture and society as a whole.

Strategic national documents that define the question of development of digital skills of the Serbian population [2][3] emphasize that education is the key sector for the development of

digital competences and skills of the population through formal and non-formal education, continuous adaptation and modernization of the curricula, and learning 21st-century skills. Notwithstanding the fact that digital competences occupy a special place in the strategic national and international documents, their assessment has significant implications for educational decision makers, educational institutions, as well as for participants in the educational process [5]. In general, reliable data regarding the position of a country on the DigComp index can provide guidelines for improving citizens' digital competences and achieving goals related to employment, communication, learning, leisure, and participation in society [6][7].

1.1. Digital competence – approaches to definition and research/assessment

Digital competence encompasses a set of skills, knowledge, values, abilities and strategies needed for critical, creative, ethical and flexible use of information and communication technologies and digital media for professional work, leisure, learning and participation [8]. It is also defined as the ability to access, manage, understand, communicate, create and evaluate information in a safe and appropriate way for the purpose of employment, work and entrepreneurship [9]. Similarly to the above definitions, in the context of teaching and learning, digital competence integrates the knowledge, abilities, skills, values and strategies related to the teaching profession needed to use information and communication technologies and digital media in a creative, thoughtful, flexible and safe way in an online and offline environment [10] [11]. Policy-based definitions and reports point out that digital competence integrates digital skills with the social and emotional aspects of using and understanding digital devices [12].

Digital competence is recognized as one of the key competences for lifelong learning, necessary to all citizens for employment, professional work, active citizenship, social inclusion, and leisure. The concept of digital competence was developed by the European Commission in 2006 [13]. As it is a constantly evolving concept, it was redefined in 2018, and among other things, it now encompasses critical and responsible use and implementation of digital technologies for learning, work and participation in society. It involves information and data literacy (ability to understand, communicate and create data as information), communication and collaboration (interaction through digital technologies, participation in society through the use of public and private services, participatory citizenship), digital content creation (programming), safety and competences related to cyber security, issues related to intellectual property, and problem solving [7].

Some definitions of digital competence can be seen in the views of certain authors [14][15][16]. Digital competence involves confident and critical use of electronic media for work, communication and leisure [16]. These competences refer to logical and critical thinking, communication skills and information management skills.

However, in addition to the problem of defining the concept of digital competences, open issues also arise regarding their operationalization and measurement, which gave rise to different digital competence frameworks, both at national and international level. Numerous instruments for the assessment and self-assessment of digital competences, based on different theoretical and strategic frameworks, have been developed in the research field [17][18][5]. In addition to DigComp 1.0 and DigComp 2.0, there are other international frameworks as well, including the European Competence Framework for Educators, or DigCompEdu. The first reference framework that defines digital competence as a combination of 21 individual competences. A new reference framework that operationalizes this concept in five areas was developed and accepted in 2016: information and data literacy; communication and collaboration; digital content creation; safety; and problem solving [19].

Regardless of the approach to their definition, it can be noted that digital competences represent a combination of knowledge, skills and values related to digital technologies. Specifically, the basic constituents of digital competence are: knowledge, skills (e.g. ability to implement processes) and values (e.g. mindset, assessment).

1.2. Digital competence Framework DigComp 2.0

The European Digital Competence Framework – DigComp 2.0 – provides a matrix for understanding the core competences needed by all citizens to adapt and actively participate in the digital world. Namely, modern technologies, such as robots, artificial intelligence, virtual and augmented reality, as well as numerous negative phenomena arising from them (e.g. misinformation and digital bullying) have given rise to new demands for the development of citizens' digital competences [19]. The updated European Digital Competence Framework considers the knowledge, skills and values needed by citizens of the 21st century.

The DigComp 2.0 defines five areas of competences that operationalize the concept of digital competence both in scope (extension) and content (intensity). They are the following competence areas: (1) Information and data literacy; (2) Communication and collaboration; (3) Digital content; (4) Safety; and (5) Problem solving. The first three areas cover competences that are applied within specific activities and uses, whereas

the remaining two are applicable to any activity performed through digital technologies. For example, problem solving is highlighted as a special and final area of competence to emphasize the importance of this aspect for the appropriation of technology and digital practice.

The structure of the updated model of digital competences for citizens is presented below, according to the defined areas of competence [19].

1. Information and data literacy
   - 1.1. Browsing, searching and filtering data, information and digital content involves articulating information needs; searching for data, information and content in digital environments; creating and updating personal search strategies.
   - 1.2. Evaluating data, information and digital content involves analysis, comparison and critical evaluation of the credibility and reliability of sources of data, information and digital content; analysis, interpretation and critical evaluation of the data, information and digital content.
   - 1.3. Managing data, information and digital content involves organizing, storing and retrieving data, information and content in digital environments, as well as their organization and processing into a structured environment.
2. Communication and collaboration
   - 2.1. Interacting through digital technologies - interaction through a variety of digital technologies and understanding appropriate digital communication means for a given context.
   - 2.2. Sharing through digital technologies - sharing data, information and digital content with others through appropriate digital technologies;
   - 2.3. Engaging in citizenship through digital technologies - participating in society through the use of public and private digital services; seeking opportunities for self-empowerment and for participatory citizenship.
   - 2.4. Collaborating through digital technologies - using digital tools and technologies for collaborative processes, and for co-construction and co-creation of resources and knowledge.
   - 2.5. Netiquette – being aware of behavioral norms and know-how while using digital technologies and interacting in digital environments; adapting communication strategies to the specific audience; awareness of cultural and generational diversity in digital environments.
   - 2.6. Managing digital identity – creating and managing one or multiple digital identities to protect one's own reputation.
3. Digital content creation
   - 3.1. Developing digital content – creating and editing digital content in different formats, to express oneself through digital means.
   - 3.2. Integrating and re-elaborating digital content – modifying, refining, improving and integrating information and content into an existing body of knowledge to create new, original and relevant content and knowledge.
   - 3.3. Copyright and licenses – understanding how copyright and licenses apply to data, information and digital content.
   - 3.4. Programming – planning and developing a sequence of understandable instructions for a computing system to solve a given problem or perform a specific task.
4. Safety
   - 4.1. Protecting devices - involves protecting devices and digital content, and understanding risks and threats in digital environments, as well as safety and security measures.
   - 4.2. Protecting personal data and privacy – involves protecting personal data and privacy in digital environments, understanding how to use and share personally identifiable information while being able to protect oneself and others from damages.
   - 4.3. Protecting health and well-being – ability to avoid health-risks and threats to physical and psychological well-being while using digital technologies; ability to protect oneself and others from possible dangers in digital environments (e.g. cyber bullying), and awareness of digital technologies for social well-being and social inclusion.
   - 4.4. Protecting the environment – awareness of the environmental impact of digital technologies and their use.
5. Problem solving
   - 5.1. Solving technical problems – identifying technical problems when operating devices and using digital environments, and solving them.
   - 5.2. Identifying needs and technological responses – assessing needs and identifying, evaluating, selecting and using digital tools and possible technological responses to solve them, as well as adjusting and customizing digital environments to personal needs (e.g. accessibility).
   - 5.3. Creatively using digital technologies involves using digital tools and technologies to create

knowledge and innovate processes and products.

5.4. Identifying digital competence gaps – ability to understand where one's own digital competence needs to be improved or updated, as well as supporting others with their digital competence development (keeping up-to-date with the digital evolution).

2. RESEARCH METHODOLOGY

2.1. Research aims and tasks

The survey aimed to identify the level of digital competences of students in Serbia. The aim was implemented through two research tasks:

(1) Examine how students in Serbia assess the level of their digital competence in relation to the areas defined in DigComp 2.0 (information and data literacy, digital content creation, communication and collaboration, safety, and problem solving);

(2) Determine whether there are differences in the students' self-assessment of digital competences with regard to university, scientific field of study, year of study, frequency of use of ICT devices (computer, tablet, smartphone) in teaching and everyday activities.

2.2. Research methods, techniques and instruments

A descriptive method, and techniques of surveying and scaling were used in the research. A questionnaire was created to examine the socio-demographic characteristics of students. An assessment scale (DigComp 2.0 Assessment Scale), which includes 23 items categorized into five subscales, in line with the defined areas in the Digital Competence Framework for Citizens DigComp 2.0, was created for the purpose of examining students' digital competences. These are the following areas: information and data literacy, digital content creation, communication and collaboration, safety, and problem solving. The development of digital competences was assessed on a three-point scale (3 – I'm confident I know/can do, 2 – I'm somewhat confident I know/can do, and 1- Idon't know/cannot do), whereby a higher score indicates more developed digital competences of a student. The reliability of the assessment scale on the student sample was 0,86 expressed by Cronbach's alpha.

The first subscale, information and data literacy, included three items (item 2: "I can evaluate which information on the Internet is reliable, and which is not".) The second subscale – digital content creation – included seven items (item 6: "I can create simple digital material (text, images, and presentations"). The third subscale – communication and collaboration – included five items (item 14: "I use digital technologies to make bank and doctor's appointments, etc"). The fourth subscale – safety – included five items (item 16: "I can protect my personal data, and am aware of the risk and dangers in the digital environment (e.g. I use antivirus software, passwords, etc.)"). The fifth subscale - problem solving – included three items (item 22: "I know how to solve routine problems that arise when working on a computer/laptop (e.g. close a program, restart the computer, reinstall a program, and connect to the Internet)"). The values for Cronbach's Alpha (Table 2) indicate varying internal reliability of the subscales, from questionable to satisfactory (values ranged from 0,54 to 0,71).

2.3. Research sample

The survey was conducted on a suitable sample of 183 students from four administrative districts in Serbia (Moravica, Zlatibor, Južna Bačka and City of Belgrade). The structure of the sample by the selected socio-demographic characteristics is given in Table 1.

2.4. Organization and research process

The survey was conducted during April and May 2022, in two ways: electronically (Google forms) and directly, by distributing the questionnaire in print form to the respondents.

2.5. Data processing

The collected data were processed in the IBM SPSS Statistics 20 statistical software suite and analyzed descriptive (arithmetic mean, standard deviation, frequencies, percentages) and inferential statistics (one-sample t-test, one-way ANOVA non-repeated measures).

3. RESULTS AND DISCUSSION

The first research task is aimed at assessing the level of digital competences from the perspective of students. The average value of the level of digital competences of students on the scale M=59,96; SD=5,01) indicates a moderately high level (Table 2), which is also visible when the result is divided by the total number of items on the scale (M=2,71; SD=0,23).

Table 1. *Socio-demographic characteristics of student sample (N=183)*

Socio-demographic characteristics	Modalities	(f)	(%)
University	University of Kragujevac	92	50,3
	University of Belgrade	72	39,3
	University of Novi Sad	19	10,4
Field of study	Social sciences and humanities	109	59,6
	Technical sciences	23	12,6
	Biotechnical sciences	22	12,0
	Medical science	16	8,7
	Natural sciences	10	5,5
	Arts	3	1,6
Year of study	One	12	6,6
	Two	26	14,2
	Three	77	42,1
	Four	50	27,3
	Other (five, six)	18	9,8
Frequency of using computer in teaching	Every week	18	9,8
	Once a week	27	14,8
	Once a month	65	35,5
	Never	73	39,9
Frequency of using smartphone in teaching	Every day	150	82,0
	Once a week	19	10,4
	Once a month	3	1,6
	Never	11	6,0
Frequency of using computer in everyday activities	Every day	12	6,6
	Once a week	32	17,5
	Once a month	59	32,2
	Never	80	43,7
Frequency of using smartphone in everyday activities	Every day	167	91,3
	Once a week	9	4,9
	Once a month	0	0,0
	Never	7	3,8

The results of the one-sample t-test indicate that the level of students' digital competences (min.=46; max.=66; AS=59,96; SD=5,01) is significantly higher than the theoretical mean of the scale (min.=8; max.=69; t(137)=37,733, p<0,01).

In this way, the results unequivocally show that students assess their digital competences as highly developed, while their assessments differ significantly from the theoretical mean of the scale.

Table 2. *Descriptive parameters for scale of digital competences as a whole and subscales (students' self-assessment)*

	M	SD	N	α
Total scale Digital competences	2,71	0,23	23	0,86
Information and data literacy	2,81	0,24	3	0,54
Digital content creation	2,79	0,24	7	0,70
Communication and collaboration	2,74	0,29	5	0,67
Safety	2,62	0,36	5	0,71
Problem solving	2,56	0,43	3	0,71
Legend: M – arithmetic mean; SD – standard deviation; N– number of items; α - Cronbach's Alpha				

The obtained results are consistent with related research. Analysis results [20] show that students in Serbia possess satisfactory level of digital skills, especially in the domain of information and communication technologies, but also that there is significant room for further development of these skills in the domain of problem solving and software use. In addition, the results of this study indicate that the observed digital skills of Serbian students are at a somewhat lower level than the skills of their fellow students from the EU, especially in the domain of more complex digital skills (problem solving and software use) and their application.

When the defined areas of digital competences are considered, the obtained results indicate that students in Serbia believe that their digital competences are most developed in the following areas: information and data literacy (M=2,81; SD=0,24), digital content creation (M=2,79; SD=0,24), and communication and collaboration (M=2,74; SD=0,29). On the other hand, students assess their digital competences as less developed in the remaining two areas: safety (M=2,62; SD=0,36) and problem solving (M=2,56; SD=0,43). It can be assumed that students perceive competences related to solving technical problems, and ensuring the protection of device, data, health and the environment as more complex competences that require additional work, and whose successful implementation implies help and support of others. It is also possible that study programs and teaching material at different faculties do not sufficiently incorporate elements from the last two areas of competence, given that they cover different scientific fields. Some previous research [21] shows that librarianship students assess their digital competences as most developed in the field of information and data literacy, followed by communication and collaboration, while on the other hand, they perceive their competences in the domain of solving technical problems and

involvement in active citizenship through digital technologies as least developed, similarly to our own findings.

The second research task aims to examine the significance of differences in the perceived level of digital competences between students, in relation to the university where they study, field of study, year of study, and frequency of use of ICT devices in teaching and everyday activities.

Table 3. *Significance of differences in the perceived level of digital competences between students*

Variables	Modalities	F
University	University of Kragujevac	F=3,907 p=0,02*
	University of Belgrade	1-2
	University of Novi Sad	1-3
Frequency of using smartphone in teaching	Every (work) day	F=3,869 p=0,01**
	Once a week	1-4
	Once a month	2-4
	Never	
Frequency of using smartphone in everyday activities	Every day	F=10,095
	Once a week	p=0,00**
	Never	1-2
		2-3
Note: *statistically significant at 0,05 level; ** statistically significant at 0,01 level.		

As suggested by the results presented in Table 3, it is established that the university where a student studies significantly determines their self-assessment of digital competences (F=3,907; p=0,02). At the level of pairwise comparison (LSD), significant differences between the students of the University of Kragujevac (M=59,96; SD=5,05) and the University of Belgrade (M=59,80; SD=5,12) were identified, as well as between students of the University of Kragujevac (M=59,96; SD=5,05), and those from the University of Novi Sad (M=59,54; SD=4,86). The assumption is that the identified differences arose as a result of the sample structure, but also due to the lack of standardized teaching content referring to the use of modern digital technologies.

Moreover, according to the results of this research, students who use smartphones more frequently in teaching assess themselves as far more digitally competent than their fellow students who do not use smarthphones for learning purposes (F=3,869; p=0,01). Specifically, students who use smartphones in teaching on a daily basis for learning purposes (M=59,98; SD=4,94), as well as those who use it once a week (M=59,89; SD=4,93) assess the level of their digital competences as significantly higher than students who never use smartphones for the same purposes (M=54,72; SD=6,13). In addition to the above, the frequency of using the smartphone in everyday activities represents a significant determinant of self-assessment of one's digital competences (F=10,095; p=0,00). Significant differences were identified between two pair groups: (1) between students who use the smartphone every day (M=59,91; SD=4,92), and those who never use it (M=51,42; SD=5,59); as well as between (2) students who use the smartphone once a week (M=59,00; SD=5,33), and those who never use it (M=51,42; SD=5,59). These results are consistent with similar research on the relationship between the use of ICT technology and ICT competencies [22][23][24][25]. Eger et al. [22] discovered that there are large variations in student ICT competencies, and the application of digital devices (primarily smartphones) in leisure activities, and in learning. Although not unequivocal, a significant and positive relationship was established between the use of ICT in different contexts and student digital literacy, expressed as a measure of self-efficacy in the use of information and communication technologies [23][24], or a measure of performance on ICT competency tests [25]. Students who frequently use ICT in social communication achieve higher scores in computer and information literacy than those who use ICT less frequently for the same purpose (e.g. once a week, or never), and the direction of this effect was consistent across the 21 countries surveyed [25]. More frequent use of smartphones in one's free time has a positive effect on the increase of student digital competences, and consequently, on the frequency of ICT use in teaching, for learning purposes. On the other hand, the improved digital competencies of students have a positive effect on the frequency of ICT use in different contexts (learning, free time, work, etc.).

4. CONCLUSION

The development of digital competences not only improves the quality of life of citizens in the general population, but also strengthens local and regional development, as well as the development of society as a whole. Due to the fact that digital competence is inseparable from other lifelong learning competences needed to live and work in the 21st century, the modified European Competence Framework DigComp 2.0 is an important reference framework for understanding and assessing digital competences of students, as well as current and future citizens.

The results of the research give rise to two conclusions:

First, that students assess their digital competences as highly developed, both at scale level, and at the level of observed areas of competence (information and data literacy; digital content creation; communication and collaboration; safety; and problem solving); and

Second, data that refer to the impact of certain socio-demographic variables indicate that there are significant differences in the self-assessment of digital competences between students from different universities, in relation to the frequency of using the smartphone in teaching and everyday activities.

It is encouraging that students consider themselves competent enough to live and work in the digital world and environment, but we must not overlook potential subjectivity in the assessment of one's own competence. Some authors [17] suggest an alternative - using objective research instruments to determine the level of students' digital competence, based on the performance and demonstration of digital competence (knowledge, skills and values), in addition to self-assessment and self-reporting. A potential factor that can influence the results of the ANOVA test, and at the same time represents the limiting factor of this study, is the difference in the number of samples across the compared student groups.

Given the multidimensionality and fluidity of the concept of digital competence, as well as results of this research, there is a need to improve students' digital competences in the domain of safety and problem solving while they are still at university, especially because these competences are applicable in all activities supported by digital technologies. Understanding and observing the principles of safe use of digital content, and solving problems related to the use of digital devices and technologies are necessary competences on a personal, professional and social level. In the system of higher education, the assessment and development of students' digital competences remains a great challenge, but also an opportunity to adequately and critically respond to the challenges of society's transformation and overall digitalization.

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User Experience Design of University Schools' Web Portals: Comparative Analysis of State-owned Technical Faculties in Serbia

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Abstract: *In aim to improve information service to students and all university schools information stakeholders, it is very important to make and maintain institutional web portals structure and design to be modern, functional and pleasant for use. This paper is focused on analysis of web portals designs, with special attention to university portals of technical sciences schools having information technology-related study programmes. In this empirical research, an evaluation model to be applied upon the sample web portals is formulated according to the framework of user experience design cumulatively, by extraction of web pages, elements and their characteristics from web portals in the research sample. This evaluation model is applied in analysis of characteristics of each item in the sample, i.e. each web portal of schools of technical sciences that belong to state-owned universities in Serbia. Conclusions are related towards formulating a set of web design quality characteristics which could be applicable in benchmarking, redesign or creating new web portals.*

Keywords: *web design, evaluation model, software quality, technical sciences university schools.*

1. INTRODUCTION

In the modern world, it is a common practice to have all important institutional information at the appropriate web site [1]. Most universities have their web portals with all university and affiliated schools data joined under the common URL [2], which makes web design and data organization at web pages harmonious.

There is a significant role of social media and social networking web sites [3], as well smart educational software for mobile devices [4] in higher education. Still, educational institutions' web portals keep their importance for information presentation and educational process support, and, therefore, remain in scientific and professional focus, particularly for the aspect of their quality evaluation and ranking [5].

Aim of this paper is to address the web design aspect of educational web portals – particularly for schools of technical sciences at universities. Sample for this research represent faculties of technical sciences at Serbian state-owned universities. By analysis of web portals of these educational institutions, a cumulative evaluation model will be created and applied to all web portals in the sample. This way, a comparative analysis of web design characteristics of these web portals will be performed.

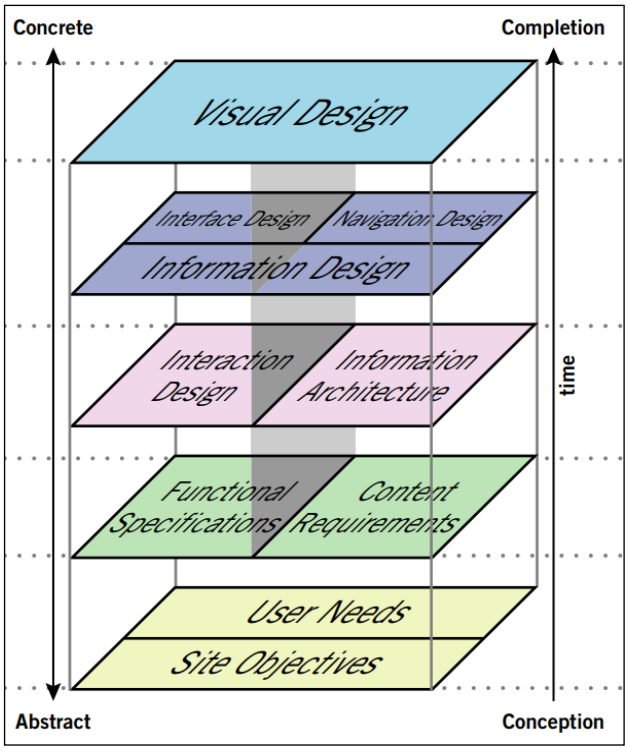
The structure of this paper is as follows: section two brings theoretical background with explanation of basic terms related to human-computer interaction (HCI), web sites user experience and web design aspects; section three provides a short literature review of related work regarding HCI development and evaluation of university web portals; section four presents research method and sample; section five presents results of the empirical research and the last section provides conclusions and future work directions.

2. BACKGROUND – HCI, WEB USER EXPERIENCE AND WEB DESIGN

According to [6], the Human-Computer-Interaction (HCI) could be categorized as a craft, applied scientific and engineering discipline, which "concerns humans and computers interacting to perform work effectively" [6]. This definition implies three components that are part of the scope of the general problem addressed by the discipline o HCI – human, computer and work (domain of application). General HCI problem could be decomposed to [6]: a) Design of humans interacting with computers (human factors, training and ergonomics with physical and mental aspects); b) Design of computers interacting with humans (software engineering hardware design).

Interaction design aspect of HCI has been particularly addressed as a scientific field [7], where engineering, anthropology and behavioral scientists could make influence to the results of HCI practitioners. In [7], it has been stated that in early days of HCI, term "design" within HCI was related to usability engineering, i.e. "the process of modeling users and systems and specifying system behavior such that it fitted the users' tasks, was efficient, easy to use and easy to learn". In later definitions [7], creative design is distinguished from engineering design, where creative designers continually reframe the problem, i.e. constantly question about the underlying assumptions that are directing the product development.

According to [8], important aspects of web site design that could influence web sites user experience are: information architecture, site architecture, page structure, interface design, graphic design, typography, images and video. Elements of user experience are defined at [9], with the concept of basic duality in web design – having web pages as software interface and information resource based on hypertext system. By the development of web technologies, there is a sophisticated diversification and integration of front-end and back-end parts of web applications. According to [9], elements of user experience design are presented at Figure 1.



Web design, according to [9] is oriented towards enabling appropriate web site user experience and it is based on user needs and the web site objectives, which are formulated into functional and content requirements, followed by interaction design, information architecture, information design, interface design, navigation design and visual design.

3. RELATED WORK

3.1. HCI Development

In [10], a brief history of HCI is given with presenting important aspects such as user interface design, activity and linguistic theories-based approach and contextual design (having context of the interaction in focus). According to [10], recent research in HCI field is directed towards "practice" as a paradigm, where particular areas of application could be addressed, such as information systems and computer supported cooperative work. Other relevant "practice" oriented aspects of modern HCI include: performance measurement and adjustments, digital ecologies (i.e. family of artifacts), materiality of artifacts and embodiment with human activities and solving problems in real world.

HCI area follows information technology and application changes (they are called "waves"). Integration of different waves is addressed in [11]. According to [11] [12] there were three mayor HCI waves with focus on:

1. First wave – cognitive aspect of human being, industrial engineering and ergonomics;
2. Second wave – groups of people working with multiple applications, work settings within well-established communities of practice, situated action, distributed cognition, activity theory, information flow;
3. Third wave – interactive computing always present in life (both work and home), applications are built on the fly, collaboratively by people in specific context, meaning construction, creation is variable (people and context change, big diversity of actors, needs and contexts, hyper-relativization), new elements as factors of interaction (culture, emotion, experience), extension to personal life, art and leisure (non-work, non-purposeful, non-rational), designers seek inspiration from use.

Having "computer" side of HCI in focus, there are recent results in using patterns and pattern languages in both software engineering and design part of the HCI development [13]. According to [13], "patterns provide some rationale for particular design decisions", but also they provide alternative patterns for similar problems, that could be used in different contexts; the patterns are often provided together with advice on the context of applicability. Research [14] provides insight in recent trends in HCI research and practice with using artificial intelligence and machine learning techniques in: explainable artificial intelligence systems, recommender systems, context-aware systems, rules extraction and production, implicit sensing etc.

3.2. Evaluation of university web portals

University web portals have been evaluated from different perspectives.

In [15] results of empirical research on university websites effectiveness are presented. Particular design characteristics that were examined were: information content, navigation, usability, customization, download speed, security. The empirical research has been conducted upon 50 colleges and universities in USA. It has been concluded that universities should improve updating information, presenting layout and visual attractiveness, and offer a better support to navigation, search and location of information, customization and security.

Research [5] presents an approach to rank educational web sites on usability. Factors that affect the usability of a website are defined according to literature review and they are: ease of use, response time, download speed, navigation, accessibility, personalization, availability, content, security and aesthetics. The importance of each of these factors were estimated by decision makers, where linguistic scale values were related to fuzzy numbers for importance level of the factor influencing usability. After formulating the decision matrix, four educational web sites were evaluated and applicability of the proposed evaluation model was empirically proved.

Accessibility of higher education institution web sites in the State of Kuwait has been examined in research [16]. The evaluation criterion was the conformance to the WCAG 2.0 Web Content Accessibility Guidelines standard. Sample consisted of 41 homepages of higher education institutions and colleges. In the research some tools were used, such as AChecker, Total Validator, WAVE etc. It has been concluded that none of the analyzed web portals were fully conformed to the WCAG2.0 standard. It was clear that these web portals were not developed to be aligned with WCAG2.0 standard and that they need to be improved, in aim to provide appropriate accessibility to people with disabilities.

4. RESEARCH METHODOLOGY

4.1. Research method

Research method in this paper is related to:

1. Creating an evaluation model to be applied in comparison of web designs included in user experience design;
2. Applying this evaluation model to elements of web design at university schools of technical sciences web portals.

The model for user experience design evaluation is created:

- According to [9], including aspects of user experience design;
- Enhanced user experience aspects with accessibility aspect and details about media;
- Having detailed elements and characteristics obtained by cumulative approach, where each detected characteristic at particular web portal is integrated in the common evaluation model, to be applied to the whole sample.

The process of creating the evaluation model is presented at Figure 2.

4.2. Research sample

In this research, sample consists of web pages, elements and characteristics extracted from web portal designs of public (state-owned) university schools of technical sciences in Serbia (excluding University of Novi Sad, Technical Faculty "Mihajlo Pupin" in Zrenjanin). Criteria for selection of state-owned university schools (faculties) is to analyze schools of technical sciences (having word "technical" or "electrical engineering" in their names) having study programmes in information technologies, computer science and software engineering field. The sample (faculties and URLs) is presented at Table 1.

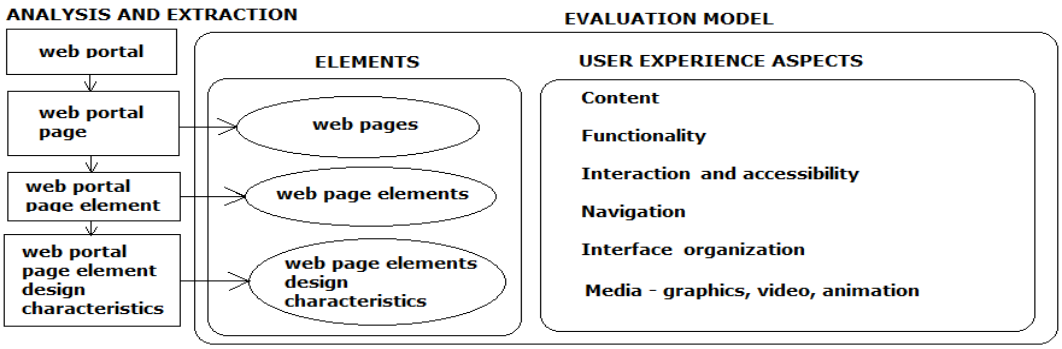


Figure. 2. *The analysis of web portals and creation of cumulative evaluation model for evaluation of web portals user experience design*

Table 1. *Research sample – web portals of state-owned faculties of technical sciences in Serbia*

No	Public University School of Technical Sciences	Web portal URL
1	University of Belgrade School of Electrical Engineering	[17]
2	University of Novi Sad, Faculty of Technical Sciences	[18]
3	University of Nis, Faculty of Electronic Engineering	[19]
4	University of Kragujevac, Faculty of Technical Sciences Cacak	[20]
5	State university of Novi Pazar, Department for Technical Sciences	[21]
6	University of Pristina, (temporary in Kosovska Mitrovica), Faculty of Technical Sciences	[22]

In analysis presented in this paper, both Serbian and English versions of these web portals were analyzed. Examples of web pages from university schools' web portals, that present information about IT-related study programmes are presented at Figures 3-8.

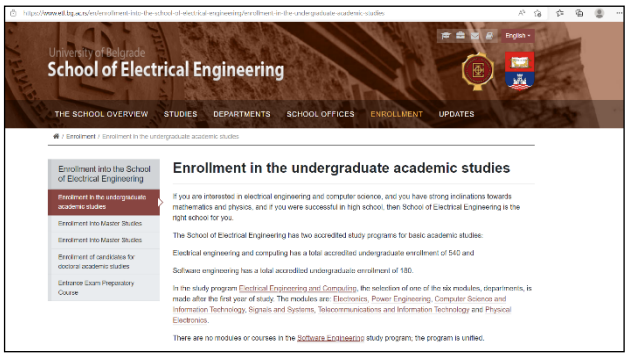


Figure 3. *IT-related study programmes at [17] (English version page)*

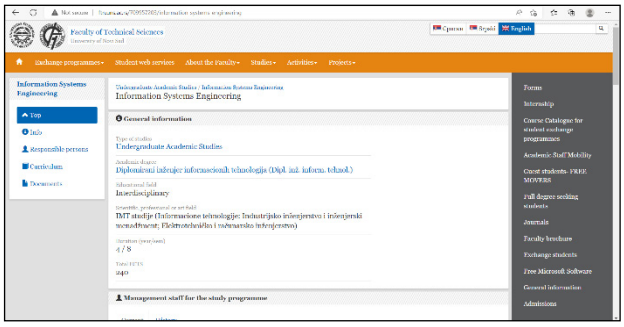


Figure 4. *IT-related study programmes at [18] (English version page)*

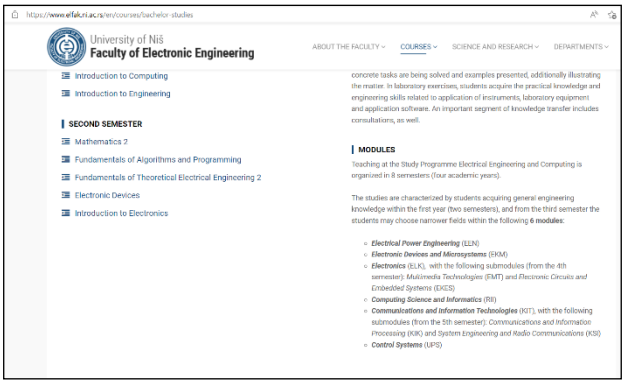


Figure 5. *Undergraduate study programe modules at [19] (English version page)*

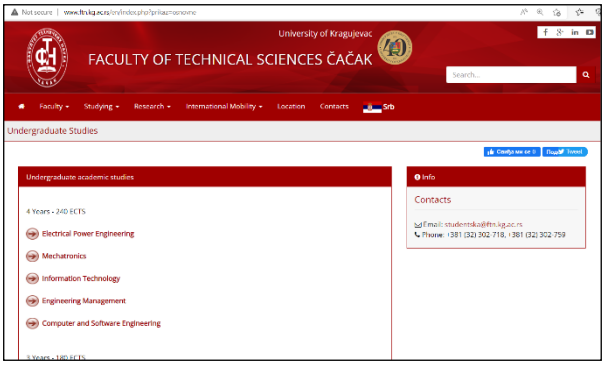


Figure 6. *Study programmes including the IT-related at [20] (English version page)*

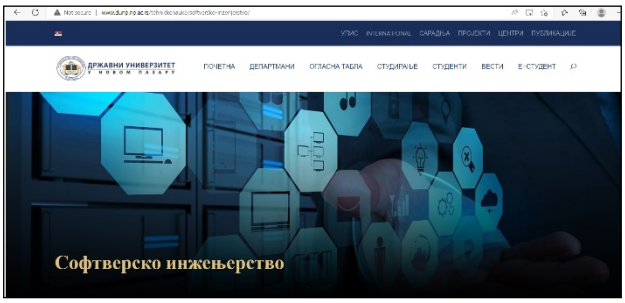


Figure 7. *Software Engineering Study Programme at [21] (Serbian version page)*

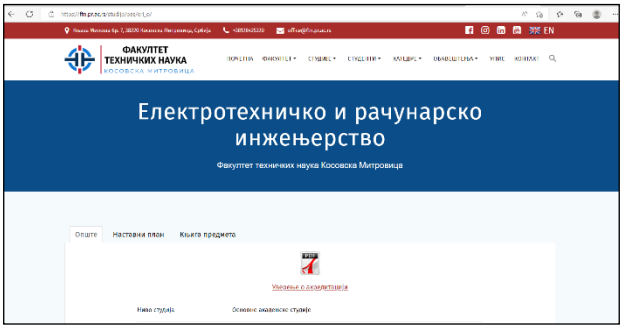


Figure 8. *Study programme in electrotechnical and computer engineering at [22](Serbian version page)*

5. RESULTS AND DISCUSSION

Analysis of user-experience design has been performed according to the proposed evaluation model (presented at Figure 2), upon the sample web portals of Serbian state-owned technical faculties and the results are presented in following tables. First column at each table represents sample item number, while the rest columns are related to particular most important elements and characteristics at sample web portal pages.

Table 2. *Content accessible from the first page*

Sample item No.	News	Management, departments, services offices	Accreditation	Study programmes, enrollment	Scientific conferences, projects, technical solutions and publications	Documents legislation public procure-ments	Mobility	Stud. organizations	Jobs, Internships
1	GAC	DDM	DDM	SP, E	no	D	yes	no	J, I
2	LA	DH	DH	SP, E	C, Pub	L, PP	yes	yes	J, I
3	PAN	DDM	DDM	SP, E	no	DDM	no	no	no
4	G,UT	DDM	DDM	SP, E	DDM	D, L	no	yes	J, I
5	PAN	DDM	no	SP, E	Pro, Pub	L	yes	yes	no
6	PAN	DDM	DDM	SP, E	no	D, L	no	yes	no

News at first page are at some portals categorized to: general news, announcements and contests (GAC). Sometimes news are prioritized (very important/all news (PAN)) or categorized as latest and archive (LA), while at some portals news are categorized as general (G) and by user types (UT) (students, teaching staff).

Regarding organization of the institution, it has management, services offices and scientific-educational departments and their data are usually accessible via drop down menu items (DDM) or via direct hyperlinks (DH) at first page.

At most web portals, accreditation data and documents are provided within separate pages, not directly from the first page. Study programmes and enrollment data are available at all web portals. Scientific conferences, project, technical solutions and publications are insufficiently present at the first (home) pages. Documents and legislation are mostly reachable from the first pages, while public procurement is directly accessible from only one web portal. Mobility, jobs/internships contests and students' organizations are partially present.

Table 3. *Functionality*

Sample item No.	Online enrollment registration	Enrollment preparation and news registration	Log In joined	Separate student portal	Separate employee portal	Web portal search	Address book	E-mail service
1	yes	yes	No	yes	Yes (E)	no	yes	yes
2	yes	no	No	yes	Yes (TS)	yes	yes	yes
3	yes	no	Yes (FS, S, TS)	no	no	no	no	yes
4	yes	yes	DIR	yes	Yes (E)	yes	Yes (DDM)	no
5	no	no	No	No	No	yes	no	no
6	yes	no	No	No	No	yes	no	yes

FS – future student, S- students TS – teaching staff, E – employee – DIR – joined login form, but with subform for students, DDM – available from drop down menu

Regarding functionality, it could be concluded that most of faculties have online enrollment registration (registration for applying to enroll for the study admission), while only two faculties have enrollment preparation registration online forms. At only one faculty there is joined log-in page for future students, students and teaching staff, while most faculties have separate log-in forms for students and employees/teaching staff. These separate log-in forms enable entry to separate web portals for students and employees/teaching staff. Web portal search, web email service and address book are available at most portals.

Table 4. *Interaction and accessibility*

Sample item No.	Languages	Hiperlink type	Image slider	User types categorization of content	Accessibility - graphical settings	Accessibility – reading (audio) content	Cookies	User feedback	Mobile version applied
1	S, Ch, E	T, I, Im, A	Au, Ar, P	Sm, Em, Gm	no	no	no	no	yes
2	S, Ch, E	T, I, Im, B	Au, Ar, P, T, H	no	no	no	no	yes	yes
3	Ch, E	T, I, Im, B	Au, B	no	no	no	no	no	yes
4	Ch, E	T, I, Im	Au, Ar, P, T, H	Sn, En, Gn	no	no	yes	no	yes
5	Ch, E	T, I, Im, B	no	No	no	no	no	no	yes
6	Ch, E	T, I, Im, B	Au, B	no	no	no	no	no	yes

Languages: S – Serbian Latin, Ch –Serbian Cyrillic, E-english; Hiperlink types: T-text, I- icon, Im- image, A-area, B - button;
Image slider: Au – automated, Ar- arrows, P – progress bar T – text, H – hyperlink, B – button; User categorization: S E G m/n – students/employees/general menu-news;

As for interaction and accessibility, all web portals have English version, as well as Cyrillic Serbian version, while two have also Serbian Latin versions of pages. Hyperlinks are regularly texts, icons and images, while most of web portal use also buttons and only one uses area as a hyperlink (i.e. click on the area invokes animation). All except one web portal have automated image sliders, where most of them have arrows, progress bar, but also buttons, hyperlinks and text above images. Only two web portals have explicit user types' categorization regarding offered content. None of the web portals offer accessibility adjustments (settings for users to adjust colors, contrasts) or other accessibility options (such as audio content – reading of the web site content). Only one web portal offer using cookies and only one web portal enables users to leave their comments on the usability (user feedback). All web portals have mobile versions, which are automatically adjusted when user screen shrinks or it is loaded at mobile devices.

Table 5. *Navigation*

Sample item No.	Dropdown menu	DDM fixed	Site map	Site map location of page	Separate menus	Multiple menus at first page	Home	On Top icon	Menu at mobile version
1	ST, 2C, SIp	no	no	yes	yes	Left, top (DDM)	icon	no	H l, C, Op, A, Lo
2	2C, S	no	yes	No	yes	Left, top (DDM), right	icon	No	C, T
3	2C, Sir	yes	no	no	no	top (DDM)	Word	hover	H, r, O, C, A
4	2C, S	no	no	yes	yes	top (DDM), collapsible right	icon	hover	H, r, To, C, A
5	2C, SIr	yes	no	no	yes	top (DDM), right	Word	no	H, r, Op, C, Ro, A
6	2C, SIr	yes	no	no	yes	top (DDM), down (footer)	Word	no	H, r, C, Op, Ro, A

Dropdown menu (DDM): ST – semitransparent, 2C – two colored items, Sip – sub items popup, S – simple (no subitems), SIr – with subitems opened right, Mobile menu: H- hamburger menu, C - collapsible with subitems, r – right position, l – left position, T- top position, To – top position when opened, O – over content, Op – partially over content, Lo – Left position when opened, Ro – right position when opened, A – animated appearance when opened

When navigation is concerned, it could be concluded that half of web portals have dropdown menus fixed, most of them have DDM with sub-menus, which appear right, two of them have simple dropdown menus without sub-menu items. Most of them are two-colored for the items background, while only one applied semi-transparency as well. Only one web portal has site map and only two has site map position displayed at the top of pages that are loaded. Most web portals have separate menus presented out of dropdown menu – some at left position, some at right and some at footer. Back to home is mostly by word in dropdown menu, while in two cases a house icon is used. Back to top is applied only in two cases, when the icon of an arrow hovers while content is scrolling. Most web portals have right positioned hamburger menus (only one does not have), whose content appear with animation and have items that are collapsible (enabling to open sub-items).

Table 6. Interface organization

Sample item No.	Appearance type at first page	Simlicity (minimalist design)	Content columns	Collapsible content	Tabs at first page	Tabs at other pages	Mobile version outline
1	columns	3	3	no	No	no	Sm, Im, 1c
2	columns	4	5	no	No	no	C, Im, 1c
3	image	1	3	no	No	yes	F, Im, 1C, T
4	columns	2	2	yes	yes	no	Im, 1c, 2c
5	image	1	3	no	No	no	Sm, Im, 1c
6	image	1	4	no	No	yes	Im, 1c

Mobile: Sm – separate menus, Im – images, 1c – one column content, C – collapsible, F- fixed baner with menu, T- on top icon

Interface organization could be presented with respect to desktop and mobile version. As for desktop version of web portals, half of web portals have one-image appearance at first page, having the rest of first-page content accessible after scrolling, while other half has column-arranged content of first page, having separate menus, texts and images organized in columns. Three of six web portals have a 3 columns interface organization (as a rule, middle column is broader). Others have 2, 4 and 5 columns organization of content. Only one of portals have collapsible content and three institutions are using tabs to present similar content at first and other pages (categorized by types of users, types of documents, organizational structure elements etc). According to elements that are present at first page, estimated simplicity (minimalist design level) of web portals are: half (3 od 6) have level 1 (minimalist), while one has level 2, one 3 and one level 4 (the most complex).

As for mobile version outline, most content is presented in a one column style and using both text and images. One institution presents content in 2 columns at non-first page, one has both hamburger as a main menu and also separate menus, one has collapsible content and one has "on top" icon provided.

Table 7. Media

Sample item No.	Dominant background color	Back-ground colors of DDM	Font colors	Images color effects	Banner image	Icons	Images	Video	Animation (other than image slider and hamburger menu)
1	white	Yellow, brown	Black, white, orange	Colorized baner	Colorized photo	H, Sp, Ep, We, Ad, Sp, Ep, D, Cal, Con, M, ST, Di, Pw, PP, Pd, Emp	Small, Middle	yes	Dropdown list fade in, dropdown subitems appearance
2	white	Orange, light gray	Black, blue, white	Dark edges of image on mouse move	no	H, La, S, Os, E, N, A, SN	Small, Middle	yes	no
3	white	Light gray	Black, gray, blue, white	Colorized photos	no	L, C, Lo, We, SN	Small, Middle, Large	yes	dropdown item mouse move underline, page loading progress animation
4	white	Red, light gray	White, red, light gray, black	no	Abstract stylized	Sn, S, Lo, H, La, Tn	Small, Middle, Large	yes	Logo, link images in strip, enrollment icon fade in
5	white	Gray	Dark blue, black, orange	Linear gradient of photo with color	No	La, S, SP	Small, middle	no	dropdown item mouse move underline
6	white	Light gray	Black, blue, white, red	Colorized photos with animated gradual lighting fade in	no	L, SN, C, La, SP, Se, St	Small, middle	yes	no

DDM – dropdown menu; Icons: L –location, SN – social networks, C – contact, La- Languages, SP – study programmes, Se – services, St – statistics, S – search, H – home, Lo – login, Tn – types of news, We – web email, Os – organization structure, E – employees, N – news, A – archive, Ad – address book, Sp – students portal, Ep – employee portal, D – documents, Cal – calendar, Con – contests, M – mobility, ST – online teaching service, Di – diploma lists, Pw – public view, PP – public procurements, Pd- public defending of theses, Emp – employment contests

As for the media category, it could be concluded that all web portals have a dominant white as a background color. Gray is mostly used as a background color for dropdown menu items, together with yellow, orange and red. Font colors are mostly black, white, orange, blue and red. Most web portals do not have a banner image, but when it is present, it is stylized abstract or colored photo. Images are mostly adjusted for fast loading and they are mostly small or with middle size, rarely large. Images are processed with colorization, gradient with colors or dynamically changed on mouse move (animated gradual lighting to fade in or change lighting at borders). Icons are minimally used for most common purposes, such as languages, login, search, contact and social networks, while sometimes they are present in the content to illustrate study programmes, organization, statistics etc. Video is present at almost all web portals. Animations are used for special effects with loading pages, dropdown lists, image sliders, appearance of hamburger menu at mobile version, but also for animated logo and important links emphasis with fade in effect (such as enrollment news) etc.

6. CONCLUSION

The aim of this paper was to conduct comparative analysis of educational institutions' web portals, with special emphasis on university schools of technical sciences. The sample for this empirical research was chosen to be Serbian faculties of technical sciences that are affiliated to state-owned universities.

Results of this research are twofold. First result is an evaluation model for university schools' web portals, based on categories of user experience design and cumulative approach of extraction of contents, elements and characteristics of analyzed web portals. Second results are analysis data that are obtained according to previously created evaluation model and conclusions that could be drawn regarding the empirical research sample.

It could be concluded that the evaluation model has been successfully created and applied upon the web portals in the sample. Analysis data regarding application of the evaluation model show that most of the analyzed web portals have similar content, functionality and interface design.

Results presented in this paper could be beneficial in two aspects. First aspect is related to the formulated evaluation model for user experience assessment of university schools' web portals. Second aspect is related to the elements and design characteristics that are integrated from multiple sources (different web portals) and could be used in directing future development of new or improving existing education institution web portals.

Limitations of this research are related to: a) the formulation of the evaluation model, which takes certain aspects of user experience design and cumulative approach of extracted elements and characteristics from the sample; it should be based on detailed related work in this area and their results integration and it should take all necessary aspects, elements and characteristic into account; b) sample for application of this empirical research is limited to 6 items, i.e. web portals; there should be a broader sample of more items to be analyzed to draw statistically-valid conclusions; c) in some of particular analysis, only first page was analyzed or randomly selected other pages; detailed analysis of all pages, or most of them, should be conducted in aim to get more precise results; d) web technology change, so this evaluation model is applicable in near period of time; it would be beneficial to make an universal evaluation model, but this way granularity (i.e. preciseness) of the evaluation model will be lost, so appropriate optimization between general setting and preciseness should be accomplished in future evaluation model proposals.

Future work could be directed towards creating evaluation models for university web portals that are based on standards and different approaches and methods of software evaluation. Such models could be applied to larger sample and include university schools web portals from different countries. New web portal evaluation models should consider application area, but also a proper trade-off between general setting and preciseness of elements and their characteristics to be evaluated.

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Professional paper
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Development of information system for digital dialogue in teaching using RESTful service

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Abstract: *Digital dialogue in teaching, as an asymmetric, multi-user communication system, represents an indirect connection between teachers and students in real time. For this type of communication, it is necessary to ensure the fastest response of clients and to ensure parallel processing as well. The features of RESTful web service, such as: possibility of caching, uniform interface and explicit use of HTTP methods, recommends it as a key component in the information system for digital dialogue in teaching. This paper presents a project for development of such information system using RESTful web service and a description of its advantages compared to other solutions.*

Keywords: *digital dialogue, RESTful, web services, Java, mobile learning*

1. INTRODUCTION

The deployment of mobile devices requires technology that connects mobile systems with a conventional distributed computing environment. If a programmer is writing an application that requires some computation in one place, the write method is computed in the code in that one place. However, if data computation is required in other parts of the application, in distributed systems, it would be impractical to maintain. If a single change is needed in that method, all instances need to be found to edit (and retest).

Such a scenario would benefit from the application of a web service for optimal functioning and improvement of business agility. Web services may be the perfect candidate for such connection, since strong interoperability is a key requirement of this technology. Considering the fact that mobile computing environment is very heterogeneous in terms of hardware platform, operating system and programming language, the integration of mobile computing with web service technology can provide many advantages to both sides [1].

Mobile device technology is in daily development – phones and tablets are becoming computing capable [2], so with appropriate web services they can be equal partners of the web application architecture (they can be a web service client or a web service provider).

Digital dialogue in teaching relies on the use of mobile devices in its key segments [3].

The information system for digital dialogue in teaching contains two functionally different components [4]:

- communication system for dialogue in immediate teaching and
- communication system for DLS support (*Distance Learning System*) (*Figure 1*).

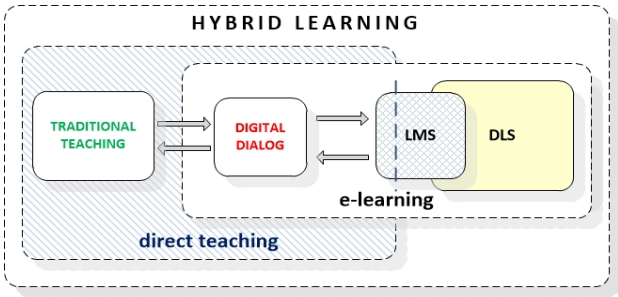

Figure 1: *General scheme for digital dialogue in teaching*

Subjects in the digital dialogue are: student, teacher, parents, professional services, school management and institutions of the Ministry of Education. Each of them can have appropriate, limited access to the system (*Figure 2*).

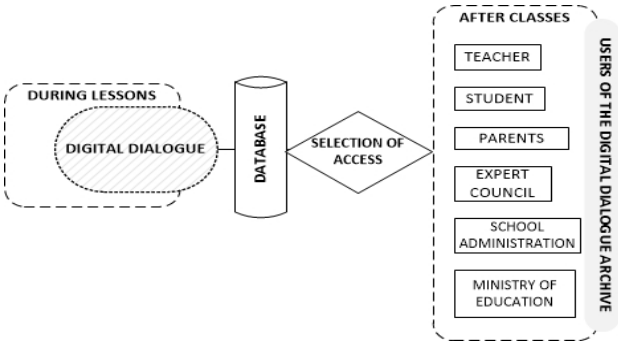

Figure 2: *Users of digital dialogue*

Realization of digital dialogue in teaching requires electronic components for a standard CRS (*Classroom Response System*) environment, which implies an information system that has its own appropriate hardware, system and dedicated application software, database, communication system and data processing methods [4].

The communication system for the implementation of digital dialogue in direct teaching should connect all subjects of the teaching process, through the functioning of the Internet and wireless networks.

The system for connecting students' devices with the teacher's computer can be based on different technologies: *infrared* (IR), *radio-frequency* (RF), SMS, Wi-Fi, LAN. It is necessary to ensure that the broadcast of a large number of responses from students' mobile devices - PRS (*Personal Response System*) in real time is accepted.

The server application accepts client requests and processes them through its interface. The entire system works using web service technology. The application is three-tiered. The upper layer consists of a Windows-form client application for teachers and a web (Android) application for students. These two client applications provide an interface through which data is forwarded to the components. On the middle layer are the components, which enable communication with the database, perform all operations on databases and pass data between layers. They contain most of the system logic. The bottom layer is the data layer.

2. CHOICE OF THE DEVELOPMENT PLATFORM

The server application was implemented in the Eclipse EE (Java Enterprise Edition) IDE 4.24.0 environment in the Java programming language (java.version-17.0.3).

Such an environment already has built-in functionality for handling REST services, which means that there is no need to use an external one or create your own. All persistent data is stored in MySQL database. This approach enables the installation of the entire system within a school or college at the local level by creating a desktop application. Of course, the principle is the same in the case of setting up a web application on the server side (*Figure 3*).

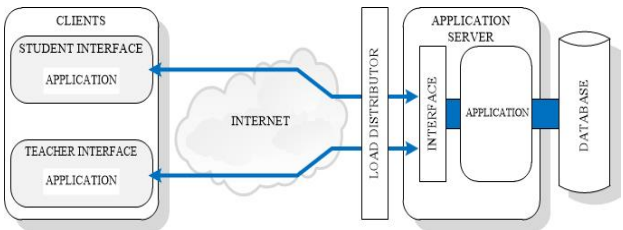

Figure 3: *Communication system for digital dialogue*

2.1. Selection of web services in the application

The choice of web service presents the next step. Web services are basically pieces of software that can be made available over the Internet [4]. They provide an interface between client applications and the server they reside on (*Figure 4*). In essence, this means that web services can be developed in any programming language and then integrated in a relatively simple way [5].

The three main ways of developing web services or APIs (*Application Programming Interface*) are: SOAP (*Simple Object Access Protocol*), XML-RPC (Remote Procedure Call) and REST (*Representational State Transfer*) [6]. A web service has a unique URI (*Uniform Resource Identifier*) that is used to call its function over the Internet.

2.2._SOAP web service as a standard

SOAP is a standardized protocol that enables communication between web services and clients via HTTP (*Hypertext Transport Protocol*) or SMTP (*Simple Mail Transfer Protocol*). Data is transferred using XML (*Extensible Markup Language*). SOAP supports the concept of stateless and one-way message exchange. On the other hand, developers through applications can create significantly more complex interaction patterns, for example request-response, request-multi response, etc.

To use the service, SOAP clients must know the available service directory, the names of the offered operations (*functions*) and the address of the end point for connection. The web services directory itself should be published using the XML-based WSDL (*Web Services Description Language*).

Server applications, developed in Java EE code, SOAP messages can be processed through the JAX-WS API interface (*Java API for XML Web Services*). It is not necessary to use the service directory.

Web services based on the SOAP platform have the following characteristics:

- asynchronous processing
- reliability
- stateful operation – If the application needs additional information, SOAP can offer additional specification in the structure of the web service to support the query (security, transactions, etc.)

There are a number of publicly available SOAP services. The most popular public SOAP services are used on web pages that display weather forecasts, exchange rates, currency conversions, stock prices, etc. Many of them are free, can be connected to the application, but the user is responsible for the appropriate user interface to display the obtained data.

2.3._A RESTful web service as an alternative

REST is a special concept in which domain URLs represent managed objects, and management is realized via HTTP methods. REST is platform and language independent and resistant to Firewall [7]. In fact, the only protocol that REST uses is HTTP. Unlike SOAP and XML-RPC, REST does not require XML Wrappers. This is possible because, as we said, objects are represented by URLs, and behavior is defined by basic HTTP methods: GET, PUT, POST, DELETE.

Responses are also forwarded using the HTTP protocol, but the format itself is not strictly defined. It can be XML, JSON or some other meta language.

The GET method is used to retrieve data, POST to create new data, PUT to update and DELETE to delete data.

Global features of RESTful services are:

- Stateless
- Cacheable
- Uniform interface URI
- Explicit use of HTTP methods
- XMS and/or JSON transfer

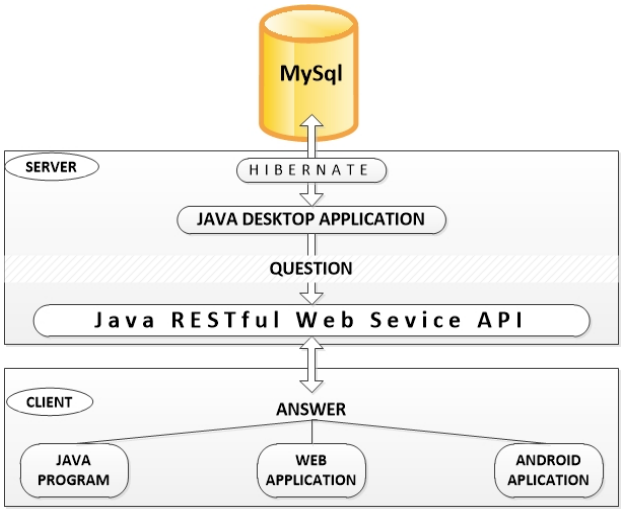

Figure 4: *Information system for digital dialogue for the classroom – architecture*

3. APPLICATIONS IN THE DIGITAL DIALOGUE SYSTEM

3.1._Java desktop application on the server

The desktop Windows application is intended for administrators and teachers. It allows viewing and updating data on system users, both students and other teachers, tasks and tests, viewing statistical data on the use of the application and setting the parameters necessary for the correct operation of the application.

The application itself on the server is composed of two basic modules:

- *Creator* – a module that contains forms for entering data about students, classes and groups, for creating questions with answers, for grouping questions according to teaching units and forms for creating tests.
- *StartDialog* – a module that contains forms for selecting a group of questions or a test and the process of activating the digital dialog itself.

All data in this application is filled in by the teacher. If he knows the curriculum and students well, the teacher can enter most of the data at the beginning of the school year (**Figure *5***).

A set of 5 – 10 standard questions is formed for each class of processing new material. Tests are created for refresher classes (*Figure 6*).

The Creator module in the desktop application does not require a web connection, but a *MySQL* database connection is required.

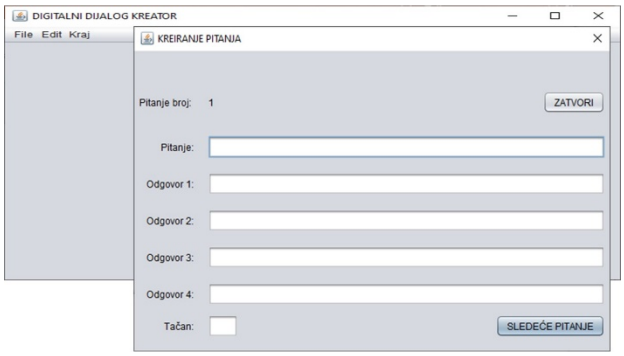

Figure 5: *Form of Java application for entering questions*

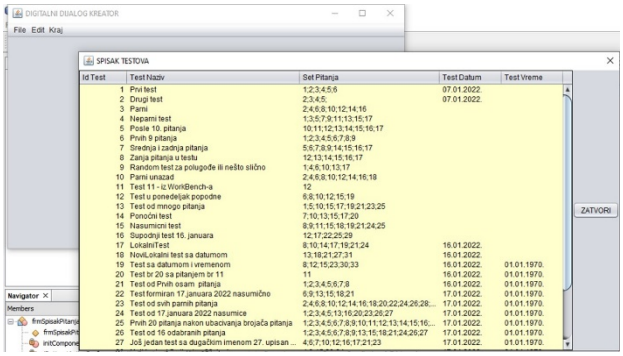

Figure 6: *Form of Java application for creating a group of questions in a teaching unit*

3.2._Java android client side application

On the client side in the digital dialog is an application whose most important role is to provide the user with a display of questions and the possibility of the simplest possible answer.

Since the factor of response speed is also significant, they are most often realized through the form of Multiple Choice Questions (*Figure 7*).

Figure 7: *Client-side Android application*

Unlike the Java application on the server, which is entirely developed in Eclipse IDE, the client application is implemented in the Android Studio Arctic Fox development environment based on REST services [8]. Each client application functions independently, while on the server, after logging in, a new program thread is created for each individual user.

4. STARTING A DIGITAL DIALOGUE

Before the beginning of the class for which the digital dialogue is planned, the teaching topic and the method of communication in the dialogue are chosen (*Figure 8*). Starting the dialogue can be realized in two ways:

- *Student Passed Dialog* – students answer each question successively in their own rhythm, which is mostly not practiced and rarely used in digital dialogue,
- *Teacher Passed Dialog* – the teacher initiates a question and determines the time for providing an answer depending on the current number of received answers, difficulty, type of question, etc.

The second method provides the opportunity for teachers to, at their discretion, allow students a longer or shorter time to provide an answer to each question.

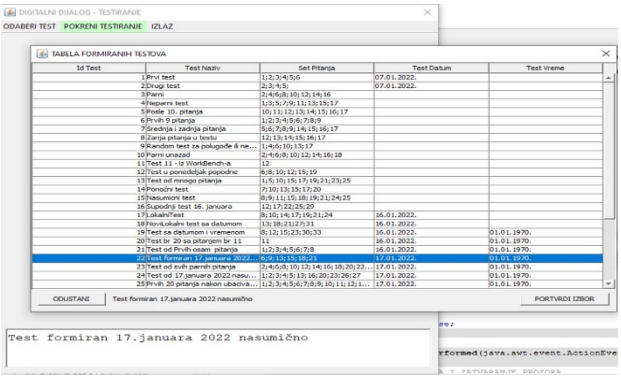

Figure 8: *Form for choosing a test or teaching unit*

During the lesson, the lecturer teaches the lesson using an interactive white board or a projector in the multimedia classroom or computer room.

At the end of each logical unit, according to the teacher's assessment, a question is asked on the board and thus begins the digital dialogue. Students receive a question on their mobile phone, which also appears on the server, with the teacher and have a short period of time to provide an answer (*Figure 9*). The questions are related to the content of the immediately presented material, with the aim that the students notice the most important details of the lecture, keep their attention and check their knowledge. It is also expected that the teacher will receive reliable feedback on the engagement of each student and find out how many students have understood the segment of the teaching material presented.

After each answer, the students wait for a new question, which is also initiated by the teacher.

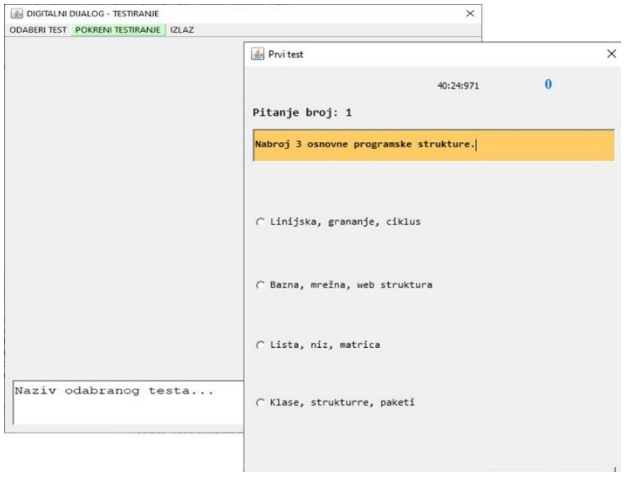

Figure 9: *Window tor displaying questions on the server side*

All questions and all student answers are accepted and automatically recorded in the database. Lesson reports and results of the digital dialogue can be selectively downloaded by students, parents, teachers, professional services or the school director (*Figure 2*), as authorized participants in the digital dialogue. The lesson report includes:

- the total results of all students' answers in the form of a table,
- a report on the activities of each individual student,
- report on individual answers for each question,
- data for analytical purposes, obtained from special database queries.

5. CONCLUSION

After testing, we can conclude that the information system, which uses a RESTful service in its applications, is fully functional. However, the REST service is expected to enable more efficient responses in digital dialogue with a larger number of participants and in multimedia communications.

This could be achieved in university lectures with a large number of students. However, in practice there were not enough opportunities to compare with the previous version, based on SOAP, so these measurements can be done in some future works.

Analyzing the works of other authors [9], [10], [11], [12], [13] and through the process of developing the entire information system for digital dialogue, we came to the following conclusions:

- SOAP and REST cannot be directly compared, since the former is a protocol and the latter is an architectural style,
- REST is protocol independent and not necessarily connected to HTTP,
- REST is more dynamic, no need to create and update UDDI,
- REST is not limited to XML format only,
- RESTful web services can send plain text/JSON/XML,
- SOAP is more standardized and new, greater security,
- The SOAP client works as a custom desktop application, tightly coupled to the server,
- by using SOAP, constant updates are required after each change, but it is easier to determine whether the contract is being followed,
- the client can use the REST service without knowing the API, only the entry point and the media type,
- in SOAP, the client needs prior knowledge of everything it will use, or it won't even start the interaction,
- The REST client can be extended with code on request delivered by the server itself,
- A REST application can use any protocol for which there is a standardized URI scheme,
- REST is more difficult to develop at first, but pays off over time with easier evolution on the server side and client resistance to changes

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Session 2:
Educational Technology

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Session: *Educational Technology*
Original research paper
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To MOOC or not to MOOC? Exploring MOOC readiness of YNSPEED project participants

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Abstract: *Massive Open Online Courses (MOOCs) have become one of the most prominent extensions to distance learning, especially during the pandemic and in the post-pandemic period. With the growth in the number of users of MOOCs (220 million users in 2021, excluding China) (Shah, 2021), educational opportunities within the field have been enhanced for both learners and course designers. The paper investigates the readiness of youth workers from 5 countries (Romania, Spain, Poland, Cyprus and Serbia) to engage in MOOCs either as learners or as instructors, after the training activities on MOOCs within the YNSPEED project have been completed. The data were collected using a questionnaire which was designed partially from the Driha et al. (2016) questionnaire and by a number of originally developed questions. Data were further analyzed using the SPSS software and descriptive statistic approach. The results suggest that although as many as 73.3% of the respondents have never completed a MOOC, MOOCs are perceived as an enhancement that might bring numerous benefits, but not offer the core value that traditional education brings. Apart from improving digital literacy skills, the results suggest, that MOOCs should provide a full course experience with high-quality content delivered by a renowned lecturer/university from abroad, at a lower cost, finalized by a certificate.*

Keywords: *MOOC; project; readiness; youth workers.*

1. INTRODUCTION

Since their first launch in 2008 when they emerged as an alternative to traditional learning and the progression of distance learning, Massive Online Open Courses (MOOCs) have been perceived as either disruption or a threat to higher education [9]. It was mainly to their easy accessibility for all who were interested to sign up, that MOOCs supported the democratisation of the educational processes across the world, providing learners with a unique learner experience to enhance their skills and earn a certificate at the same time. However, it came as a surprise that in the decades prior to the COVID-19 pandemic, the completion rate in various MOOCs was rather small (less than 10%) [11], and the number of MOOCs drop-outs was rather high. Some of the listed reasons for these unfavourable data were lack of time to complete the course or the inadequate level of instruction (too basic or too advanced).

The situation dramatically changed once the pandemic occurred, when offers to enrol on a MOOC errupted; one of the leaders in MOOC providing, Coursera, reported to have had as much as 607% increase in US enrollment only in March and April 2020, while, similarly, another MOOC provider, Udacity, had a 44% increase in weekly active users in a similar period. What is more, Udacity offered a special ''quarantine special'' to its learners by allowing free monthly access to a number of MOOCs that would otherwise cost nearly 400 dollars [1]. In the post-pandemic uncertainties caused by disrupted economies in the societies which were dramatically shaken due to the outburst of the pandemic, securing steady employment became crucial. To be able to obtain additional certificates, acquire new skills and update their resumes, young people rely on MOOCs as an affordable and self-paced non-formal way of education. In that context, it is of great importance to investigate the readiness of non-formal educational structures to engage in either designing or promoting MOOCs, as an educational add-on that can significantly affect career paths and employment prospects.

1.1. Background of the study

The YNSPEED project, co-funded by the Erasmus+ Programme of the European Union, was jointly carried out by five European institutions: IREA (Romania), EURECAT (Spain), BADEN (Serbia), Regionalne Centrum Wolontariatu (Poland) and Open University of Cyprus (Cyprus). The main goal of the project was to provide youth workers with the critical skills that are considered compulsory for active and responsible digital citizenship. The project aimed at addressing the hot topics of the nowadays digital era such as fake news, artificial intelligence, sustainable development and learning English with technology. In order to support open

and innovative practices for informal learning using digital platforms, tools and materials, the courses addressing these topics were implemented through a MOOC platform, which could be accessed by youth workers and youth aged 16-35, willing to develop and improve such skills, adjust to new social and economic context and thus, in a long term, improve their employability.

1.2. Review of literature on Massive Online Open Courses (MOOCs)

MOOCs have become one of the most prominent extensions to distance learning, especially in the pandemic and the post-pandemic period. With the growth in the number of users of MOOCs (220 million users in 2021, excluding China) [2] educational opportunities within the field have been enhanced for both learners and course designers.

Interestingly, current research on MOOCs reported that a high percentage of students/young adults have never taken a MOOC before, although they express readiness to get involved. For example, those percentages range from 55% [3], to 69.5% [4], to over 91.3% [5] of young adults who have never enrolled on a MOOC.

Research showcases that the readiness to engage in MOOCs is a strong predictor of future dedication to engage in MOOCs as a learner. In 2017 Fook et al. [10] explored students' readiness and competence in using MOOCs. Their findings revealed that the respondents' readiness to engage in MOOCs was at a moderate level, but the study also confirmed that there was a positive relationship between students' readiness and competence in using MOOCs.

Subramaniam et al. [5], investigated the readiness levels of adult students studying in Malaysian higher education institutions. The researchers inferred that measuring MOOCs' readiness can be seen as one of the necessary prerequisites to the MOOC's enrolment. Their research study confirmed that the majority of respondents (70%) reported that they had not taken fully online courses before and an even higher percentage (91.3%) had not enrolled in any MOOC.

Similarly, in their study, Tahiru and Kamalludeen [4], researched the acceptance of MOOCs among postgraduate students in higher learning institutions in Malaysia, and their readiness to use them for learning. This study has found a low level of awareness and usage of MOOCs among postgraduate university students. The findings reveal that a majority of postgraduate students did not have knowledge of MOOCs, and very few had any actual usage of MOOCs. However, most demonstrated a positive attitude towards MOOCs and expressed an intention to use the platform for academic purposes. The authors conclude that each faculty should encourage lecturers to flip their classrooms with MOOC technologies and learning materials for effective utilization of the system so students will really feel the need to utilize these services that come at less or no cost.

Comparably, Zulkifli et al. [7] investigated students' readiness in using MOOCs in their teaching and learning activities. The findings showed that the level of readiness for students to use MOOC is at the highest level with an overall mean of 4.02.

On the other hand, the main aim of Sezgin's study [6] was to identify the possible roles of MOOCs in the faculty-based teacher professional development. It was found that most of the preservice teachers and teacher trainers are uninformed or under-challenged about the MOOCs, but the vast majority of them reported that these open courses would be beneficial for teachers and preservice teachers. Some negative views of preservice teachers about the MOOCs are concerned with two specific views: language constraints and costs of certain courses.

In a Malaysian setting [4], recent research on students' readiness to use MOOCs for learning was conducted. The majority of the respondents had never heard of MOOCs prior to filling out the questionnaire (68.4%). In addition, a high percentage of the respondents never enrolled in any of the courses offered by MOOC providers (69.5%). The results of this research indicate that a majority of the respondents agreed that using MOOCs would help them get the latest updates in their areas of study and explore various educational topics within or out of their scope of the study.

Driha et al. [3] also recently reported on the BizMOOC project – Knowledge Alliance to enable a European-wide exploitation of the potential of MOOCs for the world of business" (hereinafter BizMOOC). It was launched with the support of the European Commission (EC) which aims to enable businesses, society (labour force) and universities to increase their activities and better exploit the potential of MOOCs. The research sample consisted of 1.193 respondents from all over the world. The research implies that although there is a general consensus that MOOCs provide a number of benefits, they have not yet become as accepted and valued as the more traditional teaching approach.

2. METHOD

An exploratory descriptive study has been utilized for this research, by deploying a questionnaire as a research instrument to collect data. As the sample of this research included only 30 youth workers who have completed training prior to the data gathering, the exploratory design as a procedure was chosen as an adequate approach since exploratory research findings are typically not generalizable to the population at large [8].

The treatment consisted of the training course designed for youth workers organized by IREA (Romanian Institute for Adult Education), one of the partners of the YNSPEED project, from 6th to 11th June 2022, in Timisoara, Romania. 30 youth workers from the 5 partner organizations participated in the course, whose main goal was to familiarize the participants with the MOOC courses on the topics of Artificial intelligence, Fake News, Sustainable development and Learning English with technology. The participants were intended to acquire the skills and attitudes regarding the usage of a MOOC course, so as to facilitate more flexible pathways of the non-formal education process. The course also provided guidelines on how to maintain young people's motivation in learning through informal practices and how to assist them in developing personal learning strategies, since the drop-out rates regarding MOOC courses are very high.

The main objective of this research was to assess to what extent the training course influenced the youth workers to express the readiness to engage in MOOCs either as learners or as instructors, after the training activities on MOOCs within the YNSPEED project have been completed.

2.1. Instrument and the Sample

The data were collected using the Driha et al. [3] questionnaire (2 questions) designed by the BizMOOC consortium, and a set of questions designed by the authors of this paper. The first part of the questionnaire is composed of 5 demography questions, while the second part of the questionnaire is related to Specific aspects related to online learning and MOOC readiness and consists of 9 questions. The questionnaire was typed in English and distributed to the project participants via the Google Forms tool. The data were further analyzed using the SPSS software and the descriptive statistic approach. The validity of the questionnaire was assured by Cronbach's alpha. The overall scale reliability value is 0.95 which is considered to refer to higher reliability.

The sample consisted of 30 youth workers who all completed the YNSPEED project training in May 2022. The first five questions of the questionnaire refer to demography data. The respondents come from five countries that partner in the YNSPEED project: 43% come from Serbia, 18% come from Romania, 10% from Spain, 10% from Cyprus, and 19% come from Poland. The majority of the respondents belong to the 20-25 age group, while 33.3% belong to the over 35 age group. Only 10% are between 26-35 years old. As for gender, 63.3% of the sample are female, and 36.7% are male.

The respondents' educational status was asked in question 4; 36.7% have a PhD degree or a pursuing one, 33.3% of them are currently in undergraduate studies, 16.7% have a Master's degree, and 13.3% have a Bachelor's degree. Finally, although they are all engaged as youth workers (working in formal on non-formal educational sector teaching young people), the respondents' occupations differed; 33.3% are full-time students teaching from time to time or as a part-time activity, 30% are university lecturers, 16.7% are teachers/educators/ practitioners, 10% are volunteers or NGO workers, and others chose not to reveal their occupation.

3. RESULTS

Section two of the scale was entitled 'Specific aspects related to online learning & MOOC'. The first two questions investigated whether the respondents have previously completed and/or designed a MOOC. As many as 73.3% of the respondents have never completed a MOOC, whereas 26.7% have completed a MOOC with/without a final certificate. 13.3% of the respondents have designed a MOOC before, and 86.7% have never designed a MOOC.

Question 3 (adapted from Driha et al.) was intended to explore the potential benefits of MOOCs for society in general (Table 1).

Table 1. *Benefits of MOOCs for society*

(3) Potential benefits of MOOCs for society. MOOCs will…	Std. Dev.	Mean
Benefit my personal development allowing me to better perform in my current job	1.06	4.10
Contribute to my personal improvement and leisure	1.09	4.10
Help me to develop skills for a new job	1.13	4.03
Benefit my future career	1.08	4.00
Facilitate new connections/networks	1.13	3.60
Not give any tangible benefit	1.01	4.26

The results imply that the respondents feel that MOOCs are not beneficial to society et large (M=4.26), but they believe MOOCs will influence the enhancement of both professional and personal skills and growth that will lead to a person's more meaningful career and a satisfying private life. These results are compliant with the results of [3], and are partly compliant with [4] who found that the respondents wish to explore various learning topics in and outside their programs of study (71.6), but also to fulfil their curiosity about learning (71.1%).

Question 4 was also borrowed from the Driha et al. BizMOOC questionnaire and is related to MOOCs expectations the participants would have if they enrolled on one. The results showcase (Table 2) that the participants expect to improve their digital skills, creativity and flexibility the most (M=4.3), then to 'Get low-cost or free opportunities for learning' (M=4.26), 'Encourage flexible thinking through innovative ways of learning', and finally to

'Obtain knowledge from a well-known institution from abroad for free' (M=4.20) respectively.

Table 2. *Expectations from MOOCs*

(4) MOOC expectations: To what extent do you have the following expectations towards a potential MOOC you would enrol? I expect it to allow me to…	Std. dev.	Mean
Get low-cost or free opportunities for learning	1.11	4.26
Have the most up-to-date information on a subject	0.99	4.10
Better understand a detailed aspect related to the subject	1.11	4.06
Obtain knowledge from a well-known institution from abroad for free	1.10	4.20
Provide a comprehensive overview of a specific subject from both academics and practitioners	1.01	3.86
Encourage flexible thinking through innovative ways of learning	1.03	4.20
Improve digital skills, creativity and flexibility	0.95	4.30

When compared to the responses given in the Driha et al. [3] research, the results are very similar. In the [3] sample, the answer with the highest score was 'Obtain knowledge from a well-known institution from abroad for free' (66.9%), followed by 'Have the most up-to-date information on a subject' (59.1%), and 'Better understand a detailed aspect related to the subject' (58.9%). Our findings are also in line with Tahiru [4] who found that 75.3% of the respondents said they would use MOOCs to broaden their understanding of their area of study. These imply that MOOCs are perceived as opportunities to improve skills or acquire knowledge from lecturers or universities which would otherwise be inaccessible and/or expensive. However, dissimilar to our finding that the most important expectation from a MOOC is enhancing digital skills and creativity, BIZ MOOC respondents scored the lowest for the statement 'Improve digital skills, creativity and flexibility' (41.3%). This might suggest that the discrepancy in the answer comes from the fact that the group of YNSPEED participants completed the training on MOOCs which might have influenced their responses here, in a way that they believe MOOCs significantly affect our soft skills. Another reason might be the size of the sample, and the context, so we must take into account that, unlike BizMOOC sample who belongs to a general population, our sample comprises formally educated youth workers who are engaged in education and training themselves.

Another remark has to be made here, and that is that similarly to [3], [4] found that about 76.3% of the respondents said they would explore the courses available in MOOCs that are related to their study after creating an account with a selected provider.

The fifth question was designed to explore which elements of the MOOCs the participants perceive as relevant to their personal development (Table 3).

Table 3. *MOOCs for personal development*

(5) MOOC´s elements most relevant for personal development are:	Std. Dev.	Mean
Gratis/for free	1.08	3.73
Complete online provision	1.05	3.73
Open licence to re-use parts of the course	1.13	4.03
A full/complete course experience	0.95	4.16
Certificate of competences	0.97	4.23
Assessed by anyone	1.14	3.73
Exchange in/improve foreign language skills	1.12	3.90
No entry qualifications needed	1.30	3.80
Intercultural exchange	1.17	3.80
Large numbers of participants	1.24	3.33

The response with the highest score was 'Certificates of competences' (M=4.23), while important aspects of MOOCs were also 'A full/complete course experience' (M=4.16) and 'Open licence to re-use parts of the course' (M=4.03). The 'Large numbers of participants' aspect was assessed as irrelevant and scored the lowest (M=3.33). Similarly to this, [4] also found that 71.1% of the respondents in their research wished to obtain more MOOC certificates.

Question 6 was composed to explore what are the important MOOCs aspects that make participants want to sign up for one as learners. The results (Table 4) reveal that the respondents feel that skills improvement (M=4.33) and knowledge of a particular topic (M=4.20) are the most vital aspects, whereas the least important motives to enrol on a MOOC are entertainment (M=3.33) and curiosity (M=3.76). Obtaining a certificate has a score of M=3.90 which is also of high (but not the highest) importance.

Table 4. *MOOCs' aspects useful for learners*

(6) How important are the following aspects when/if you decide to enrol on a MOOC/as a learner?	Std. dev.	Mean
Enhancing knowledge on particular topics	1.06	4.20
Skills improvement	1.03	4.33
Curiosity	1.10	3.76
Entertainment	1.24	3.33
Certificates	1.30	3.90
Hearing experts on the topic of my interest	1.10	4.23

Question 7 aimed at investigating a field preference if a potential MOOC was designed. As illustrated in Figure 1, 26.7% of the respondents would like to design a MOOC that would thematically deal with Professional skills development, and 23.3% believe that they would opt for an IT-related MOOC. Career development as a field of interest was selected by 20% of respondents, Language learning by 13.3%, and Hobbies and entertainment by 10%. Finally, Life hacks or self-help was chosen by only 6.7% of respondents. These results imply that almost 50% of the respondents place professional skills and career development above other fields, which they recognize as potentially attractive for students and/or they feel competent enough to design a MOOC that enhances those skills.

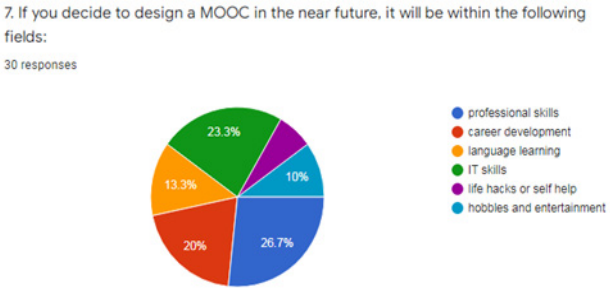

Figure 1. *Thematic area of the potential MOOCs to be designed*

Question 8 was related to the project participants as potential MOOC creators (Table 5). To the question 'If you decide to design a MOOC, how important are these for you to include', the respondents reported that, out of 4 options, implementing high-quality content is crucial (M=4.60), whereas earning money from a MOOC scored the lowest (M=3.16).

Table 5. *MOOC's aspects useful for designers*

(8) If you decide to design a MOOC, how important are these for you to include:	Std. dev.	Mean
To implement high-quality content	0.93	4.60
To make it massive/easily accessed	1.05	4.07
To promote your skills and expertise	1.36	3.87
To earn money	1.23	3.16

Finally, question 9 (Table 6) was designed to explore what prevents the respondents from designing a MOOC. The 'No time' response scored the highest (M=3.76), whereas 'No target group' scored the lowest (M= 2.33).

Table 6. *Reasons for not deciding to design a MOOC*

(9) To what extent do the following aspects prevent you from designing a MOOC?	Std. dev.	Mean
No IT knowledge	1.62	2.73
No knowledge of pedagogy/teacher education	1.57	2.40
No time	1.04	3.76
No target group	0.92	2.33
No idea what to do	1.17	2.43

4. CONCLUSIONS AND IMPLICATIONS FOR FURTHER RESEARCH

With the growth in the number of users of MOOCs (220 million users in 2021, excluding China) [2], educational opportunities within the field have been enhanced for both learners and course designers.

In this study, we investigated the readiness of youth workers from 5 countries to engage in MOOCs as learners or designers after they have completed a training program on MOOCs within the YNSPEED project. Interestingly, as many as 73.3% of the respondents have never completed a MOOC, and. After the MOOCs have been around for more than a decade now, it comes as a surprise that youth workers who are employed in the educational sector and are well-educated themselves, have not completed any of the MOOCs available on the market. One of the reasons might lie in the education pathway they undertook – as the majority of them have been university educated, it is likely that they still do not recognize the value of MOOCs, as compared to the more traditional educational instruction. That the assumption we argue here might be correct, there is evidence in their attitude that MOOCs cannot benefit society at large, but can rather enhance personal skills development and help build a career path regardless of the formal education a learner has previously acquired. In other words, MOOCs are perceived as an add-on to a completed formal education, as an enhancement that might bring additional benefits, but not the core value a traditional education brings to students.

Apart from improving digital literacy skills, youth workers feel that MOOCs should offer learners a full course experience with high-quality content from a renowned university from abroad, presumably at a lower cost, followed by a certificate. If they were to be engaged as MOOCs designers, these youth workers would create a MOOC that would be related to professional skills development or language learning. However, lack of time prevents them from engaging in MOOC design, and they also report that earning from a MOOC is not a necessity. The next stage of the research would be to investigate whether the participants of the project have

designed a MOOC or at least completed one, and to explore to what extent their attitudes towards MOOCs have changed.

The practical implications of this study suggest that MOOCs should remain in the realm of the non-formal, deliberately chosen educational practice, and especially implemented in programs or training that aim at developing professional and/or soft skills. Having in mind that MOOCs are regarded as useful only as long as they provide certificates and quality content that could be re-used by the students (and for free), we come to what MOOCs basically are: chunks of online instruction offered to the "masses", usually of inadequate level to suit the needs of learners. Although there is the overall tendency that MOOCs are perceived as beneficial, in order to increase the number of enrolled students, in the years that come MOOCs will have to offer much more than what they offer today. Maybe some of the youth workers involved in the YNSPEED project will change the market for MOOCs, by implementing new perspectives and fresh approaches to the field.

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Modern Educational Technologies in Professional Training of Student in Technical Institutes of Higher Education

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„Tell me a story about something and I will forget it.
Show me something and I will recollect it.
Let me do it and I will remember it."
Confucius

Abstract: *A new stage in the development of presentday society is evidenced in which modern technologies are an inseparable part in social experience hence the need of their application in instruction and training. New forms of providing education involve interactivity and collaboration in the process of learning. This work aims to demonstrate the authors' attitude toward contemporary educational technologies and their application in the professional training of students following engineering degree courses. Here we make a review of some modern educational technologies employed in professional training, which are separated into three groups: situational or problem-oriented situational, discussion-based and experimental-empirical methods. Here the application of one concrete method from each of the three groups is also demonstrated in the context of active training of students following degree courses in technical institutes of higher learning.*

Keywords: *modern educational technologies, professional training, students in technical degree courses*

1. INTRODUCTION

Some substantial changes in economy, science, culture and education took place over the last decade as a result of the progress made in technologies. A new stage in the development of present day society is evidenced in which new technologies have become an inseparable part of social experience hence the need of their application in instruction and training.

"Educational technologies" as a term refers not only to technical equipment which aid the process of teaching and learning, but also include pedagogically grounded decisions of choice; formation and application of a series of methods, techniques, forms and means of training, which provide achievement of assigned educational goals in accordance with the concrete educational medium and the specifics of trainees. The objective to be attained is to enhance effectiveness of both teaching and learning by means of educational technologies.

New forms of education are characterized by interactivity and collaboration in the process of training. Various approaches to defining educational technologies can be formulated as an agglomeration of methods for implementing syllabuses and curricula, which present a system of forms, methods and means of training that are instrumental in reaching educational goals. Variances in educational technologies are normally determined by the differences in applied educational means.

Variety in educational systems allows the strong aspects of education to be adapted to the formation of a renovated model, which will fully correspond to

modern conditions and the ever increasing competition in all aspects of life.

The aim of this work is to demonstrate the authors' attitude toward modern educational technologies and their application in the professional training of students in technical institutes of higher learning.

2. EXPOSTION

There are a number of opinions and concepts concerning the necessity of applying technologies in education with regard to both theoretical and practical aspects of pedagogy. According to one of them, the emphasis is laid on technology components in both processes of teaching and learning. Technologies, in this particular aspect, are regarded mostly as didactic and pedagogical means and aids. In this way some "technology-based" methodological systems are created such as audio-visual, computer-aided, communication, integrated, etc. Another view in this line is that technologies are related, most of all, with techniques, methods and forms of teaching: discussion-based, group work, teamwork, situational, role-play and some other.

Achieving higher efficiency in learning does not imply that mere application of technologies will guarantee increased interest in the input on behalf of students and trainees. Knowing the styles of learning is a firsthand necessity. In order to increase the variety of teaching strategies it is important for teachers to be not confined to their personal preferences, but also take into account those of their students. A large number of teaching styles are available, which reflect individual preferences to the ways of grasping and processing information, and structuring the learning environment; therefore, approaches to and methods of teaching should be of good variety. In this way dissatisfaction with learning, which oftentimes is motivated by the objective necessity for the individual student to conform to the style of perception and learning, will be overcome and prove favorable for the enhancement of his\her personal motivation.

Motivation is many-sided and variable; it is not a characteristic feature of personality rather it could be defined as the enabling force which shapes people's conduct over a certain period of time. In the context of education, it is one of the most widely used notions that underlies the structure and meaning of qualitative learning in modern educational institutions. The phenomenon of motivation can be defined as the inner impulse, drive or urge to act and make a personal commitment in the process of learning. Generally, it is described as internal state which stimulates, directs and sustains behavior by taking a prominent place in the structure of personality.

Interactive methods and interactivity, in general, as an approach in the course of learning, have their part of ever increasing importance in the process of study at all levels of education. The notion *interactivity* is a compound of *inter* (between, jointly) and *activity* (action, pro-activeness), which in the pedagogical context is interpreted as the interaction between instructor and trainee or the interaction between trainees for the purpose of achieving specific educational objective. According to Ivanov, interactivity could be regarded in two aspects: as a process and as a product. Interactivity regarded as a process implies interaction with another person in verbal or some other physical way whereas, if regarded as a product, it could be defined as "characteristics of the consumer – system or consumer – document, which in some instances is referred to as 'quasi interaction"(Bretz). Very often "interactivity" designates interaction with computer or some other technical system. [1, pp. 209). Interactivity occurs in the so called "interactive system of learning" which is a combination of numerous study situations, whereby various types of knowledge and information are exchanged between participants in the learning process. There are two such systems: one of them is "people oriented" and is based on the interaction between the subjects in the process of learning; the other is known as "technology-based system of learning" and comprises the interaction taking place between learners and technical aids [2, pp. 39-40]. In the age of high tech structures and resources, the interaction type "learner – information technologies" appears to be a major prerequisite for quality knowledge and skills.

Within the context of the process of learning and taking into account the specifics of professional training, we can note several types of highly effective interactive methods which may be divided into **three major groups**. [3]

3. METHOD

One of the groups includes the so called ***situational or problem-situational methods.*** Their special feature in the course of learning is the remake of situations, which are close to real life, for the purpose of using the experience of the trainees| learners| in solving a certain problem. Problem-situational methods create favorable environment for development of analytical capabilities and finding adequate solutions to real practical problems. The group of situational methods includes a solution to a case study, or course project in particular. Said case study presents concrete information which is connected with various aspects of reality such as social environment, social problems, interpersonal relations and so on. Normally, it is about some conflicts, controversies or challenges. Participants

are assigned the task to analyze the information by drawing upon the experience and knowledge they have gained so far, then make assessment of and find out a solution to the concrete problem. Case studies can be on decision making, evaluation, investigation or others. A good example of finding case study solution is the course project in the subject of "Technology oriented design" which is part of a Master's degree course program. Here the task is to review a draft design of a switch, find out its errors and weak points with regard to design workability and make workability assessment. Fig.2 illustrates the so called mixed type design of switch breaker (featuring 6 contacts in 2 parts and secured position of switching for the actuating cam). In addition to plastic made parts (a, b), the washers cut out from hard cardboard (c,d) plus the large quantity of metal parts, increase the production cost and make the unit assembly cumbersome. Weak points of this design are the many spots for setting which reduces accuracy; three-positional bearing around the axis of parts in the securing bolts 2; expensive tools for the plastic parts, large amount of work needed for adjustment and tightening, a good number of parts and unreliable switching-on. The task is to make proper changes in design. Three alternatives for change have been proposed concerning the submitted design.

Alternative I: Replacement of free bearing support with two point bearing support; centering stopper on the lid for the purpose of easier assembly, simplification of contact springs fixation; simplified parts made by means of pressing; cheaper tools for manufacturing; greater strength of the body design which eliminates the need of fixation elements; enhanced possibility for more precise assembly.

Alternative II: Excessive use of plastic made parts; cleaning of cam; adjustment of intermediate plot B ; replacement of assembly screws with tubes made of hard card to envelop the body, which will provide greater stability; rolls are replaced with simplified small steel balls. Still remaining weak points: too many threads in the plastic parts (18 screws and 18 thread holes), free bearing support in the nested metal bearing socket, which is made by automatic turning; the cam disc is moved toward the axis for no particular reason; assembly takes too long time.

Alternative III: Axial bearing in the cover and body wrapping; plastic parts tied together in the slot opening with the bottom part, which supports the contacts by means of fixation bolts and nuts. The axle is situated on the switching cam. Threads for fixation of contacts are eliminated by making use of molded sockets to counter unscrewing of nuts 'b' which lie in the direction of molding. Easier assembly with no use of threads and free access for the tool securing fixation bolts. Molded centering core for enabling simultaneous switch-on of all six contacts.

Conclusion: Alternative III is the most appropriate.

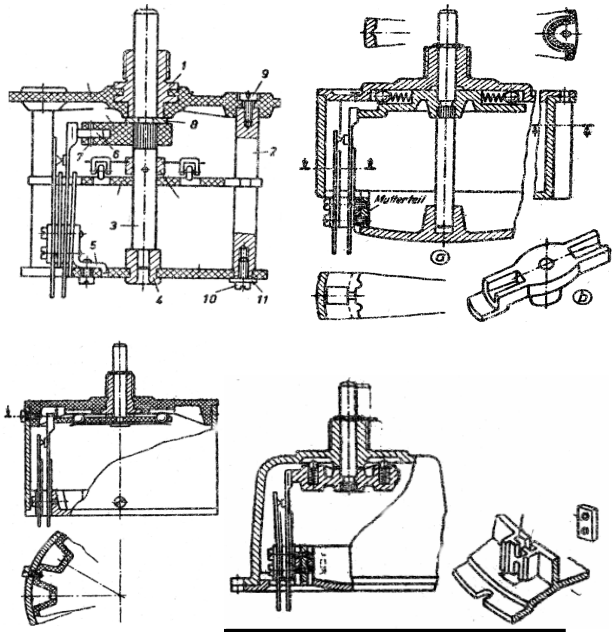

Figure 2. *Design of mixed type: Alternatives I, II, III [4]*

Tests also pertain to this group. An example of such a test, containing 55 questions and 21 tasks plus another 30 questions for the purpose of self-preparation in the subject of "Micro and nanotechnology, has been developed and presented in [5].

The second group of interactive methods are the so called ***discussion-based methods.*** They, too, are based on the interaction between participants in the process of learning and most often are reduced to discussing different issues and problems. Opinions are shared for the purpose of making proposals, decisions and expression of points based on mutual consent between participants in the discussion. Another example of developing different solutions and their subsequent incorporation into learning is presented in [6]. Discussions held are presented in [7, 8].

Another popular discussion-based method is the so called ***brain storming*** which was initially created in the 1940ies and further developed in 1953 by Alex Osborne in his book 'Applied Imagination'. It is a method for stimulating individual creative thinking in learners whereby a collective solution to a problem related to creativity is found by means of mutual consent on behalf of participants. Brainstorming and its varieties (straight and reverse brainstorming plus combination of the two) appear to be a very useful way of stimulating learners for more creativity, generating of genuine ideas and their blending into effective solutions [9]. Reverse brainstorming aims specifically at finding out flaws in products and their ensuing elimination. Outcomes are forwarded to experts or managers for assessment and selection of promising, functional proposals. This in turn develops in

students skills for teamwork, critical analysis and builds self-confidence and capacity for financial management. Learners opt on real technical tasks or those belonging to everyday life and participate in didactic games. Examples of such training, in which the author of this paper participated, are the classes in Methodology of practical development included in the program of "Precision Engineering Technology" that is taught at the Technical University of Darmstadt, Germany. Assigned tasks in which direct brainstorming is applied are on developing domestic products such as nutcrackers, robots for didactic games in football, basketball, climbing as well as assignments on industrial introduction: self-adjusting driver's seat in conformity with the size of the driver and many other. Example of reverse brainstorming is the preparation of expert assessment of machinability in the subject "Technology-oriented design" taught in the Master degree courses of "Mechanical Engineering' and "Mechatronics".

The third group includes the so called ***empirical methods.*** One of the most widely applied among them is known as ***project work***. |Implementation of research projects helps students to work out their individual intellectual and formal autonomy and build their practical background as well. In doing this they are supposed to go through the following three stages:

- *Cognitive* – constructing the content of educational activity, the process of realization and awareness of the tendencies in the development of the educational/academic degree "Insights into future".
- *Managerial* – orientation toward the set target, planning and control over the process of achieving the goal.
- *Developing* – forecasting processes, formation of personal skills of social importance and support of individuality; qualitative change in both subjects and objects; arising of new forms, innovations and novelties; transformation of their internal and external relations.
- *Sustaining culture* – planning of ways for reproduction and development of culture; selection of culture-oriented content and remake of cultural samples and norms, aiming at education of young people.
- *Motivational* – development of inner and outer motivation for active participation in the process of learning based on important and interesting information on culture, tradition, history and language of the country whose language is being learnt.
- *Informative-educational* – realization of such methods of instruction as demonstration, explanation, investigation of facts, events and processes.
- *Heuristic* – orientation toward individual discovery of what is new, based on the previous experience of learners and directing them to active cognitive activity. Development of control programs and tuning of CNC machines.
- *Control* – implements current and stage by stage monitoring.
- *Reflex and assessing* – determining the level of acquisition of knowledge, skills and habits in the process of project realization and in accordance with program requirements.
- *Communicative* – the project aims at developing communicative competence of learners. Communicative competence implies the ability of future specialist to live among other people plus the ability to interact, be part of a team, and collaborate in achieving mutual understanding. In essence communicative function and its major point is in getting ready to be involved in an optimal interactive system, which operates bet-ween individual units and participants and also interacts with external structures [3].

The project-based method is an approach to learning which adds further dimension to traditional methods and, in addition, allows to be used at all levels, ages and capabilities of the learners. Instruction in the subjects "Mechanical and precision engineering technology" and Technology of mechatronic systems" requires that students in the degree courses of "Mechatronics", "Mechanical and precision engineering" and "Environmental protection engineering" should develop a project on "Design of technology processes in manufacturing parts; assembly technology, adjusting and tests of devices and machines". This course project includes two work-pieces which are machined with and without chip removal plus developing a device for the first machined part and a tool for the second one. Here is provided and example of machining of a part belonging to the group "Axles and shafts". The manufacturing technology process for machining of a shaft is as follows:

1. Positioning to contact.
2. Outer planning.
3. Drilling of hole with bit φ 7, 8 position 2 of revolving head.
4. Core-drilling of φ 8, 8 at position 3 of revolving head.
5. Finishing external turning at position 4 of φ27,5.

6. Finishing external turning at position 5 of φ 23.

7. Chamfering and face turning of the step at position 6 plus profile machining with reach over carriage 2.

8. Making chute and chamfer with tools fixed on reach over carriage 3 and 4.

9. Cutting with tool 5 on reach over transition 4.

Work technology process for machining of exemplary part for serial production is presented on Fig.3 [7]. Methodological instructions on the project are given in [8].

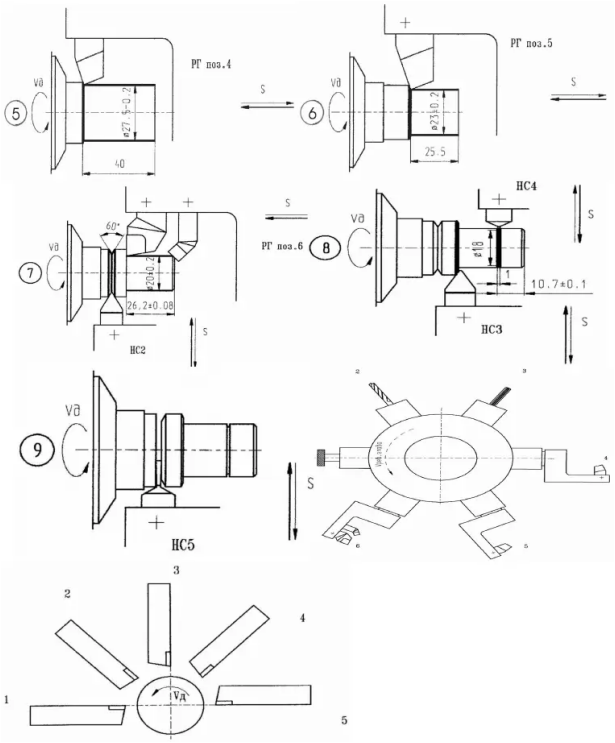

Figure 3. *Work technology process for machining of shaft*

Multimedia presentations are of particular importance in the system of modern methods and forms of instruction. Using them during instruction in professional subjects has gradually turned their application into a method of organizing active, creative teamwork of students, which facilitates acquisition of knowledge by making the entire process more interesting. Presentations allow for the teaching input to be perceived as a system of memorable images that contain exhaustive and well-structured information. This method is close to electronic instruction and is applied in distant learning. Unique in their resources, multimedia presentations make up a genuine model of activeness and pro-activeness in individuals thus enabling them to form skills for collecting, processing and presenting information by novel interactive methods. Students' individual performance in presenting a new product before an audience consisting of their colleagues will have a serious effect. Similarly, it can change their motivation for work; something which is valid especially for students who do not seem quite interested in the taught subject. A proper example of that is the project for multimedia instruction in the subject of "Technology of mechanical and precision engineering" Technical University of Gabrovo, Bulgaria [10, 11, 12]. The European Dual Research and Education – EUDURO project was developed over the period 2015-17 in joint partnership with participants from the University of Wismar, Germany. A model of instruction in engineering subjects taught in technical degree courses at TU-Gabrovo is presented in [13]. A summary of the applied modern educational technologies in professional training of students, following degree courses included in the professional trend of "Mechanical engineering technology" in Technical Institutes of Higher Learning, is given in [14].

4. CONCLUSION

In closing it can be said that:

1. Interactive methods set the participants in a mode of continuous discussion thereby allowing for expression of personal opinion, and suppose available usage of constant feedback.
2. Interactive methods enable participants to construct behavioral strategies. They also are a natural form of work due to the necessity of alternative interaction between teacher and student; of conducting dialogues, and developing interactions based upon group activities.
3. By applying these methods along with the rules of group work, we establish a model of dialogue that is different in terms of quality, and of interaction between teacher and student that contributes to the personality development in young people.

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Augmented and Virtual Reality in Education

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Abstract: *Technological advances have enabled the sustainability and desirability of augmented and virtual reality in many domains. When it comes to their application in education, it should be noted that they provide new models of learning that better meet the needs of modern society. The paper presents an overview of previous research on augmented and virtual reality in education. By reviewing and analyzing related works, relevant results were obtained on the application, benefits, and impact of augmented and virtual reality on the educational process. The paper aims to examine the importance of introducing augmented and virtual reality in education based on the analysis of the results of previous research and to present the reasons for the justification of their application, which will become a reality shortly.*

Keywords: *augmented reality; virtual reality; education*

1. INTRODUCTION

Augmented reality and virtual reality are modern technologies that are developing rapidly. While augmented reality is a technology that offers reality modified by computer-generated data, virtual reality is designed to replace reality with simulated data of various kinds. Their educational potential should be used to transform teaching methods and learning styles.

Virtual reality is defined as a set of technologies used to synthesize an authentic set of visual, auditory, tactile, and other sensory experiences, to provide the illusion that virtually non-existent things defined and stored only in computer memory can be seen, heard, touched, and felt some other way. This creates an interactive interface between man and virtual worlds. On the other hand, augmented reality means the real world that is expanded by computer-generated data and objects. This technology allows computer virtual images to accurately capture real-world physical objects [1].

Public interest in virtual and augmented reality is growing in both the business and social worlds. Although the concept of these technologies is not up to date, they have not yet become something that is known to everyone and has mass use. In many more developed countries, the benefits of these technologies are used in various fields such as tourism, industry, architecture, construction, military, and medicine. However, the existence of a large number of papers suggests that education is one of the most promising areas for the use of augmented and virtual reality technologies, which is one of the motives for writing the paper.

2. LITERATURE REVIEW

Although the interest in augmented and virtual reality in education has been current for many years, not much research is available that combines these two technologies. Based on the review and detailed analysis of the available literature, several relevant recent papers in this field have been singled out.

In the paper entitled "Application of virtual and augmented reality technology in education", the authors Mitrović K., Jakšić A., Ćuričić J., Bogojević B., and Gračanin D. analyze the potentials of virtual and augmented reality in education. As a result of their research, the authors cite the growing application of virtual and augmented reality technologies in education and recommend measures to improve the educational process using these technologies [1]. Elmqaddem N. author of "Augmented Reality and Virtual Reality in Education. Myth or Reality?" talks about the reasons for the increase in the use of augmented and virtual reality in education. He also states why the application of augmented and virtual reality in education is one of the ways to improve teaching and learning, as well as why they are more suitable for 21st-century students [2]. In the paper entitled "Virtual and Augmented Reality in Education", the authors Gudoniene D. and Rutkauskiene D. present a model for the development of integrated learning objects, based on the approach of virtual and augmented reality that can be integrated into other educational content. The paper presents a review of the literature on virtual and augmented reality and provides an analysis of integrated models for the implementation of the educational process [3].

Authors Daniela L. and Lytras M. talk about the transformations in the learning process that occur due to the application of augmented and virtual reality technologies in education in the paper entitled "Editorial: themed issue on enhanced educational experience in virtual and augmented reality" [4]. The author Siegle D. in his paper entitled "Seeing Is Believing: Using Virtual and Augmented Reality to Enhance Student Learning" presents the results of the application of virtual and augmented reality and highlights the many benefits of creating interesting and interactive content that enhances the learning process [5]. Empirical research comparing virtual and augmented reality technologies depending on their impact on learning outcomes is presented in the paper "Augmented Versus Virtual Reality in Education: An Exploratory Study Examining Science Knowledge Retention When Using Augmented Reality / Virtual Reality Mobile Applications". The authors of this paper, Huang K. T., Ball C., Francis J., Ratan R., Boumis J., and Fordham J., conducted research using a mobile application through which digital content was presented to students using both technologies, and then an analysis of the technology provided better results in terms of the adoption of the presented content [6]. The possibilities of applying augmented and virtual reality in collaborative learning is presented in the paper "A Review on Collaborative Learning Environment across Virtual and Augmented Reality Technology" by Wanis I. A. and Nur Affendy N. M. [7].

When it comes to the application of virtual and augmented reality in primary education, works with significant research results can be singled out: "Comparative evaluation of virtual and augmented reality for teaching mathematics in primary education" by Demitriadou E., Stavroulia, KE. and Lanitis, A. [8] and "Challenges and Prospects of Virtual Reality and Augmented Reality Utilization among Primary School Teachers: A Developing CountryPerspective" by Alalwan N., Cheng L.K., Al-Samarraie H., Yousef R., Ibrahim Alzahrani A and Sarsam S.M. [9].

Most related research relates to the application of augmented and virtual reality in higher education. Some of them that will be the subject of analysis in the part of the paper related to results and discussion are: "Experiential learning through Virtual and Augmented Reality in Higher Education" by Jantjies M., Moodley T. and Maart R. [10], "Use of Augmented and Virtual Reality in Remote Higher education: A Systematic Umbrella Review" by Nesenbergs K., Abolins V., Orman is J. and Mednis A. [11], "Virtual and augmented reality effects on K-12, higher and tertiary education students' twenty-first-century skills "by Papanastasiou G., Drigas A., Skianis C., Lytras M., Papanastasiou E. [12], and" Augment reality and virtual reality for the improvement of spatial competencies in Physical Education "by Gómez-García M., Trujillo-Torres J., Aznar-Díaz I., and Cáceres-Reche M. [13].

3. RESEARCH METHODOLOGY

3.1. Subject and goal of the research

A review and analysis of existing research on augmented and virtual reality in education is the subject of research. The systematic search of the e-repository aims to obtain as much published research literature relevant to the field of research, and then perform their analysis and present the research results.

The research aims to systematically review and analyze the published relevant literature to examine the application of augmented and virtual reality in education, point out the importance of introducing these technologies and present the reasons for their justification. By the set goal of the research, it is possible to single out the following research questions:

- What is the time distribution of published papers dealing with the research of the application of augmented and virtual reality in education?
- What do previous studies on the application of augmented and virtual reality in education show?
- What are the advantages of augmented and virtual reality in education based on the relevant literature included in the research?

3.2 Search process and selection of relevant literature

The paper uses the method of a systematic search of electronic databases. Namely, three e-repositories "ScienceDirect", "Google Scholar" and "ResearchGate" were selected and the relevant literature was searched. During the search, the criteria were set for the works to be published in the period from 2017 to 2021, while the query used for the search was formed by entering the keywords "Augmented Reality and Virtual Reality", "AR and VR", and "augmented and virtual reality". By reviewing the obtained search results, the selection of those papers related to education was made.

The primary search of the e-repository yielded 42 results. After excluding duplicates, there were 36 left. To answer the research questions, the suitability of the obtained results was examined according to the following criteria:

- availability of work in full in English or Serbian,
- review papers on augmented and virtual reality in education,
- works on the application of augmented and virtual reality in education.

During the examination of the suitability of the obtained results according to the given criteria, 29 papers were excluded.

4. RESULTS AND DISCUSSION

The process of searching and selecting relevant literature shows that a lot of research has been done on augmented and virtual reality in education. Although the earliest research on the introduction of the mentioned technologies in education was divided, the newer ones testify to the numerous advantages of their application. Also, what can be concluded based on a systematic review and analysis of previous research is that augmented and virtual reality are technologies that reach maturity, as evidenced by the growing number of areas in which they are applied. Based on the review and analysis of previous research, the answers to the research questions will be explained through the results and discussion.

In response to the first research question "What is the time distribution of published papers examining the application of augmented and virtual reality in education?", A tabular overview of papers included in the research classified according to the year of publication was created (Table 1).

Table 1. *Papers included in the research by years of publication*

Year of publication	Review of papers
2017.	[17] [21] [22] [28]
2018.	[10] [13] [19]
2019.	[2] [3] [4] [5] [6] [7] [12] [15] [20] [24] [26] [27]
2020.	[1] [8] [9] [11] [14] [16] [18] [25]
2021.	[23]

The obtained search results from the previously mentioned e-repositories show that most of the papers were published during 2019, and it can be concluded that at that time there was the greatest interest in the field of research. The number of published papers is decreasing in 2020, while in the current 2021 only one paper was published. During the process of searching and selecting relevant literature, following the selected selection criteria, it was noticed that in several recent works there is a separation of augmented and virtual reality technologies, ie, authors prefer to research the application of one of these technologies. Consistent with this observation, future research should be limited to research on one of these technologies.

The answer to the second research question: "What do previous researches on the application of augmented and virtual reality in education show?", required a review and detailed analysis of works based on which they were categorized depending on the degree and field of education. The categorization includes only those words that describe the application of augmented and virtual reality in education in whole or in part. Figure 1 presents the percentage of selected works by the level of education, while Figure 2 presents the share of selected works by field of education.

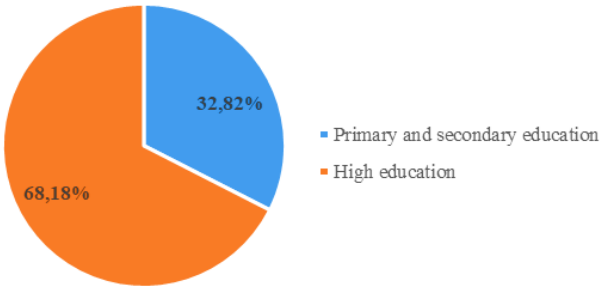

Figure 1. *Share of selected references by the level of education*

The categorization of papers according to the level of education shows that there is a much larger number of published papers on the application of augmented and virtual reality in higher education, compared to primary and secondary. As the papers mainly present the real results of research conducted in various higher education institutions around the world, it can be concluded that the application of augmented and virtual reality technologies is more prevalent in higher education.

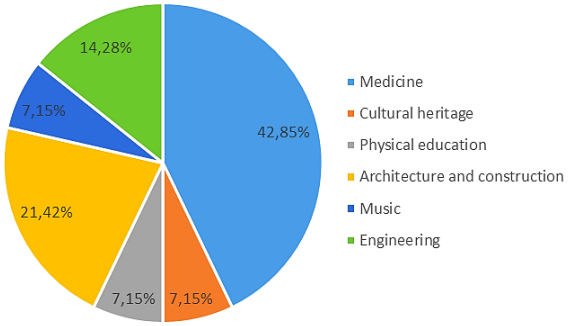

Figure 2. *Share of selected references by field of education*

The categorization of works according to the field of education shows that in terms of the application of augmented and virtual reality in education, the field of medicine is the most researched. As for other areas of education, the results show that there is a much smaller number of published papers, however, as the papers are mostly more recent, an increase in interest in research in other areas of education can be expected.

The third research question: "What advantages of augmented and virtual reality in education can be distinguished based on relevant literature included in the research?", requires a synthesis of the advantages presented in the works covered by the research. Based on the relevant literature included in the research, the most significant advantages of augmented and virtual reality are:

- The ability of virtual reality technology to offer immersive alternative reality, while augmented reality technology can upgrade existing reality so that the physical world and all accompanying

real and virtual objects are perceived as existing in the same place [27];

- Improving literacy in the digital age, creative thinking, communication, collaboration, and problem-solving [11];
- Improving traditional curricula to meet different learning needs of students [11];
- Enabling new types of learning through practical experience in different educational fields, using augmented and virtual reality technologies to simulate such learning environments [17];
- Promoting decision-making when interacting in a virtual environment, providing independence in researching and understanding complex concepts [1];
- Ability to adopt a system of collaboration in different applications that allow multiple users to work together in one common space and task [7].

5. CONCLUSION

The purpose of the review paper is to present the author's approach and examples of the application of augmented and virtual reality in education. A brief, representative overview of published papers is given, to examine the possibility, advantages, and impact of the application of virtual and augmented reality technologies in education. Examining and analyzing papers published in this field, it is concluded that there are promising results that indicate that the application of augmented and virtual reality technology improves learning outcomes and brings many benefits to various fields of education. Also, it was noticed that in future research it is necessary to separate these technologies and investigate their individual potentials in education.

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Online tools for new teaching concepts and new teaching conditions

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Abstract: *Technology is today engaging students from all levels of education in a ways that older generations thought of as the distant future. This paper provides a theoretical clarification of the concepts of e-learning and online learning, provides an overview of their application through all levels of education in Serbia, and presents the role of these systems in modern education. Also, the paper presents the most commonly used platforms and tools for e-learning with the recommendations of possible areas of their usage.*

Keywords: *e-learning, online learning, online tools for education, LMS*

1. INTRODUCTION

Young people and children grow up in a media environment, which is a significant challenge and (development) task for themselves, their parents and education system. The education system today has a very complex role to play: it has to develop basic knowledge from one subject area, but to teach students how to trace the role of that area in the world's development, to teach them how to interconnect with all the people that have similar area of interest and to do that using modern technology. Another world said, the education system has a role to teach young people how to become the citizens of the world in 21th century. This is a very demanding task because young people are growing with technology that can easily take all their attention in none desired direction and education system must find a way how to teach on interesting and inspirational way.

Information technologies, as a part of our lives, are constantly changing the way we live, work, think [12].

The development of the global network, as well as computer technology, have contributed to the creation of new ways of learning and the one among them is distance learning (distance learning, e-learning). Computer-assisted learning, distance learning, virtual and WEB classrooms are part of the terminology used to describe e-learning systems. It is not necessary to be online to talk about e-learning. Distance education does not necessarily imply the use of modern information and communication technologies (ICT), while this is the case with electronic education (and communication by mail is a form of distance learning). E-learning is about the use of computers, the Internet, mobile devices for exchanging information.

E-learning is a convenient and most commonly used way to implement distance education, and can be used as a supplement to classical education. Distance education is a field of education that focuses on learning methods and technology in order to transfer knowledge through them, usually individually, to students who are not physically present in traditional educational institutions, such as school or classroom, or near teachers.

2. DISTANCE LEARNING, E-LEARNING AND ONLINE LEARNING

When talking about distance learning, the following terms are often used: Distance Learning, Distance Training, Distance Education, e-learning (E-Learning, e-Learning), Online Education, Virtual Instruction, Virtual Education, Virtual Classrooms, Electronic Classroom, Blended Learning, etc.

Understanding these terms as synonyms is not accidental. Common for all terms is that they assume a learning process in which the source of knowledge and the recipient are physically distant and in which their relationship is mediated by the use of ICT, and individually depict the nuance of options within the distance learning process.

E-learning can be defined as the process of transferring knowledge and skills electronically with the use of appropriate computer applications, ie., dedicated programs, and learning environments. These applications and processes include learning via the web, computers, digital classrooms, and content is transmitted over the internet, intranet / extranet, audio and video tapes, satellite television.

The basic definition of e-learning is that*... the use of multimedia and the Internet to improve the quality of learning - by providing access to remote resources and services and by enabling distance communication and collaboration*." (E-learning Strategy Task Force, [28]). E-learning is a kind of communication channel, a channel through which learning takes place, like face-to-face communication, like print or phone, like TV and audio -video system. ("E-learning's greatest hits," Clive Shepherd, [29]).

In the European Community, the e-learning Action Plan defines e-learning as "the use of new multimedia technology and the internet to demonstrate the quality of learning through easier access to aids and advice, as well as distance learning and collaboration."

Distance learning originated long before we first thought. Of course, not in the form in which we know and use it today, but it had the same role - to overcome physical distance for the sake of transmitting knowledge.

The pioneer of Distance Learning was Isaac Pitman, a shorthand teacher. He applied distance learning in his work with his students for the first time in 1840 in England. He sent assignments by mail to students, and they returned the works done to him, for the reviews. In 1858, the University of London decided that students could take exams without physical presence [22]. It was the first distance learning, primarily aimed for marginalized groups, such as women, who had limited access to educational content.

At the beginning of its development, distance learning was primarily based on using the postal system, providing the possibility of education to people who were prevented from attending classes in classical schools. Thus, the first stage of the development of distance learning was in fact correspondence learning.

Pioneer in institutionalizing this type of education was the University of South Africa, which introduced Correspondence Education courses before 1946. The largest Distance Education University in the UK, Open University, has existed since 1969. A similar one was opened in Germany in 1974, Fern Universitat in Hagen.

Today, there are more than 90 institutions around the world, most often called Open University, in English or translated into local languages and modeled on the long-established Open University of England principles, which primarily emphasize the importance of distance learning [21].

Unlike correspondence education, where the interaction between students and teachers took place mostly in one direction (teacher - student), in the online environment there are several types of interaction. In the interaction are involved: students, online interactive communication system, educational content (teaching materials), mentors /teachers. These interactions form the basis for the development of collaborative learning, which promotes learning in the online environment [11].

Information technology is an integrated part of higher education. Between 1970 and 2000, the demands of students and teachers for greater flexibility changed conditions in the learning and teaching process [14],[1].

Ratio between received and adopted knowledge is a question over all questions during whole education history. This is a very important issue and giving appropriate answer require deep analysis. In the relevant literature, numerous studies compare student achievements of traditional and online learning and teaching. Some research shows that online learners are better students while others suggest that there are no differences between study models [13].

But, in addition to the previous noted results from researches, it is important to take care about necessary knowledge and abilities associated with the performance of a specific job. Developed competencies also include adequate, moral behavior of an individual in a narrower and wider social context enriched by modern information and communication technology [21]. Information and communication, and especially Internet technology, nowadays have a strong influence on changing the economic structure of both the national and the world economy. Different information technologies and communication are closely related [10]. Receiving knowledge today deeply depend of teacher's/trainer's ICT skills. The implementation of education in the workplace is increasingly implemented with the help of information and communication technology for learning [3]. Today's teacher must be deeper involved in development of ICT. A quality teacher must master modern technology and must continuously work on himself.

On the other hand, books and textbooks used to be the main and most important source of knowledge, and today equally valuable content can be found in various sources of knowledge on the Internet. The content on the Internet is very comprehensive and available to everyone, so it is very important for users to know how to evaluate it and correctly choose sources of knowledge that have been checked [18].

3. TECHNOLOGIES FOR ONLINE LEARNING

Although we live in an advanced information age where the speed of the Internet and telecommunication networks (4G and 5G) are more than sufficient, many have found themselves unprepared by the great demand for online learning and teaching, created by the Covid19 pandemic. During the lockdown and virtual lectures, a large number of systems could not accept a large number

of users (students), blockages occurred. The system could not accept everyone turning on the video at the same time, chat messages were delayed, sound was blocked, etc. [8]. Some old questions surfaced us and the main is IT infrastructure.

Numerous new perspectives and opportunities are lighten up since 2020, within them and the usage of internet in educational process, as the internet, has already proven itself as an exceptional tool in science and education [8]. The application of ICT in education includes, among others, the individual learning and teaching, practice and revision, group learning and teaching, e-mail communication (student, teacher, parent), some pedagogical documentation, administrative work and much more [11].

Among most emphasized benefits from learning in online environment belongs increasing interactivity between participants, where we have interactions among [19]:

- Student/online interactive system,
- Student/educational content,
- Student/student,
- Student/mentor (teacher/trainer) [11].

The other most cited benefits are:

- more effective visualization of contents,
- better communication between students and mentors,
- effeciveness of time usage (there is no need to travel),
- easier revision of materials (teacher's and student's),
- one-to-one approach etc.

In this way of learning, part-time students are more motivated and they accive better results then in live model of teaching [4].This can be explained with the fact that in online learning they have specialy defined termins for lectures that are adapted to their working time [9].

The structure of four areas of ICT usage that influence on digital literacy achievement is shown on Fig. 1 [17].

The main noted obstacles in online learnings evidented in the literature are:

- high level of frustration,
- declain of satisfaction,
- frustration caused by technical problems,
- lower level of interaction with mentors,
- lot of emails and interactions on online platforms [7].

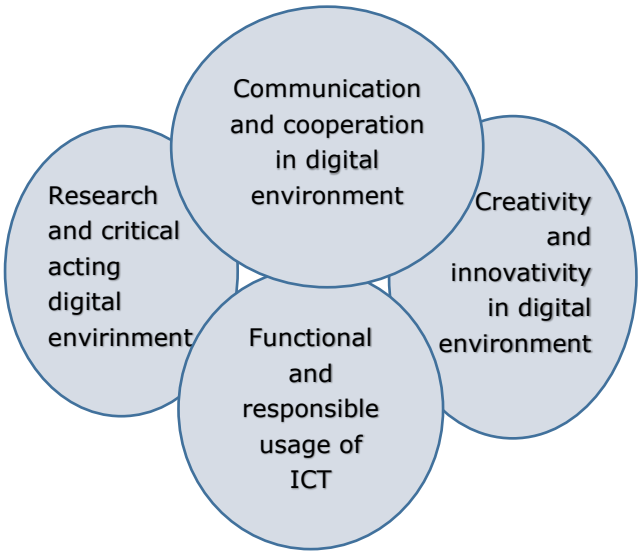

Figure 1. *The structure of cross-curricular topics in the use of information and communication technologies*

In all disscusions about IT, it is important to think about all good and bad sides of IT usage, so the innovation direction in the area of IT could be lead in a proper way. It is very important to emphasize that all ecologycal dimensions must be taken into consideration when debating about IT and online learning [15].

4. THE MOST POPULAR SYSTEMS FOR ONLINE LEARNING

The role of all educational systems today is, to prepare young workers to become citizens and workers of the 21 century. Tools on the network like as: Zoom, Teams, Skype, Moodle, Google Hangouts etc. are well known among wider population. Most popular tools are Zoom and Microsoft Teams. Their main comparative characteristics are given in the table 1.

For education system the especially interesting are Learning Management Systems (LMS). LMS is a software system that is designed to contain in one place everything that teachers and students need for online learning [23].This system of learning can be used independently or in combination with traditional way of learning (blended learning).

Most LMSs are web-based, to facilitate access to learning content and administration. They are used for training in industry (financial services), in educational institutions as support for classical lectures in classrooms or for offering courses to the general population.

Table 1: The comparison between Zoom and MT

TOOL	Zoom	Microsoft Teams
Usage	Easy, free of charge	Complicated, free of charge
Message exchange	Yes	Yes
Audio/video call	Yes	Yes
Files exchange	Yes	Yes
Group call	Yes	Yes
Screen sharing	Yes	Yes
Data protection	Bad – in the development phase	Good

LMSs are developed on different development platforms (Java/J2EE architecture, Microsoft.NET, PHP), and usually use a database at their *"back"* end. Some systems are commercial, do not have a free license or access to the source code is limited, while others are free, open source, and have a wider application.

Platforms for the creation and delivery of WWW program support for learning began to develop since 1996. All the necessary tools for implementing the "WWW class" are combined: creation and delivery of learning content, quizzes and tests, communication, student data recording.

Platforms allow storing learning content, providing additional information needed for learning, and can give information to participant in various ways.

Functions are divided into two groups:

1. the administrative and
2. the teaching.

In most cases, they have two interfaces (based on roles in education processes):

1. author's - serves for teachers who generate content and
2. user's - for students.

The entrance to the platform is in the form of a portal.

The administrative functions of the LMS include all data records necessary for the functioning of the platform, which are not specifically related to the processes of knowledge transfer:

1. records of subjects and users of the platform (students, teachers),
2. user registration for courses (subjects),
3. creation of permissions and user groups,
4. reporting on class attendance, progress, status and learning results, i
5. support for the creation of teaching materials

The most important teaching functions of the LMS are:

- organization of learning content - in the form of lessons and modules,
- navigation – sequence of learning content in a specific order, visual aid (buttons of a standardized design),
- knowledge check - usually through tests and quizzes for (self) checking of students' knowledge,
- computer communication - allows students and teachers mutual communication that can be private and public, synchronous and asynchronous,
- authoring tools - not all parts offer a complete authoring environment, but they still have the ability to save learning content on the WWW server and link them, and create tests and discussions.

The advantages of LMS are:

1. represent more "economic" knowledge transfer,
2. teaching has been technologically improved, and materials and activities are more accessible to students,
3. it still supports the classical model of learning in a class or group,
4. students are grouped, they start learning at the same time,
5. periodically receive materials and all are expected to complete the tasks at the same time (within the class or planned implementation time),
6. can be used as a supplement to classroom teaching and in mixed model of e-education.

4.1 Moodle LMS

The most popular and mostly used LMS on Western Balkans is Moodle. Moodle is an acronym for Modular Object-Oriented Dynamic Learning Environment. The application is used for creating and maintaining online courses via the Internet and distance learning. There is a large number of users of the application (more than 150 thousand registered users) due to excellent documentation and support.

Moodle is an open source project in which users can view the source code, with the possibility of changing the application and adapting it to their own needs. Although it is protected, users are allowed to use, copy and modify the code, if they allow others to use the code under equal conditions, the original license and protection are not changed and the same license is applied to any other work that comes from Moodle. The application can be downloaded for free from the

official Moodle website. As a web-based platform, it allows access from any location in the world and only requires a device with internet access. The default interface enables compatibility with mobile devices, different web browsers and different operating systems. One of the advantages is the existence of the Moodle community (https://moodle.org) which serves for information, discussions and cooperation between Moodle users (administrators, lecturers, researchers, instructional designers and programmers).

The main Moodle features are [16]:

- the creation of a large number of courses,
- the course planning - schedule of activities, calendar,
- the management of users, user roles and user groups on the course,
- the work with already existing files and educational contents,
- checking knowledge and evaluating users,
- monitoring of user activities,
- the numerous tools for communication and collaboration between users,
- the application management – backups, statistics, logs,
- help for users.

Moodle allows constructive approach to learning, because:

• Moodle philosophy" is socially constructive - students learn best if they interact with the learning material, create new material with other students and have a dialogue with them,

• Moodle has interactive and static elements on the Moodle course.

Roles on the Moodle system represent levels of editorial rights, that is, each role has certain authorizations and restrictions on work (except for the administrator role). There are several roles: manager, course creator, lecturer, lecturer without editorial rights, participant and guest.

The Moodle platform has the possibility of applying different types of activities that can be used in its lessons in order to present the content to the students, where some type of activity and interaction is required from the students (e.g. communication, discussion, answering short questions, solving tests and/or tasks, submission of homework, selection, etc.). Activities can be graded and are displayed as items in the grade book. Each activity can be individually edited depending on the needs of the course and lesson [24], [25], [26], [27].

As for online professional practice, for some professions it is relatively easy to do, e.g. in computer science or social science. For some fields such as medicine, professional practice is feasible only with physical presence, so in those cases, professional practice can be carried out when the conditions are met or with the consent of students to practice and face first-hand a situation like the current pandemic [23].

Beside Moodle, there are numerous LMS systems for e-learning and the most popular are:Google Classroom, Edmondo, BlackBoard, Canvas, Teams etc. The logos of some of them are given on Fig.2.

Figure 2. Mosty used LMS systems

4.2 Interesting tools for online learning

As a main education problem today most often communicated problem is dealing with kipping attention of students. In order to make teaching interesting, lot of online tools are available, such as:

- AnswerGarden – a tool for group online discussion or surveys; teachers can use this tool to get real-time responses from students to questions posed,
- Buncee - a content creation and presentation tool that helps students and teachers to visualize, communicate and interact with concepts and ideas in class,
- ClassKick - This app allows teachers to assign assignments to students so that both the teacher and other students can comment on the assignment,
- Crowdsignal - create online surveys, quizzes and questions quickly and easily. Students can respond using smartphones, tablets and computers, and information can be collected for reports,
- Edmodo – an interactive learning platform, where students and teachers can solve questions together,
- Expeditions – Google Expeditions is a learning app that allows teachers and students to go on over 1,000 tours in virtual reality and 100 in augmented reality. You can swim with sharks, visit outer space and more, all without leaving the classroom,
- Flipgrid - students can record 15 second to 5 minute video clips to respond to assigned topics; teachers and other students can leave comments,
- Google Forms - The Google Drive app allows you to create documents that

students can work on simultaneously using their smartphones, tablets and laptops,

- Kahoot - a game-based teacher-student exchange system, where teachers can create quizzes using online content,
- Micropoll - a tool for quickly creating surveys and analyzing responses. Surveys can also be posted on websites,
- Quizalize - a tool that allows teachers to easily create tests and homework for students. Teachers can see how students have done and identify areas that need improvement.
- Sparkpost - Adobe application that allows teachers to add graphics and visuals to flashcards,
- Visme - free software for creating infographics,
- Visme - free software for creating infographics,
- Zoho Survey – creating surveys that students can access and respond to via mobile devices. Teachers can see results in real time etc [27].

Teachers and trainers in the area of programming, can also use [28]:

- Petlja – material for teaching informatics and computing in primary and secondary schools in the field of programming on Serbian,
- Startit - a series of articles about programming in the Serbian language.
- FreeCodeCamp - a list of sites on the Internet for learning programming - everything is free, but it is in English.
- School of Code - a commercial programming school, with plenty of free online materials
- Web programming - a collection of articles for entering the world of web programming. Everything is localized in the Serbian language,
- Kampster - there are free of charge online programming courses, as well as a communication system with students. They also have a solution for schools - a distance learning platform.

For implementation some teaching methods in primary and secondary schools, like inverse classroom, Youtube channels can be used as a part of preparation for those type of lessons or for discussion sessions. Some of the suitable channels are:

- https://www.youtube.com/education
- https://www.youtube.com/user/teachers
- https://www.youtube.com/user/BIEPBL
- https://www.youtube.com/user/Discovery Education
- SUPER SCIENCE – a series of video clips that provide answers to unusual questions, from why the sky is blue to what virtual reality is. The narration is in the Serbian language, and the narrators are some of the famous people from Serbian culture and art who explain the phenomena in a sympathetic way.

As the main skills that are needed for the 21 century are: creativity, critical thinking, ability to observe, problem solving ability, ability to make decisions, it is recommended development of these skills from the early age. These skills can be acquired through specific approach to the tasks, which can be given through interesting media. Some online tools that can be used are:

- Peekaboo Kidz – video clips for young children, which provide answers to various questions such as: *Why? How?,*
- Art for Kids Hub - over a thousand drawing instructional clips and intended for younger ages.
- Crash Course – a channel that explains scientific phenomena in a humorous way. It covers a variety of topics, from historical facts to astrophysical quirks. It is intended for high school students, but with adaptations and with some more detailed analysis, it can, also, be used for higher grades of elementary school.
- AsapSCIENCE – a collection of animated clips dealing with answers to various scientific questions. Witty animation can be very interesting for lower school age children, even when the topics are very difficult to understand.
- It's AumSum Time - animations on various questions starting with: *What if...?* This is interested for the students of lower grades of elementary school, such as :*What if we lived on Mars?*.
- National Geographic - a collection of video clips that accompany articles on the National Geographic website. Particularly interesting are the 360º video clips, such as the exploration of a coral reef where the viewer can control the image and travel along the seabed.
- Kurzgesagt - In a Nutshell - animated short video clips that provide answers to questions from various fields with the motto: *nothing is boring if told well*. They can be used for all grades.

For secondary school, in making lectures of physics and chemistry more interested, this two Youtube channels can be very helpful:

- The Organic Chemistry Tutor - a collection of video clips presenting instructions for solving problems in organic chemistry.
- Step-by-Step Science - explained concepts in physics, chemistry, mechanics, electronics and astronomy for middle school students

For academic level of teaching, this Youtube channels are very much used:

- MIT OpenCourseWare – recordings of lectures by professors who teach at MIT University. Various topics, such as bitcoin economy or stellar archaeology are some of the themes that are processed. It is intended for HE students, but in some adapted form it can be used also for students of vocational secondary schools.
- Educational Documentary - a large collection of feature-length documentaries produced by the BBC, National Geographic, History Channel, Discovery Channel, etc. – duration of session is 30 to 90 minutes.
- Philosophy Tube – a collection of video stories related to philosophy in a very modern and entertaining way. It deals with various topics, from Introduction to Hegel's philosophy to some contemporary ethical dilemmas [27].

5. CONCLUSION

With the traditional system of learning, students and adults eventually lose interest in the subject and perceive the material as an obligation. For many years, e-learning forms in Serbia have been understood as an additional type of learning, and not as an added value to the existing education system, learning or online learning. Loss of interest in learning is a prerequisite for early school leaving, which does not fit at all into the concept of lifelong learning, on which future social progress is based. In the conditions of life in which an individual suffers from a lack of time, one of the ways to satisfy the need for education, in the presence of lack of time, is certainly electronic or online education.

Regardless of the fact that the Kovidom-19 pandemic significantly accelerated the raising of digital skills of all participants in the educational process, it seems that the results in the implementation digital tools are still slightly improved. We can not neglect that the application of e-learning is still not properly noticeable, especially in rural schools and underdeveloped areas of the Republic of Serbia. So, in Serbian area, e-learning is still not developed with the same intensity as in European countries. Of course, there are areas in which the complete way of education can be transferred to the digital sphere (social sciences), while in others physical presence is mandatory (medicine, technical sciences), at least in the segment of exercises and practical teaching.

Like any innovation, e-learning is a concept that is better accepted by younger teachers. The reasons certainly lies in the fact that investments in educational IT infrastructure have been intensified only in recent years (especially because of Kovid-19), and that younger staff in private life, in the largest percentage, use IT technologies intensively.

Further development of this area will certainly depend on the state's ability to invest in infrastructure and training of teaching staff, not only to acquire technical IT skills, but also training on creativity in the IT environment. Online learning, especially blended or hybrid learning requires space redesign and mastery of time management skills. This will play a crucial role in the realization of the concept of lifelong learning, which permeates all existing occupations today.

Good organization can take advantage of all the advantages of e-learning, and minimize the disadvantages (differences between users are lost, better personalization is achieved and the possibility of progress towards personal affinities and abilities is opened, so through a combined approach raises interest in teaching, experiencing electronic learning as something new and enjoyable, they create a competitive spirit, and learning outcomes become better).

The reformed education system, legislation and the development of scientific research projects are the main types of support for the implementation of e-learning in the modern education system. Development and growth of IT sector in Serbia in a last few years gives the encouragement for further investment in educational infrastructure.

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Micro:bit as a new technology in education in primary schools

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Abstract: *Micro:bit as a new technology in education provides the solution for the gap between abstract and often incomprehensible frontal teachings and new wave of practical teaching, which forces individualization and independence of students. At the same time, by teaching students digital-technical literacy in a fun way, it increases interest and strengthens students' will for the subject. The advantages of this device are not only oriented towards the students, but also towards the teachers and the entire school system. Modernization and the introduction of new approaches are paving the way for the schools of the future both in Serbia and around the world. The paper shows theoretical part on the basics of micro:bit, device layout, its specification and programming languages in which it is performed as well as the practical part.*

Keywords: *micro:bit; digital literacy; block programming; Informatics; education*

1. INTRODUCTION

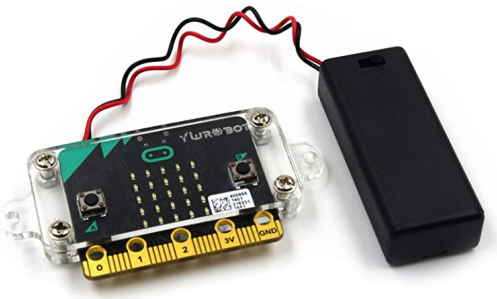
Digital literacy is a key skill of the 21st century. Despite the fact that information and digital technologies have become expressions that we can hear in everyday conversation, the fact is that a large number of adults in Serbia do not have even a basic knowledge of working on a computer. The school system serves us to get to know students from an early age and to teach them to handle different software. The purpose of this is to enable students to grow and develop in the future, as it is inevitable to have computer skills and the use of basic web tools both through schooling and in the business world.

Increased interest in information technologies and their promotion by educational institutions has led to the reform of curricula in Serbian schools. The most noticeable changes are seen in the subjects Engineering and Technology and Informatics and Computing. The focus of this paper is on the description of the micro:bit device, which has found its role in helping students to visualize abstract concepts of programming, as it has been taught since the fifth grade of primary school.

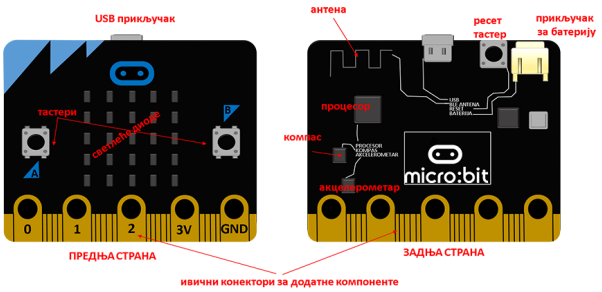
The year 2020 brought many changes in the teaching process and education. The COVID pandemic has brought about the introduction of distance learning. The problem arises because for such teaching, students, as well as teachers, are expected to have a considerable level of digital literacy. Most homework is based on an internet platform, diaries are electronic, classes are held online, and it is simply impossible for someone who is not trained to work on a computer to follow all the events within a subject.

Micro:bit is often described as a pocket computing platform [1]. This device is in fact a programmable microcomputer, intended for simple learning of the basics of programming and electronics. In addition to computer science and technical subjects, it can also be used in the teaching of electronics, mathematics, physics and related subjects because it encourages logical thinking with students. It also encourages learning to solve problems through algorithmic schemes.

Micro:bit was created through a partnership between educational institutions, the BBC as well as software and hardware companies. The device is designed so that it is simple enough to allow a quick start, and yet powerful enough to run applications (Figure 1).



Visually micro:bit resembles a microchip, which was the designer's idea. The core or "brain" of micro:bit is reflected in the ARM processor (Advanced RISC Machine), while on its surface there are twenty-five LEDs that can be individually programmed and that allow communication between users and devices (Figure 2).



The official specifications of micro:bit are [2]:

• Micro-controller: 32-bit ARM Cortex M0 +

• Sensors: accelerometer, compass, gyroscope

• Hardware: two buttons, LED matrix 5x5,

• Communication: Bluetooth, USB, radio

• Connectors: three general power connectors and a JST battery connector

• Dimensions: 43 mm x 52 mm

• Package contents: Micro:bit, USB cable, battery holder and batteries.

The physical components on the front of the micro:bit and their properties are:

• Display – Arranged in five rows and five columns, there are LED lights, which, depending on the program or application, light up as a visual component of the device. They allow you to display text, numbers and images. They can be programmed individually via pins or terminals or by connecting additional sensors to existing code.

• Keys – There are two keys on the front marked with the Latin letters A and B. They allow the device to start, so they serve as a type of detector. They serve to interact with the user.

• Pins – Located on the bottom edge of the device, representing the I/O (input / output) connectors. At the edge of the micro:bit there are 25 leads (pins) - 5 large and 20 small. The five large, base pins are marked with 0, 1, 2, 3 V and GND. Pins 0, 1 and 2 are general purpose input-output pins. Through them, using wires with crocodile clips, we can connect various additional sensors to the micro:bit, but also control numerous devices. Pins 3 V and GND (Ground – ground, ground) are used for power supply. At the output of this pin we get a voltage of 3.3 V in relation to the ground. The other 20 small statements can be used to communicate and manage additional components.

• Light sensor – Allows you to detect ambient light waves. The LEDs can be rotated to become an input component, then the LED panel itself becomes a light sensor.

• Temperature sensor – It is built into the plate itself and measures the outside temperature on the Celsius scale.

• Radio – Wireless component, allows communication between micro: bit devices.

The physical components on the back of the micro:bit and their properties are:

• Bluetooth sensor – Wireless component, allows communication between micro:bit devices and other computers, mobile phones or tablets, by receiving and sending Bluetooth signals. Communication works in both directions.

• USB connector – Connects a micro:bit to a computer. It is also used as an input to power the device.

• Compass sensor – Detects the Earth's magnetic field to determine the direction of movement or in which the micro:bit is facing. In order for the measurement to be accurate, it is necessary to calibrate the compass beforehand.

• Motion sensor (accelerometer) - Measures the change in movement of the device in the x, y and z coordinate system. It can also detect other activities such as tilt, free fall or vibration.

• Processor – The core of the device, powered by, and in addition to LEDs, is the most important part of the micro:bit. Controls the microcomputer, executes commands written in the appropriate program code.

• Restart key – Restart the device.

With the help of a relatively small micro:bit board, we can control a large number of devices, so that in addition to the above subjects in primary schools, micro: bit has found its role in electronics, robotics, and other fields.

2. THE USE OF MICRO:BIT IN TEACHING

The "Schools for the 21st Century" project, funded by the United Kingdom, aims to provide new technologies for use in teaching in six countries of the Western Balkans in three years. At the beginning of 2020, an action was carried out at the Metropol Hotel in Belgrade, where 17,500 micro:bit devices were awarded to 480 primary and secondary schools in Serbia. The project is an ambitious idea of the British Council to help develop skills in students aged 10 to 15 [3].

Micro:bit acts as a mediator between modern and traditional teaching. It is a kind of microcomputer that allows students to design their own projects through online platforms and programming tools. How the micro:bit which is used in teaching can be seen in students' projects. Students of the elementary school "Sveti Sava" from Nis made a meteorological station and in that way connected programming, informatics and physics, while

students of the elementary school "Kralj Petar Prvi" from Nis made a feeder for animals.

For work in micro:bit, the curriculum in the seventh grade envisages only four school hours, and in the eighth grade ten. With the help of various web manuals, teachers can interest students in other projects that can be realized independently using web tools.

In Serbia, the most widespread site is "Petlja", which educates primary and secondary school students in information and technical fields and sets various projects that students can do independently [4]. These tasks are never mandatory, but for those students who have a desire to expand their knowledge, they can be very instructive and interesting. For students, especially those interested in programming, the site describes some possibilities of interactive work with micro:bit connected to a personal computer, which can be very useful during the development of more demanding programming projects. More about them in the chapter on micro:bit in the teaching of Electronics. These tasks are given in such a way as to inspire students to new, original ideas and research work, an opportunity that they rarely get within the school itself.

Learning through micro:bits has become interesting for students, they are more motivated to work and develop logical and critical thinking during classes. Therefore, another 35,000 micro:bit devices are planned to be delivered soon across schools in Serbia.

Research conducted in the Western Balkans in 2018 shows a positive impact of micro:bits on programming lessons. According to their results, as many as 100 % of teachers believe that micro:bit is a useful tool in teaching, and 90 % of teachers believe that micro:bit encourages students to learn programming and computing outside the school [5].

2.1. The use of MICRO:BIT in Informatics

Micro:bit is a device primarily designed to facilitate the teaching of algorithmic thinking and programming to students in primary schools. Each component of the micro:bit enables the realization of a theoretical idea. On the official website of micro:bit, we can see the influence it had on the development of teaching informatics in schools. In addition to all programs that have adapted their interface and entered into partnership programs with BBC micro:bit to the community of teachers both internationally and within Serbia, the introduction of micro:bit in teaching has definitely revolutionized not only teaching programming but also other subjects. Regarding the results of the introduction of this device only in computer science teaching, there is data that indicate that as many as 86 % of fourth grade students in Danish primary schools have expressed a desire to learn about technology and computer science after using micro:bit [5].

The number of projects within informatics is huge and depends on the motivation and imagination of the subject teacher.

2.2. The use of MICRO:BIT in Electronics

Until recently, what made electronics interesting for eighth grade students were the sets provided by the school, where it was possible to make simple electrical circuits, usually connected to a smaller battery.

With the introduction of micro:bits, the subject of electronics in primary school gained a whole new dimension. Connecting additional components to the micro:bit creates new possibilities for creating electrical circuits with a higher level of interactivity. Additional components are connected using twenty smaller pins located along the lower edge of the device. Through these pins it is possible to read values from numerous sensors and control various devices. The application of micro: bits only shows how important, but also simple is the use of programming and modern technologies in solving problems from different disciplines, such as electronics in this case. Just some of the examples of projects that take place in eighth grade classes are:

2.2.1. LED - Light Emitting Diode

LEDs are one of the additional components of micro:bits that are primarily presented to students. The diode consists of two electrodes, one longer, positively charged anode and one shorter, negatively charged cathode. If you want to turn the LED on and off via the micro:bit, you need to connect it so that the shorter pin is connected to the GND pin (ground), and the longer pin receives a positive voltage from one of the micro:bit pins.

In order to achieve a successful electrical circuit, we add a resistor, which we can see in Figure 3 on the left [6]. In more complex projects, in order not to increase the number of conductors, we use a protoboard – a plate with holes on its surface, which are interconnected by metal connections and allow us to easily connect and test the electrical circuit, shown in the picture on the right (Figure 3).

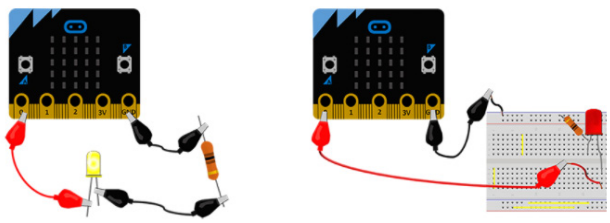


Figure 3. *Example of connecting LEDs to micro:bit*

2.2.2. Photo Resistor

With the help of photo-resistors, it is possible to determine the brightness of the room more

precisely. When the micro:bit is not illuminated, its resistance is high, however, as the illuminance increases, the resistance decreases. Knowing this, we can easily calculate the brightness level through the value of the resistor [6].

Micro:bit actually reads the change in voltage across the photo-resistor, not the change in resistance of the photo-resistor. The photo-resistor is great for projects related to energy saving, security systems with the use of lasers and the like. The connection method can be seen in Figure 4

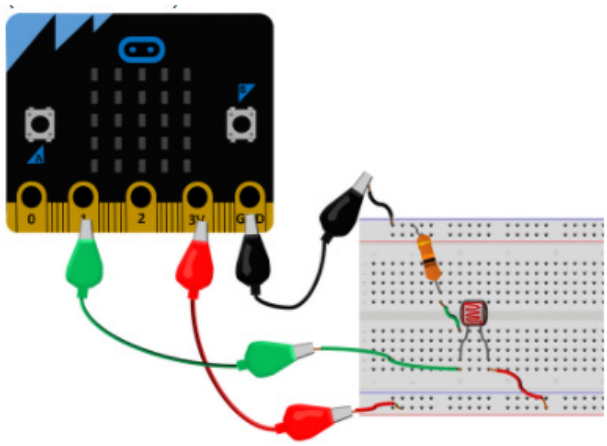


Figure 4. *Example of connecting a photo-resistor to a micro:bit*

2.2.3. Servo motor

With servo motors, it is possible to control the angular position, mostly in the range from 0 to 180 degrees. We connect servo motors with three wires: red, brown and yellow. If we want to control this motor via micro:bit, we need to connect the red wire to positive voltage (pin 3 V), brown to GND, and yellow (signal) to one of pins 0, 1, or 2. Unfortunately, micro:bit without additional equipment and power supply has the power to start only one servo motor, but even that is enough to understand the way it works. The connection method can be seen in Figure 5 [6].

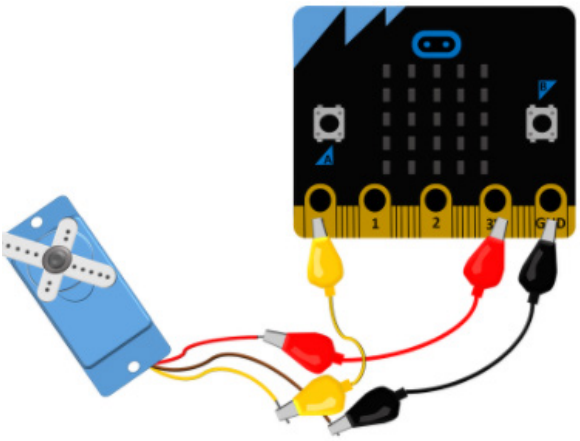


Figure 5. *Example of connecting a servo motor to a micro:bit*

2.3. The use of MICRO:BIT in Mathematics

As a science, mathematics is fundamental for many others, including informatics and programming itself. Thus, the micro:bit can be used not only as a programming tool but also to learn simpler mathematical problems.

For teaching mathematics to second grade students, micro:bit states that students behave like toys according to micro:bit and can hardly wait to teach mathematics.

The greatest benefit was seen when learning the multiplication table. This in-game teaching took place in pairs. Keys A and B were set to display two random numbers after pressing them. The students' task was to guess the product of those two numbers, and by pressing the B key again, they would get the correct answer. The student who received the correct answer received one point and the one who collected the first five points won. This interactive way of teaching allows students to learn the basics of multiplication in an interesting way.

In addition to the multiplication table, there are also programs for teaching division. The principle of the program is similar to the previous one, only instead of pressing the B key again, the quotient is displayed by pressing the A and B keys at the same time, in order to show the students this additional micro:bit function. In the third grade, addition and subtraction programs were made, as well as sharing with the rest. All through play and in a way that increases students' motivation to learn during the realization of classes [7].

2.4. The use of MICRO:BIT in Robotics

Why is it important to teach children robotics and automation? Precisely for that reason, that they are growing up at a time when technology is developing at an incredible speed. More and more devices that surround children use some elements of automation and robotics. For that reason, it is very important to start teaching about these current scientific disciplines at school, so that children can be prepared for all the novelties in the field of technology [8]. The idea is to learn the basic concepts, ways of using and applying robots, and for those who are interested, maybe creating them. The main goal of these lectures is to direct students to the development of cognitive skills for successful solving of technical problems.

It is important to make a clear distinction between robots used in computer science teaching and the basics of programming and robotics within technical education. Different programs such as mBot and Arduino are used for the needs of technique and technology in primary schools. Both programs are built on the Open Source principle and are used to create electronic prototypes. The working environment is similar to a micro:bit, where various electrical circuits are programmed in a visual way via blocks, as well as commands for starting the robot. The main way of programming is through Python, and the program itself contains additional components such as artificial intelligence

and indexes of terms. Within the program, there are also already made simulators of various robots, from cars to robots with "hands" or grips. In addition to the above programs, micro:bit is also used in the teaching of robotics and electronics. Its advantages over others are that there is no need to install integrated development programs, as there is an option for internet programming. The micro:bit components we have already mentioned in previous chapters are very important for teaching robotics and electronics such as accelerator, sensors, compass, etc.

2.5. The use of MICRO:BIT in Nature and society

Although at first glance it is difficult to determine the importance of micro:bits in the social sciences, a review of the literature and various researches leads us to the opposite conclusion. From simple applications of already existing micro: bit components, such as compass and thermometer, to teach students spatial orientation, all the way to some more complex projects. One of the examples of the application of micro:bit in the social sciences is described within the project "Planting digitally", where elementary school students were introduced to a new way of using information and communication technologies in everyday teaching [9].

The task of this project was to monitor the growth and development of the bean plant using micro:bit. The device would inform students about weather conditions, soil moisture and control the watering of the plant. The project was also done in cooperation of upper grade students with lower grade students. Many educators agree that sometimes students learn best from other students, their peers, rather than from teachers or authorities. The students were then divided into two groups: one that watered the plants in the standard way and the other that controlled the flow of watering through micro:bit. The second group, although technologically equipped, had problems with programming, because the challenge was to make the program so that the plants get the exact amount of water they need. Despite these difficulties, the students found this interesting because it was actually a real challenge to learn from their mistakes and correct them. In addition to micro:bit, in collaboration with a computer science teacher, students recorded their results in Excel spreadsheets, and photos of progress were transferred to the One Drive map, which only they had access to.

In addition to cooperative learning, the introduction of technological aids also made a great contribution to the positive results of this project. In this way, the students learned not only programming, but also responsibilities towards the group and the project and tolerance towards other participants. Connecting subjects such as Nature and Society with Informatics and Computing has led to even greater interest of students in both subjects, to the satisfaction of both subject teachers. These students were shown that each subject is important and that they depend on each other as one big coherent whole of the school system. No teaching topic is one-dimensional and can be expanded in different ways, which can only lead to even better results.

2.6. Visual block editor - JavaScript Blocks

Micro:bit executes instructions given to it. The set of these instructions are called programs, which we print using programming languages or writing code. For the purposes of micro:bit programming, as already mentioned, several programming languages can be used, one of which is JavaScript [10]. There are options for text programming or block programming. It is easier for younger students to get acquainted with block programming. The blocks are of different colors that can associate them with the function they perform. JavaScript Blocks belongs to the group of visual block editors [10]. Coding is done using blocks of different colors that indicate their role. The advantage is that it can be done in the offline version, but if it is distance learning or a school is not provided with micro:bit devices, there is also an online mode. More experienced users have the ability to encode in the JavaScript itself, which belongs to text editors (Figure 6).

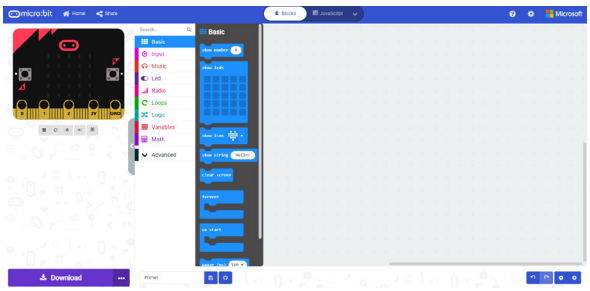


Figure 6. *JavaScript Blocks desktop environment*

2.7. Editor - MicroPython

MicroPython is another environment that is most often used in schools in Serbia. The fact that a special manual was made for both teachers and students speaks of its popularity. Micropayton is actually a version of Python used to work with micro:bit and other similar platforms [11]. Micropayton is a text editor and is intended for seventh and eighth grade students. The basics of the Python programming language are taught in the sixth grade in Serbia, so programming in the same program on the micro:bit is somehow a natural transition for students.

The focus is on the mechanisms of learning micro:bit using Micropayton as a form of textual programming, which indicates its advantages and disadvantages over block editors, but also introducing readers to one of the most used ways of teaching in our primary schools. The first

difference that can be seen is that testing the program requires an external editor **Mu**, which is designed so that even beginners can easily navigate the program (Figure 7). **Mu** is the simplest programming environment in Micropayton. Although it is suitable for beginners, some basic knowledge of the Python environment and its commands is expected. **Mu** is used in our primary schools only as a text editor but contains additional options. First of all, it is necessary to install the **Mu** environment. After the routine installation, the window from the image below opens, which shows all the possibilities of the **Mu** editor. The BBC micro:bit option is selected and resumes operation.

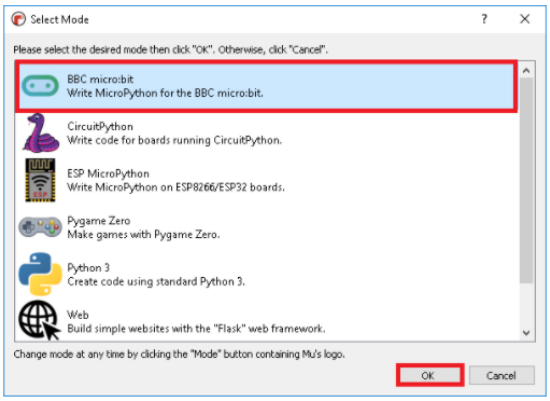


Figure 7. *Mu work environment*

3. CONCLUSION

In addition to its educational role, the school also has a development aspect. Teaching young people for the future and independent living is an important part of the education system. At a time when computers and other electronic devices have become part of everyday life, it is necessary to prepare the younger generations for life in the new digital world. Practical teaching shows better results, because students can be in direct contact with various devices and software. Numerous professional literature indicates several advantages of micro:bit, which were confirmed by the results of research conducted in this paper, based on independent conclusions.

Micro:bit as a new technology is largely implemented in primary schools. High schools are lagging behind, which leads to the conclusion that it is necessary to pay attention to the incorporation of micro:bit in professional environments. Micro:bit has increased the quality of teaching. The advantages of micro:bit are, according to teachers, improving students' individuality, better understanding of related subjects, improving logical thinking and problem solving, achieving originality in students, activating meaningful-active-perceptual thinking and facilitating teaching to teachers.

One of the rare shortcomings of micro:bit is that it is not suitable for students in the system of inclusive thinking and that it does not attract huge attention of students visually and interactively. The solution to this problem is to change the curriculum and adjust it in order to achieve inclusion and successful application of micro:bit towards inclusive students. As for the visual component, it can always be upgraded in the production itself, but the students' answers say that micro:bit it is aesthetically interesting enough that they would like to have it in other subjects, but also at home.

ACKNOWLEDGEMENTS

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Android game development

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Abstract: Mobile devices that are today at the global level with the largest usage rates are precisely those devices that are based on the Android OS platform. The work was based on the description of the created project, that is, the android game. Android games are the areas that are most represented in the IT development world, that is, the world of the mobile development application. Here, the focus is on that part of the application software, which is an integral part of the entire android package. The android system itself provides the opportunity as an open platform programming application solutions and install them on a mobile device. Through the work, its content and code in the form of scripts will be explained.

Keywords: *Android; Development; C#; Game*

1. INTRODUCTION

As everyone knows today, the mobile industry is expanding, mobile devices are those that have almost completely replaced computers today, that is, they found such wide use, that it is almost impossible to imagine life without smartphones, that is, how many of them are called "smart" devices. Mobile devices that are today at the global level in the largest usage rates are precisely those devices that are based on the Android OS platform. Every operating system, even the one on mobile devices, is composed of its operating core layout to the software part visible to the user, is, application and system software.

Here, the focus is on that part of the application software, which is an integral part of the entire android package. The android system itself provides the opportunity as an open platform programming application solutions and install them on a mobile device. That's exactly what it is

the subject of this paper, that is, an android game, which, as we know, is something without which one

an average user cannot imagine using their android device, that is, a smartphone [1].

2. ANDROID OPERATING SYSTEM

Android as a type of mobile operating system is a type of platform (OS) which open source, it is designed for creating mobile applications for other devices that starts the operating system [2].

It is very important to note that the android operating system consists of "native" applications, that is, in addition to them, from applications developed by others for free (free) installation, that is, download, or option with purchase (buy). Native android applications are pre-implemented in the android operating system, that is, they are native, as the word itself suggests, applications without which the Android operating system can not function, that is, it would not provide users with a complete experience.

For example, Java will be used to develop an Android application on one of the Java platforms DevKit. For iOS, the iOS SDK will be used, while some types of Windows platforms will use .NET framework SDK.

Android is therefore an operating system that is not used by smartphones, but also by devices such as tablet devices. It originated from an American company that is globally known, and in It represents a giant in the IT world, and that is the company Google Inc. This type of OS is based on the core of one of the most well-known OS Linux, and we can recognize it in its composition of open source software [2].

Android OS has gone through many changes in its rich history. Its public presented in a very large number of versions, some of which crashed, and some of which did not receive support, while some are listed that are still used today and receive support. The following are the Android OS versions:

- Asteroid OS (v 1. 0)
- Petit Four (v 1. 1)
- Cupcake (v 1. 5)
- Donut (v 1. 6)
- Eclair (v 2. 0-2. 1)
- Froyo (v 2. 2-2. 2. 3)
- Gingerbread (v2. 3-2. 3. 7)
- Honeycomb (v 3. 0-3. 2. 6)
- Ice Cream Sandwich (v 4. 0-4. 0. 4)
- Jelly Bean (v 4. 1-4. 3. 1)
- KitKat (v 4. 4-4. 4. 4)
- Lollipop (v 5. 0-5. 1. 1)

- Marshmallow (v 6. 0-6. 0. 1)
- Nougat (v 7. 0-7. 1. 2)
- Oreo (v 8. 0-8. 1)
- Pie (v 9. 0)
- Q (v 10. 0)
- Red Velvet Cake 11.0
- Snow Cone 12.0

2.1. Basic methods in the application life cycle

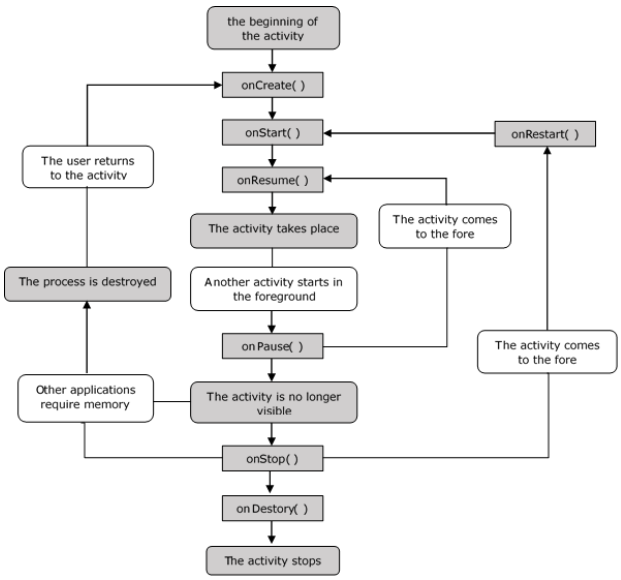

Figure 1. *Presentation of life cycle methods [3]*

Fig. 1. shows a graphical representation of the life cycle methods of Android applications.

onCreate() method is an "introductory" method to the application, it can be run when activating the application by the user, when starting this method, next the method that can be seen in the attached image is the onStart() method, which is not yet visible, until the onCreate method mentioned above is fully executed.

The **onStart()** method represents the method that will start its execution after completely executing the onCreate() method, that is, her UI will be visible right then.

onPause() the method can be activated by pressing a certain part of our interface applications, this method will be executed if the user pauses the action, or if it is current force stop, and if you completely leave the application after it, it will be activated onStop() method, but otherwise, the method that will wait for execution is the method onResume().

onResume() method is just fired after the user activation of the onPause() method, it is waiting for approval for its execution by the user, after pausing it.

The **onStop()** method represents the method that results from the activation of the onPause() method, that is, if the user does not decide to return to the application interface, that is turn off all background processes when pausing it, this method takes effect and completely shuts down the application and activates the last method in the application cycle, which is the onDestroy() method.

onDestroy() method is the one preceded by the activation of the onStop() method, it is credited to "kill" the application [3].

3. ANDROID GAMES

This type of software solution is considered an indispensable type of everyday use smart devices, primarily among the younger population. In the field of android games, there are games with educational and entertaining characters, and as such, they represent an indispensable part of the Android OS application software.

Today we see that games have greatly expanded to smart devices, and even some desktop application solutions, are also being made on mobile devices, with serious optimization. Knowing all that, we must also know that today in the IT world an incredible concentration of programmers is involved in web/android game development, that is, by developing games for certain platforms, that is, with the help of certain programs language.

In the following, the work is based on the description of technologies that are used, as well as a description of the project software used to create an android game. Technologies that are very present in the world of android games will be described in more detail, technologies that were used, namely: Unity, C#, and Visual Studio Code editor served for typing and editing the complete code that was used in the creation of the game that I will present as my project solution. The process of its installation will be presented, and some interesting details about the preparations of the aforementioned Unity IDE, that is, a powerful software package that is a coupling between the C# programming language and the API.

4. Technologies in the development of project solutions

The necessary tools with which the project solution is completed are the tools that are used today to use those innovative solutions to complete android games. A programming language was used C#, and the implementation in the code editor Visual Studio Code, and everything is included in the development environment called Unity, which works in conjunction with the aforementioned programming language. The mentioned technologies will be described below, how they function, and in the best possible way illustrate the process of creating an android game.

4.1. Description of the C# programming language

C# is one of the languages that is one of the youngest in the palette of all accessible programming languages that we can study and improve. Namely, this language was created as a product of Microsoft's development environment in 2000 [4].

We must mention that it is in the development team was Andres Heilsberg, which is also one of the most deserving for his commercial use.

This programming language supports multiple paradigms and supports the following paradigms: object-oriented, imperative, declarative, and generic, like most modern ones programming languages, such as Java and C++. Language is a general course of change and is the most suitable for the development of applications for the .Net Framework platform [4].

Today it is in conjunction with the IDE Unity package and used as a combination, they serve to create android applications, which can be presented and created as a 2D and 3D version of the game, it enables the powerful Unity, which will be discussed later in the paper [5].

5. Visual Studio Code

Visual Studio Code is a lightweight yet powerful source code editor that runs on a desktop and is available for Windows, macOS, and Linux. It comes with built-in support for JavaScript, TypeScript, and Node.js and has a rich ecosystem of extensions for other languages (such as C++, C#, Java, Python, PHP, Go) and runtimes (such as .NET and Unity) [6].

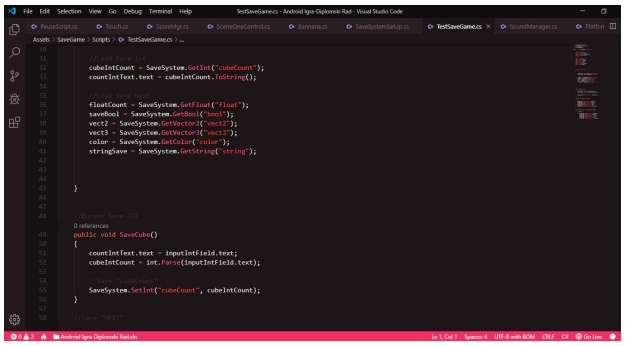

Figure 2. *Single window display in the VS Code editor*

In Figure 2, above, you can see a graphical representation of the Visual Studio Code environment editor.

It is important to note that Visual Studio Code supports the so-called extensions, which enable automatic completion of the first line of code through suggestions from extensions, it was done in such a way as to make the work of developers as easy as possible, using of extensions which are additionally implemented in a very simple way and incorporated into the autocomplete editor function, which will solve excessive syntax problems, and that they will be typed into a record soon.

5.1. Creating a Unity desktop

Unity represents an environment through which we can get a palette, that is, a variety the possibility of creating mobile applications, the creation process will be shown in the following example new project, and how to choose a 2D or 3D platform for creating an Android game.

1. Step

This step is shown in Figure 19, whereby pressing the "New" button we create a new project and that's how we start creating our project solution. After this step, I will illustrate finalizing the creation of the project, and later work will be based on a detailed description of the application which is calculated in the mentioned software.

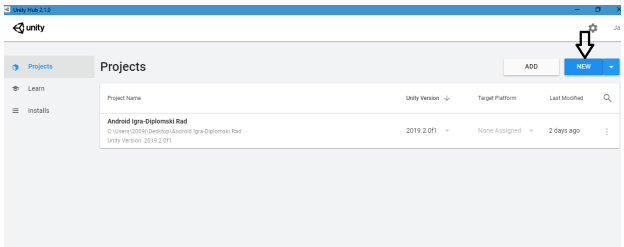

Figure 3. *Display window for creating a new project*

2. Step

After pressing the "NEW" button, we will get a window with additional settings for our project, where we will be able to enter the name of the project, its location, the place where it will save the project solution, and the platform, that is the work template. We can choose a 2D template, which will be for creating 2D applications, which is also implemented in my project solution, you also have a choice of 3D templates, and 3D with add-ons.

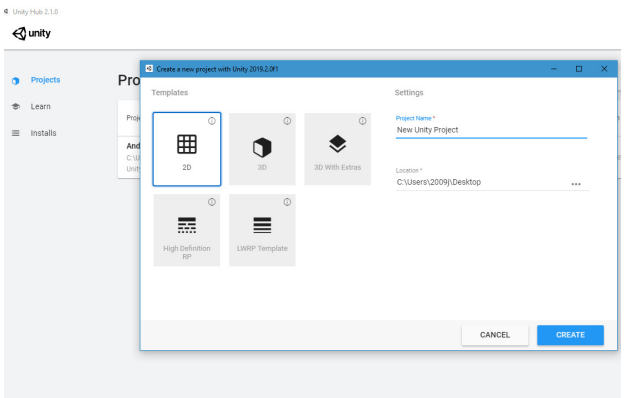

Figure 4. *Presentation of the template selection for the project solution*

As shown in Figure 5 graphic representation of the project desktop.

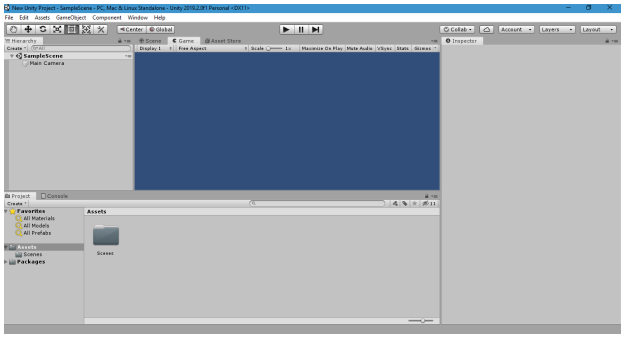

Figure 5. *Project Desktop*

6. PROJECT SOLUTION DETAILED ANALYSIS

6.1. Project solution using programming language C# and Unity + VS Code

An Android game that has been completed is a game that has been built on the previous one to the clarified template containing Unity, it was made in the 2D template and with help of the programming language specified, all objects and characters are manipulated and implemented in the project solution through Unity. Android game, that is project solution which was completed consisted of a series of implemented objects, that is, characters via assets in Unity, object, that is, characters are pre-designed and represent characters that are or drawn, or created through software tools designed for the same [7].

The game has a fun character, that is, it represents a kind of casual variant of android games, where you start your main character, a little monkey, by touching your display, on a smart device, where your goal is to collect as many objects as possible in your view banana, which will bring you good results, such as avoiding contact with an enemy object.

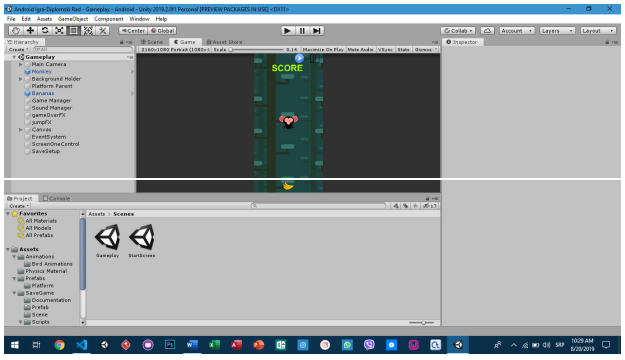

Figure 6. *The initial view of the workspace and layout of the 2D game scene*

As you can see in Figure 6, the initial screen, or layout, is shown applications, you have already learned about the working environment in the previous parts of the work. On the left side of the window, you can see that that part is reserved for the space of all Canvas, storage audio files, and all other objects present in the game.

In the particular picture, it is activated scene 1 which is named "Gameplay", and the same scene contains the initial window, that is, everything that you see on it when starting the game is related to the "StartScreen" scene.

After starting, the scene from the picture that you have the opportunity to see visually is automatically started. In the lower part of the Unity workspace, you see a space reserved for accessing the desired objects, scenes, and all other elements inserted into the environment, which is the whole process the makes the development of the game easier, that is, the accessibility of the elements is great. Implementation is on in the English language because I find it much easier to work with acronyms from their spoken language areas.

6.2. Individual description of all available folders in the project solution

In the presented folder, you can graphically see in Figure 6. the characters that are implemented in the project solution. That folder contains the main character, the little one, in its bundle monkey implemented in the environment called "Monkey", he is the main character which we manipulate through the programming language C#, while the bird and bananas are of course objects that perform interaction with the main character to achieve fun and a logical whole.

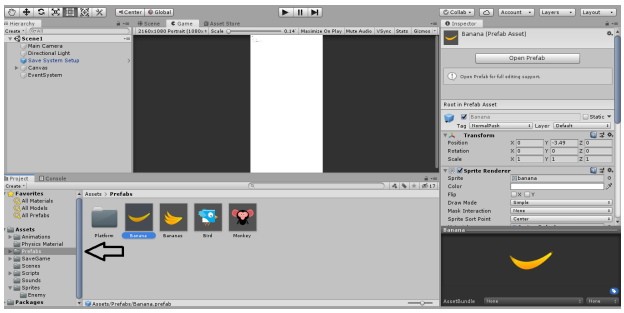

Figure 6. *View Prefabs folder*

In the folder "prefabs" we also have a folder with platforms, which contains objects, i.e. how popular are called assets, which are also used in this project solution for interaction with given objects. The folder itself is a space that is organized for storing the object material used in the project solution.

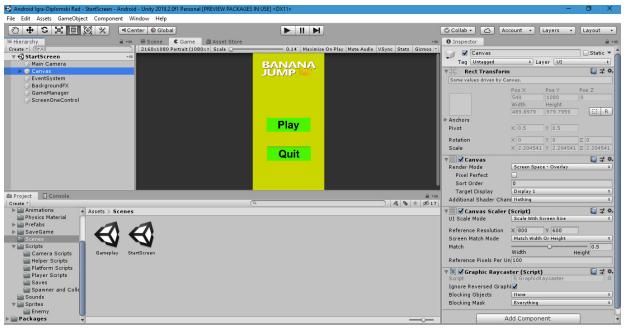

Figure 7. *Display the opening scene*

6.3. Scene 1 StartScreen

Figure 7 shows the appearance of the initial screen of the first scene of the android game. Like what you see in the left bar are all folders with manipulative scripts in their possession, that is the scripts that regulate the work of this initial scene 1.

The scene itself is set to a certain resolution, which is the appropriate resolution for most smartphones. It is in portrait with an aspect ratio of 2160x1080px. You can set yours right next to the "Scale" slider in the upper part of the workspace bar, under the name "Free Aspect".

On the right side of the window, canvas scene 1 of our android game is shown, and there are several tools on it are deserving for that design part, ie the part where you can adjust the position of this scene on your screen, whereas in my listening you have displayed values for the scene in the given image. The canvas folder and the main camera are responsible for the positioning, that is, the design of the entire scene, in the Canvas folder contains a series of elements that are shown in scene 1, that is the "Play" button, and the button "Quit", with the background color implemented in this scene, and the logo on the top bar scenes.

The work will further be based on the implementation of some code scripts, used for manipulation with objects from the Canvas, that is, the entire scene 1, the scene called "StartScreen".

6.4. Touch Script character gesture

A script to regulate fluidity and enable the operation of the entire game on the touch display of the smart device.

```
1    public class Touch : MonoBehaviour {
2      public GameObject player;
3      public int speed;
4      public float smoothing;
5      public bool pause;
6
7      void Update () {
8         if (EventSystem. current. IsPointerOverGameObject() ||
9            EventSystem. current. currentSelectedGameObject != null)
10        {
11           return;
12        }
13        if (Input. touchCount > 0 && Input. GetTouch(0). phase ==
14 TouchPhase. Stationary && pause == false)
15           {
16              Vector2 touchPosition = Input. GetTouch(0). position;
17              double halfScreen = Screen. width / smoothing;
18
19              //Check if it is left or right?
20              if (touchPosition. x < halfScreen)
21              {
22                 player. transform. Translate(Vector3. left * speed *
23 Time. deltaTime);
24              }
25              else if (touchPosition. x > halfScreen)
26              {
27                 player. transform. Translate(Vector3. right * speed *
28 Time. deltaTime);
29              }
30           }
31     }
32  }
```

The script shows in its first part which objects it interacts with, in the initial part of the code implemented the class "Touch" which is of type "MonoBehaviour". MonoBehaviour is the base class from which every Unity script derives.

When using C#, you must explicitly derive from MonoBehaviour. The following code includes instances of the class which you have the opportunity to see inside the "Touch" class, and the Update() method, which doesn't have one return result because it is of type Void.

The method itself takes the vectors, that is, the position of the main character, and if the game user presses the right or the left half of the X axis, then the object, that is, the main character of the Android game will move in the direction of the pressed part of the screen, that is, the left or right half, where the direct speed of character movement will depend on the predefined character speed value that will be the case to multiply with vectors whose values are defined in the script of our character.

```
1    public class SceneMgr : MonoBehaviour
2    {
3       public void StartGame() {
4          Application. LoadLevel("Gameplay");
5       }
6       public void Quit() {
7          Application. Quit();
8       }
9    }
```

The script you have the opportunity to see shows how the solution for launching the second stage of our project solution. We have a script class of the same name in the shown code, which in its algorithm contains the StartGame function that activates scene 2 "Gameplay", and if the user decides to leave the application, then the Quit function will be in action activated and will completely stop background processes and the application. An audio file, in mp3 format, was implemented in the initial scene for audio coverage of the scene, it's arbitrary, so you can implement any mp3 file, it's up to the game developer.

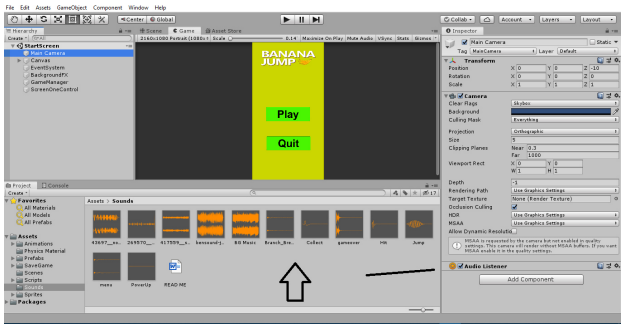

Figure 8. *Audio files and implementation*

On the stage you can find two buttons "Play" and "Quit", both buttons have implemented the function, which is predefined onClick(), through which they trigger, with scene 2 or with the

onDestroy method, if the Quit button is pressed. The following image illustrates the solution in Unity environment.

6.5. Script for creating events and buttons

```
1   public class Button : Selectable,  IPointerClickHandler,
2   ISubmitHandler
3     {
4       [Serializable]
5       public class ButtonClickedEvent : UnityEvent {}
8       [FormerlySerializedAs("onClick")]
9       [SerializeField]
10      private ButtonClickedEvent m  OnClick = new ButtonClickedEvent();
11      protected Button()
12      {}
13  public ButtonClickedEvent onClick
14      {
15          get { return m_OnClick; }
16          set { m  OnClick = value; }
17      }
18
19      private void Press()
20      {
21          if (!IsActive() || !IsInteractable())
22              return;
23
24          UISystemProfilerApi. AddMarker("Button. onClick",  this);
25          m_OnClick. Invoke();
26      }
27  public virtual void OnPointerClick(PointerEventData eventData)
28      {
29          if (eventData. button != PointerEventData. InputButton. Left)
30              return;
31
32          Press();
33      }
34
35  public virtual void OnSubmit(BaseEventData eventData)
36
37  {
38          Press();
39          if (!IsActive() || !IsInteractable())
40              return;
41
42          DoStateTransition(SelectionState. Pressed,  false);
43          StartCoroutine(OnFinishSubmit());
44      }
45
46      private IEnumerator OnFinishSubmit()
47      {
48          var fadeTime = colors. fadeDuration;
49          var elapsedTime = 0f;
50
51          while (elapsedTime < fadeTime)
52  {
53              elapsedTime += Time. unscaledDeltaTime;
54              yield return null;
55          }
56
57          DoStateTransition(currentSelectionState,  false);
58      }
59  }
60  }
```

6.6. Scene 2 Gameplay

The scene named Gameplay represents the second scene in the given project solution. This scene is exactly that "toy" scene, where we can see the whole way that everything functions as a whole.

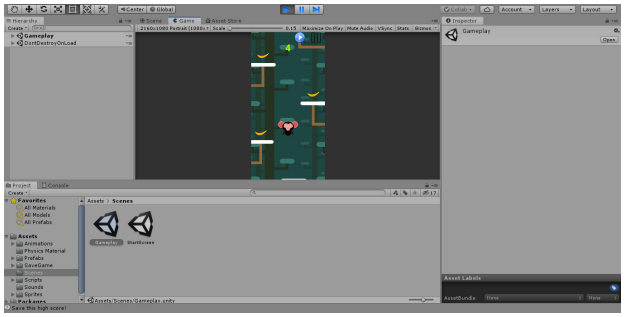

Figure 9. *Gameplay scene layout*

Figure 9 shows the Gameplay scene and its Unity environment. Of course, as I mentioned this scene is triggered when you click the "Play" button from the previous scene which is called "StartScreen".

The scene itself is in our "Gama Manager" object, inserted into the Unity environment, which you can see in the structure shown in Figure 10.

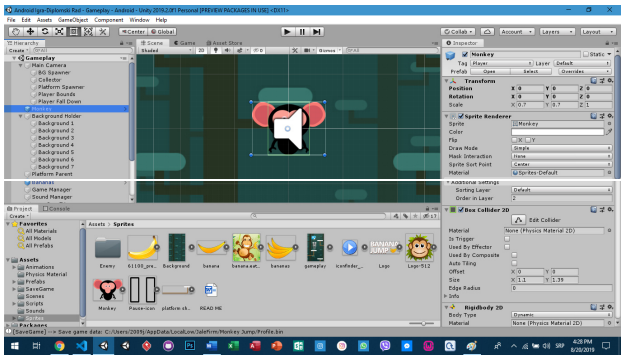

Figure 10. *Gameplay scene elements*

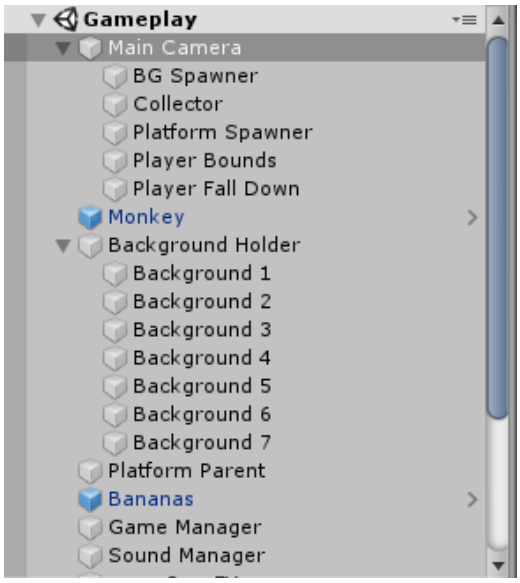

Figure 11. *Graphical representation of the Gameplay scene folder*

6.7. Main character script and implementation

As you can see in the attached image, the character of the Android game is located in folder assets, and the folder inside it is named Sprites. This character is implemented in the Unity environment into scene 2 as the main object. On the side in the bar to change the value, change positions contain clearly defined positions along the X and Y, and Z axes. Contains Box Collider which is in 2D mode and through which he will interact with his environment. It also contains in its composition Rigidbody, also intended for 2D games, in which we freed up the Z-axis rotation because it is it meant that he would not rotate unnaturally during the jump, but along the X and Y axes.

```
1   public class PlayerScript : MonoBehaviour {
3     private Rigidbody2D myBody;
4     public float move_Speed = 2f;
5
8     public float normal  Push = 10f;
9
10    public float extra_Push = 14f;
11
12    private bool initial  Push;
13
14    private int push_Count;
15
16    private bool player_Died;
17
18    public Text score;
19    public Text topScore;
20    public int point;
21    public int topEarnedScore;
22    public SaveGame saves;
23  public AudioSource gameOver;
24  public AudioSource jump;
25   void Awake() {
26      myBody = GetComponent<Rigidbody2D>();
27   }
28   private void Update()
29   {
30      topEarnedScore = point;
31      if (point > saves. earnedScore)
32      {
33         print("Save this high score!");
34         saves. earnedScore = topEarnedScore;
35         saves. SaveData();
36      }
37  topScore. text = saves. earnedScore. ToString();
38   }
39
40   void FixedUpdate() {
41      Move();
42      score. text = point. ToString();
43   }
44   void Move () {
45
46      if (player_Died)
47         return;
48      if(Input. GetAxisRaw("Horizontal")> 0) {
49
50         myBody. velocity = new Vector2(move_Speed, myBody. velocity.
51 y);
52
53      }else if(Input. GetAxisRaw("Horizontal")<0){
54
55         myBody. velocity=new Vector2(-move  Speed, myBody. velocity.
56 y);
57
58      }
59 }

60   void OnTriggerEnter2D(Collider2D target) {
61
62       if (player_Died)
63          return;
64
65      if(target. tag == "ExtraPush") {
66         point += 3;
67         if(!initial_Push) {
68
69            initial_Push = true;
70
71            myBody. velocity = new Vector2(myBody. velocity. x,  18f);
72
73            target. gameObject. SetActive(false);
74
75            return;
76   push;
77
78         }
79      }
80      if(target. tag == "NormalPush"){
81
82         point += 1;
83         myBody. velocity = new Vector2(myBody. velocity. x,
84   normal  Push);
85         target. gameObject. SetActive(false);
86         push_Count++;
87         JumpFX();
88   }
89         if(target. tag == "ExtraPush"){
90
91         myBody. velocity = new Vector2(myBody. velocity. x,
92   extra_Push);
93         target. gameObject. SetActive(false);
94         push  Count++;
95         JumpFX();
96      }
97
98      if(push  Count==2) {
99         push_Count = 0;
100        PlatformSpawner. instance. SpawnPlatforms();
101     }
102
103     if (target. tag == "FallDown" || target. tag == "Bird") {
104  player  Died = true;
105        GameOverSound();
106        GameManager. instance. RestartGame();
107     }
108   }
109   public void GameOverSound()
110   {
111      gameOver. Play();
112   }
113
114   public void JumpFX()
115   {
116      jump. Play();
117   }
118 } // class
```

The player script itself is a script that was created to manipulate the main character of my android game, this script is responsible for the complete logical interaction with the environment of the main character of the game, and the work of this script will be explained in more detail in the paper. Namely, the script contains the "PlayerScript" class of the same name, which has two functions in its composition Start() and Update().

At the end of the script we have an if loop where we enter parameters if our character comes into contact with the bird, that is, if it collides with it, then the character will die and we will activate the restart of the scene. Also at the end of the script, we have an inserted part for the audio coverage of the character death function, where it will when colliding with a bird, hear a certain arbitrary sound.

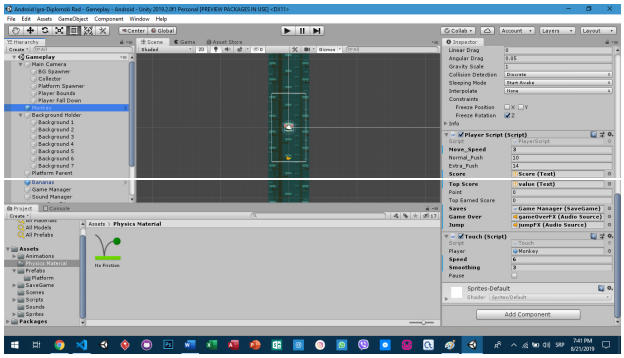

Figure 12. *Our character object and its script*

7. FUTURE WORK

The game is an antidote to boredom that is suitable for everyone. Games also have other benefits such as the brain development, solving problems, improving concentration, train speed, etc.

The mobile gaming market is an immeasurable, overall view of the mobile gaming industry. Games obviously also have more advantages, such as mobility advantages, they have more potential customers.

Considering that and the very popularity of the games, the result of this work and the development of the game presented in the work, we plan to place it on Google Play.

8. CONCLUSION

The work was based on the description of the created project, that is, the android game. Android games are the areas that are most represented in the IT development world, that is, the world of the mobile development application. This area requires a wide knowledge of many object-oriented

programming languages, and many development environments, and is considered one of the most demanding areas in the IT world. It is an interesting fact that today's programming languages in expansion precisely those that are compatible with development environments, as precisely the language that I processed in this paper, that is, which I used for the development of my project solution, which is C# [7].

This programming language, development environment Unity is a duo that is in the modern the app development world is at the top when it comes to Android games, the thought that a development environment capable of providing the user with the development of both 2D and 3D games is incredible, that is, it tells us enough about the demands and complexity of the given environment.

The paper shows in detail the preparation of software for current work. The project solution is graphically explained in detail through the scripts and images that illustrate the situation in the development organization. The user is enabled to completely create an image of what looks like an Android game development process. Complexity and demandingness are qualities that describe the process of creating an Android game, but it is safe to say that this area is one of the most enticing and beautiful in the developing mobile world, which he showed in his work specific example.

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Possible Aspects of E-Materials Application in the Teaching Process

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Abstract: *The effectiveness of the teaching process and learning is partly determined by the quality of the teaching material. Digital teaching material means all material that can be used and distributed in electronic form. This paper presents aspects of the application of e-materials in the teaching process, which are based on technological progress and the development of new possibilities. The paper discusses the types of e-materials as well as their role in the teaching process.*

Keywords: *e-materials; teaching process; types of e-materials; electronic books; multimedia learning*

1. INTRODUCTION

The latest publishing phenomenon could be said to be electronic books (also known as e-books). The basic formats of digital teaching materials are given in terms of:

- text,
- visual content (images, charts, etc.),
- animation, i
- audio and video recordings.

The term "electronic book" dates back to the late 1960s [1], and a recent definition by Feather and Sturges (1997) [2, p.130] is "book-analog text that is in digital form for display on a computer screen" (p. 130).

Multimedia teaching material is a combination of at least two or more digital formats, such as text and video, or visual elements (photos) with accompanying audio content (explanation of the visual element).

The term "electronic book" dates back to the late 1960s [1], and a recent definition by Feather and Sturges (1997) [2, p.130] is "book-analog text that is in digital form for display on a computer screen" (p. 130).

The e-book is a significant new medium that can offer additional value to the printed book through its potential to include other media pages in addition to the text on it. It is a document designed for viewing on a computer screen, which integrates the classic structure of books with features that can be provided within an electronic environment [3].

Creating teaching materials is an integral part of the professional activities of teachers. Based on experience, it can be concluded that certain forms of multimedia teaching material are very common in primary and secondary schools, such as slide presentations (PowerPoint).

However, even a cursory analysis of those presentations used in schools indicates that most are not designed in accordance with the basic principles of creating effective multimedia teaching content. Such presentations and other multimedia forms of teaching material are not only not in the function of stimulating and supporting the learning process, but they can reduce the student's efforts to master the specific content of the teaching units.

More precisely, an e-textbook is an e-book that contains educational material for teaching and learning methods [4].

In addition to the slide presentations that are standardly used in primary and secondary schools, audio and video recordings can also be extremely valuable teaching material. There has been a rapid expansion of educational multimedia since the early 1990s [5] and the conversion of printed publications such as textbooks into electronic interactive form is likely to prove useful [6]. It is argued that the e-book is particularly suitable for enhancing learning outside the classroom, and recent technological developments have produced a strong incentive to provide such electronic material for educational purposes [4].

2. TECHNOLOGICAL PROGRESS AND DEVELOPMENT OF NEW POSSIBILITIES

It is a well-established opinion that for the creation of effective digital teaching material it is necessary to have professional equipment and programs. Professional equipment can certainly contribute to the technical aspects of quality, but often this is not crucial to their effectiveness in learning activities.

Printed textbooks are also often outdated compared to e-textbooks, with the printed version usually being updated and replaced every eight years on average [7]. Current teaching activities attempt to combine the best teacher- and curriculum-based online resources. E-learning enables faster and greater access to information for education [8].

However, the accessibility of technologies and programs in recent years provides the opportunity for teachers to independently create audio and video teaching materials. Simple digital cameras, mobile phones or web cameras and microphones can be used for this purpose. Numerous web services can be used for editing and dissemination of audio and video recordings, e.g. media sharing services, podcast, videocast.

Many authors suggest that e-learning is effective because it offers great opportunities for collaboration and interaction. However, the implications of taking on this e-learning initiative should be considered, including financial support, staffing burden and changing roles [9].

Teaching materials are one of the most important components of the educational process. In a similar way to their printed equivalents, e-textbooks allow students to underline important sentences, write notes and look up unknown words. The content of the teaching material is in accordance with the educational program, so the learning material first of all plays an important role because it serves as a useful aid for the teacher to prepare for his lectures. In addition, learning materials are specifically designed to provide information to students. In this part of the educational process, learning materials serve as a source of information, where the student can refresh already acquired knowledge or acquire new ones. Furthermore, learning materials can also be used as a motivational tool for the teacher to get more attention from his students.

Learning materials not only serve as a repository of learning content, but, according to [10], materials have a hidden curriculum that includes attitude toward knowledge, attitude toward learning, attitude toward role, and teacher-student relationship, and as such enhance the teaching and learning experience. .

Despite the many advantages associated with e-textbooks, there are also some obvious disadvantages. First, problems related to screen reading should be noted, which may cause users to read more slowly or choose to print the document and review it in hard copy [11].

There are different forms of learning materials; however, it is the teacher's decision which one to use. The most common learning material that teachers rely on is the textbook. The structure of the textbook is based on the curriculum and thus determines the components of the teaching content, which makes it easier for the teacher to prepare for the lecture. Using textbooks makes it easier for teachers to control the content of lessons, teaching methods and procedures [10].

There are other learning materials that are included in educational processes such as: multimedia such as audio, video, interactive content and others. The use of additional materials depends on the limitations of the subject and mainly on the equipment in the classroom.

With the development of information technologies (IT), mostly access to the World Wide Web, education has gained new dimensions and possibilities, as well as teaching tools. Technological advances have enabled educators to provide opportunities for interactive dialogue at a distance. In addition, the impact of IT development has changed the educational environment and learning processes with the rise of e-learning.

There are also opinions that e-textbooks show complexity, which leads to various difficulties related to usability [3], [12] and some e-textbooks may promise complex addition of functionality, but actually provide limited multimedia functions. It is also necessary to ensure that there is enough memory space on computer hard drives both for storing electronic text and for running software [13], which could create problems in schools where existing computer equipment is not particularly up-to-date. Recently, some research has been done on children's understanding of e-books, mostly concerned with those concentrating on fiction. For example, Greenlee-Moore and Smith (1996) [14] investigated the effects on nine- and ten-year-old children's reading comprehension of printed narrative texts of varying length and complexity compared to the same narrative texts presented on interactive CD-ROM software on a computer. A study by Trushell et al. (2001) [15] took as his basic research to indicate that e-book reading can have beneficial outcomes for students' reading. The study investigated small groups of nine- and ten-year-old children reading an electronic storybook without teacher intervention and noted that the students' recall was influenced by a number of factors.

Many simpler electronic teaching materials such as tests, lesson preparation, worksheets, etc. They can be made by teachers, professors and professors who have average knowledge of computing and computing skills. Teachers could exchange all electronic teaching materials through specialized educational web portals.

3. TYPES OF E-MATERIALS

There is a big difference in teaching students at the elementary level or teaching at a university because of the diverse complexity of the audience. E-materials should enable different levels of

student involvement in accordance with the educational program. Therefore, it is the teacher who must be able to decide which material is appropriate for a particular type of student.

In the last century, three views of learning have developed and based on them we can find three architectures of e-learning, Table 1. We can see that the receptive architecture is based on the display of information gathering, and the directive is based on reinforcing the response. while guided discovery is based on knowledge construction review [16].

Table 1. Three e-learning architectures

Source:R. C. Clark & R. E. Mayer, e-Learning and the Science of Instruction, 2011, [16, p. 22]

Architecture	The view	Inter-activity	Used for
receptive	acquisition of information	low	training goals
directive	strengthening the response	medium	training objectives in the procedure
guided discovery	knowledge building	high	strategic goals of training

According to the e-learning architectures described above, the interactivity of lectures in e-materials ranges from low to high. For receptive classes, e-materials contain a low level of interactivity and do not offer opportunities for student responses and feedback. At this level we can classify traditional learning materials converted into digital media.

The middle level of interactivity is represented by e-materials designed for e-learning about directive architecture. The directive lecture e-materials follow the order of "explanation-example-question-feedback". The e-materials in this segment contain highly structured practice opportunities compiled for attending classes in a step-by-step manner. An example of e-material for teaching from the directive is an e-textbook, with integrated multimedia blocks and connecting concepts through lessons.

Electronic publishing is a relatively new form of content distribution for teaching purposes, therefore many definitions and categorizations of elements in this area go through a process of constant redefinition, addition and improvement. For now, there is a tentative agreement regarding the types of digital publications, while, for example, there are still discussions among authors on how best to define basic concepts such as e-Book, e-Textbook, etc.

The Networked European Deposit Library (NEDLIB) has published an overview of the standards for electronic publication in which it more precisely defines the categories of electronic publications. NEDLIB is a project initiated by CoBRA+, the Standing Committee of the Conference of European National Libraries (CENL). This document recognizes the following categories of electronic publications:

- Offline electronic publications. This category includes digital editions that can be used independently of having access to the global network. In other words, these releases are distributed on media such as CD, DVD, magnetic tape, etc.
- Online electronic publications. This type of digital publication provides educational content that is only available online or through the use of local borders. Online electronic publications can be further divided into a) static resources, b) cumulative resources, and c) dynamic resources.
- Hybrid electronic publications. Hybrid publications refer to educational content that is primarily distributed via CD or DVD, but which also features hyperlinks that provide access to content stored on a global network.

4. THE ROLE OF E-MATERIALS IN TEACHING

Contemporary trends indicate that the function of school libraries and librarians is changing significantly in accordance with the progress and development of media and information transfer technologies. In the past, printed material (books and magazines) was primarily used for the purpose of learning and teaching, while in the last two decades digital teaching material has become more and more dominant. Examples of good practice suggest that trained and specially trained librarians take over the creation of multimedia teaching materials. For example, as part of the LUMENS project at the University of Michigan, numerous librarian training sessions were held with the aim of preparing them for more successful use and creation of multimedia teaching aids. In European educational frameworks, the concept of the role of the library and librarians is also changing. So far, a lot of research has been done in this area with encouraging results. Initiatives that advocate the necessity of expanding the role of librarians are not new in the world. Some authors emphasize that the librarian's function must evolve since the ways in which information is transmitted in the 21st century have also changed significantly. In this sense, the professional training of librarians for the use of ICT is seen as one of the ways to improve the process of integrating ICT into the educational system and creating quality digital teaching materials.

Many teachers choose to use e-materials in their classrooms, because all the interactive and multimedia elements help them to attract the attention of all students and their senses. Namely, when information detects multiple channels

simultaneously, the quality of understanding and memory increases significantly due to increased activity in all parts of the brain [17, pp. 118-121].

Teaching with e-materials helps the student to transform the words and images in the lecture through working memory so that they are integrated into already acquired knowledge in long-term memory [17, pp. 31-33]. From this perspective, the structure of e-materials is in accordance with the theory of cognitive learning.

foundation is shown with two streams; one for converting words and the other for handling visual content. The basis of limited capacity is shown by the square working memory box in the middle of the same figure. In the image below, we can also see the active basis of processing interpreted by five pointers.

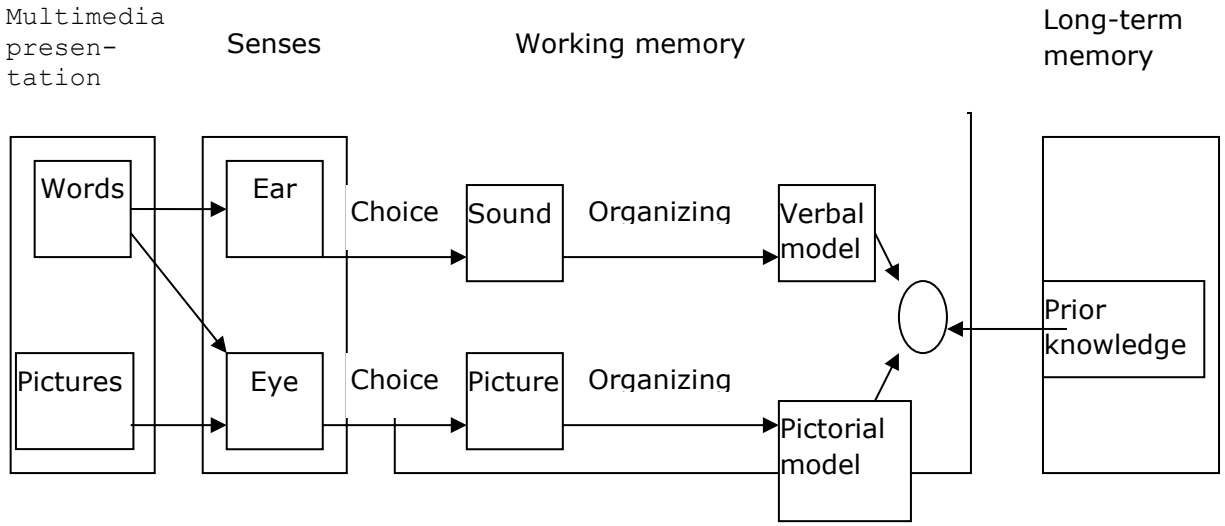

Figure 1. Cognitive theory of multimedia learning

Source: R. C. Clark & R. E. Mayer, e-Learning and the Science of Instruction, 2011 [16, p. 36]

The view of knowledge construction is presented on Mayer's theory of cognitive multimedia learning [17, pp. 31-38] based on three central foundations:

- Dual channels; this foundation declares that two independent approaches are used for data processing. The first channel processes sounds in working memory, and the second channel is used to process images. The first model results in verbal models and the second in pictorial models. The construction of both can be influenced by background knowledge stored in long-term memory [16, pp. 35-36].
- Limited capacity, as the next foundation, suggests that students are limited in the amount of information they can actively detect and integrate simultaneously [16, p. 35].
- Active processing; as the last foundation of multimedia learning, which takes place when students engage in appropriate cognitive processing during learning. The result of active cognitive processing is the development of a comprehensible subjective illustration, so active learning can be considered a process of building a model [16, p. 35].

Figure 1 shows a model of how a student learns in lectures that contain multimedia content, which is an integral element of every e-material. As we can see in the picture below, the two-channel

In Fig. 1, we can also see three important cognitive processes marked by arrows [16, pp. 36-37]:

- Choosing words and images; first, students pay attention to the important words and graphics that the ears and eyes perceive in this material - the lecture.
- Organizing words and pictures; at this step, students organize the selected words and images in their minds in an argumentative verbal and pictorial form.
- Integration; as the last step that combines oral verbal and pictorial perceptions with each other and with already acquired - background knowledge. Active learning occurs when the student is appropriately involved in all these processes [17, p. 36].

5. CONCLUSION

It should be emphasized that electronic books and textbooks (eng. eBook and eTextbook) represent only one of the ways in which authors can publish works in electronic form. Current practice indicates that electronic publishing of books and textbooks generally follows and goes through most of the stages that characterize traditional book publishing. Namely, this primarily refers to the process of writing, accepting and approving the

content of a book or textbook by the publishing house or the relevant educational authority (if it is a school textbook). However, unlike the traditional printing of books or textbooks, when publishing electronic editions there are additional, specific requirements that must be taken into account.

For the successful publication and distribution of electronic books and textbooks, it is necessary to respect certain standards and criteria for the production of such publications. Accordingly, it is necessary to adopt standards at the national level to help future authors and publishers of electronic publications. These standards must be harmonized with valid world criteria, especially with those related to the technical requirements of electronic editions.

ACKNOWLEDGEMENTS

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Implementation of new equipment for the laboratory exercises – Testing of low-voltage electrical installations

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Abstract: *This paper presents the new equipment that is used for laboratory exercises in the subject of Electrical installations and lighting at the undergraduate academic and professional studies in the Faculty of Technical Sciences in Čačak. Multifunctional electrical installation safety testers for testing domestic and industrial electrical installations were presented. A demonstration board that provides simulation of different types of faults in electrical installations is also presented. As an illustrative example, the paper presents the procedure and results obtained during the realization of the exercise - Measurement of ground fault loop impedance in TT and TN earthing systems and checking the conditions for automatic disconnection of supply.*

Keywords: *Electrical installations; fault loop impedance; laboratory exercises; testing.*

1. INTRODUCTION

Practical exercises can contribute to a better understanding of theoretical lessons that are studied during classes. Working with the new equipment in laboratories can prepare students for future professional work. For this purpose, new laboratory equipment was acquired in previous years for developing and conducting the laboratory exercises on the subject of *Electrical installations and lighting*. Through the implementation of the project "Development of higher education", the Faculty of Technical Sciences in Čačak (FTS) acquired measuring instruments with additional equipment for testing low-voltage electrical installations. The equipment is used for conducting laboratory exercises on subjects in basic academic (*Electrical installations and lighting*, *Micro-installations and components*) and basic professional studies (*Electrical installations and lighting*).

Laboratory exercises envisage that students become familiar with the method and procedure of testing low-voltage electrical installations as currently determined by the Rulebook [1] and the SRPS HD 606364-6 standard [2]. Due to the content volume of electrical installations testing, students in the laboratory conduct exercises that were previously discussed in theoretical classes (lecture and calculation exercises). The laboratory exercises include the following types of testing: Continuity (resistance measurement) of the protective conductor; Insulation resistance measurement; Fault loop impedance measurement and prospective fault current determination; Residual current protection devices (RCD) testing. In general, it is possible to realize exercises that can be simulated on the demonstration board, listed in [3]. Before exercises, students are introduced to the possibilities of instruments for electrical installations testing and additional equipment. This is done for the purpose of safe and efficient work in the laboratory.

In continuation of this paper, the second chapter describes the new equipment that students use for laboratory exercises: two multifunctional instruments for low-voltage electrical installations testing (chapter 2.1) and demonstration board for error simulation in electrical installations (chapter 2.2). In the third chapter, exercises examples of fault loop impedance measurement with verifying the effectiveness of installed overcurrent or residual current protective device in TT (chapter 3.1) and TN (chapter 3.2) systems are presented.

2. EQUIPMENT FOR THE LABORATORY EXERCISES

2.1 Multifunctional measuring instruments for electrical installation safety testing

A special type of multifunctional measuring instruments are used for low-voltage electrical installations safety testing. For conducting the laboratory exercises, students at FTS use two instruments manufactured by *Metrel*: MI 3152 *EurotestXC* (Figure 1) and MI 3155 *EurotestXD* (Figure 2) with their additional accessories (*EU*

set). These instruments have, in addition to others, the following functions [4,5]:

- Insulation resistance measurement up to 1 kV;
- Testing the continuity (resistance) of the protective conductor;
- Testing residual current devices;
- Fault loop impedance measurement and prospective fault current determination;
- Earthing resistance measurement;
- Earth resistivity measurement;
- Voltage and frequency measurement;
- Active, reactive and apparent power and voltage and current harmonics measurement.

Figure 1. *Multifunctional electrical installation tester Metrel MI 3152 EurotestXC.*

Figure 2. *Multifunctional electrical installation tester Metrel MI 3155 EurotestXD.*

Instruments MI 3152 and MI 3155 have additional accessories (*EU set*) which contain:

- Earth set, 3-wire, 20 m;
- Single phase plug commander, 1.5 m;
- 3-wire test lead, 3 x 1.5 m;
- 4-wire test lead, 4 x 1.5 m (only MI 3155);
- 2.5 kV test lead, 2 x 1.5 m (only MI 3155);
- Test probe, 4 pcs (black, blue, green, red);
- Crocodile clip, 6 pcs;
- Current clamp 1000:1;
- Current clamp (low range, leakage);
- RS232-PS/2 cable and USB cable;
- Li-ion battery pack, 7.2 V, 4400 mAh and power supply adapter 12 V, 3 A.

2.2 Demonstration board for simulation in electrical installations

The demonstration board *Metrel* MA 2067 is used to simulate different conditions in low-voltage electrical installations. This board is very practical to show the application of electrical installations safety testers in laboratory conditions. The front panel of demonstration board is shown in Figure 3-a. On the board, it is possible to simulate several different errors in the three major types of earthing systems: TT, TN and IT system. This board is capable of measuring and testing [3]: Resistance of electrical installation insulation; Continuity (resistance) of the protective conductor; Earth resistance; Specific earth resistance; Line fault loop impedance (L-N, L-L); Ground fault loop impedance (L-PE); Disconnection times and trip-out currents of RCDs; Contact voltage; Voltage and frequency, etc. The error condition is realized by turning on the control switches located on the control part of the board (Figure 3-b). With these control switches, it is possible to demonstrate 19 different errors: Line impedance (switches S1-S3); Resistance of protective (PE) conductors (switches S4-S11); Earthing resistance (switches S12, S13); Soil resistivity (switches S14, S15) and Insulation resistance (switches S16-S22). The simulated error in the electrical installation, i.e. the position of the control switches, can be physically concealed (locked) so that the students can't know the type and location of the error.

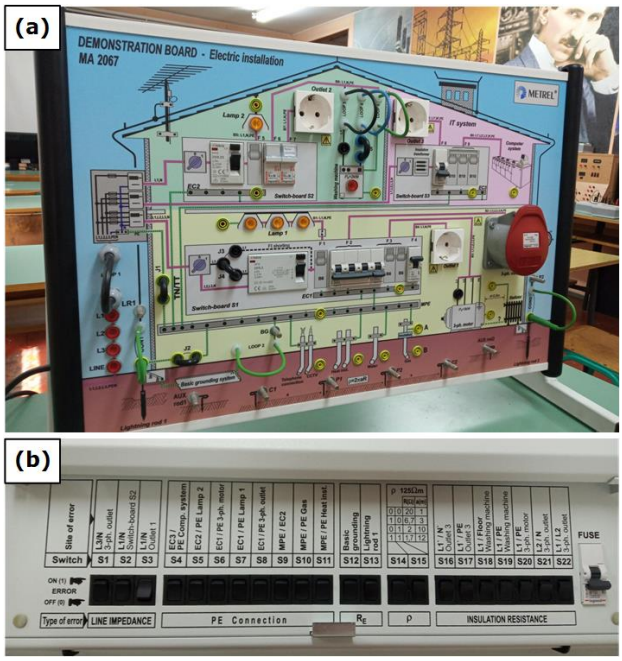

Figure 3. **(a)** *Front panel and* **(b)** *command part of demonstration board.*

3. EXAMPLES OF LABORATORY EXERCISES - FAULT LOOP IMPEDANCE MEASUREMENT

Examples of the laboratory exercises that students perform are presented in this chapter. The first part of the exercises shows the method of fault loop impedance measurement (*Z-loop*) and the fulfilment of the conditions for protection in the TT system, while the second part describes the same thing but in the TN system. The measurement of the fault loop impedance is performed in order to check the efficiency of the applied protective

overcurrent device (circuit breaker/fuse) or RCD. After the loop impedance measurement, the prospective fault current and contact voltage are determined. Then, the prospective fault current (I_{psc}) is compared with the current for the rated disconnection time of the circuit breaker/fuse (I_a) or with the rated residual operating current of RCD ($I_{\Delta n}$). The exercises were performed using the equipment shown in Figure 4.

In a TT system, the fault loop impedance is determined as [6]

$$\underline{Z}_{loop,TT} = \underline{Z}_L + \underline{Z}_{PE} + R_{Eh} + R_{Ed} + \underline{Z}_T, \qquad (1)$$

where $\underline{Z}_L$ is phase conductors impedance, $\underline{Z}_{PE}$ is the protective conductors impedance, R_{Eh} is the earthing resistance of installation, R_{Ed} is the earthing resistance of source (distribution point) and $\underline{Z}_T$ is the power transformer secondary impedance. In a TN system, the fault loop impedance is determined as [6]

$$\underline{Z}_{loop,TN} = \underline{Z}_L + \underline{Z}_{PE} + \underline{Z}_T. \qquad (2)$$

In the TT system, overcurrent protection is effective if [6]

$$Z_{loop,TT} \cdot I_a \le U_0, \qquad (3)$$

while the protection against excessive touch voltage is effective if [6-9]

$$R_A \cdot I_a \le U_C \qquad (4)$$

or [6]

$$Z_{loop,TT} \le \frac{U_C}{I_{\Delta n}} = \frac{50\ \text{V}}{I_{\Delta n}}, \qquad (5)$$

where I_a is the current causing automatic cut-off of protective device within the required time, U_0 is the system voltage to earth ($U_0 = U_{L\text{-}PE} = 230$ V), $R_A = R_{Eh}+R_{PE}$ is resistance of protective earthing (earth probe and PE wiring resistance), U_c is the limit contact voltage on exposed conductive parts and $I_{\Delta n}$ is the residual operating current of RCD. In the TT system, the RCD is most often to use for protection, and then the operating current is rated residual operating current of RCD ($I_a = I_{\Delta n}$) [6,9]. In TN system, conditions for protection with automatic disconnection of supply is [6-9]

$$Z_{loop,TN} \cdot I_a \le U_o. \qquad (6)$$

Disconnection times for final circuits (U_0 = 230 V) in TT and TN systems are 0.2 s and 0.4 s, respectively [6,8].

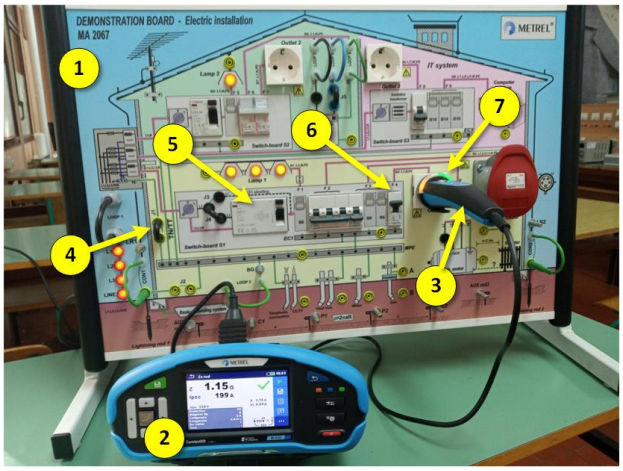

Figure 4. *Equipment used for fault loop impedance measurement:* ***1*** *– demonstration board,* ***2*** *– Metrel MI 3155 tester,* ***3*** *– single phase plug commander,* ***4*** *– jumper J1 (for TT or TN system set),* ***5*** *– RCD 25A/0.3A for protection of socket outlet 1,* ***6*** *– miniature current breaker B 6A for protection of socket outlet 1,* ***7*** *– socket outlet 1.*

3.1 Example of fault loop impedance measurement in TT system

The Figure 5 shows the results of fault loop impedance measurement on outlet 1 in the TT system (jumper J1 removed). Since the circuit of this outlet is protected by RCD $I_{\Delta n}$ = 0.3 A, the maximum permissible value of the fault loop impedance determined by expression (5) is

$$Z_{loop,TT,\max} = \frac{50}{0.3} = 166.7\ \Omega.$$

In the case without error, the measured value of the loop impedance is $Z_{loop,TT(a)}$ = 11.5 Ω < 166.7 Ω and the condition given by expression (5) is satisfied (Figure 5-a). With error simulation by increasing the phase conductor impedance (in practice, increasing the length or decreasing the cross-section area of the conductor), the measured value of the loop impedance is $Z_{loop,TT(b)}$ = 21.4 Ω < 166.7 Ω, and the condition given by expression (5) is satisfied in this case as well (Figure 5-b). If error is simulated by increasing the earthing resistance of installation, the measured value of the loop impedance is $Z_{loop,TT(c)}$ = 252 Ω > 166.7 Ω, and the condition given by expression (5) is not satisfied (Figure 5-c). In this case, the high value of earthing resistance contributes to the appearance of high contact voltage on the exposed metal parts connected to the PE conductor. Specifically, after measuring the loop impedance with error ($Z_{loop,TT(c)}$ = 252 Ω), the calculated prospective fault current has a value

$$I_{psc,TT(c)} = \frac{U_0}{Z_{loop,TT(c)}} = \frac{230}{252} = 0.91\ \text{A}.$$

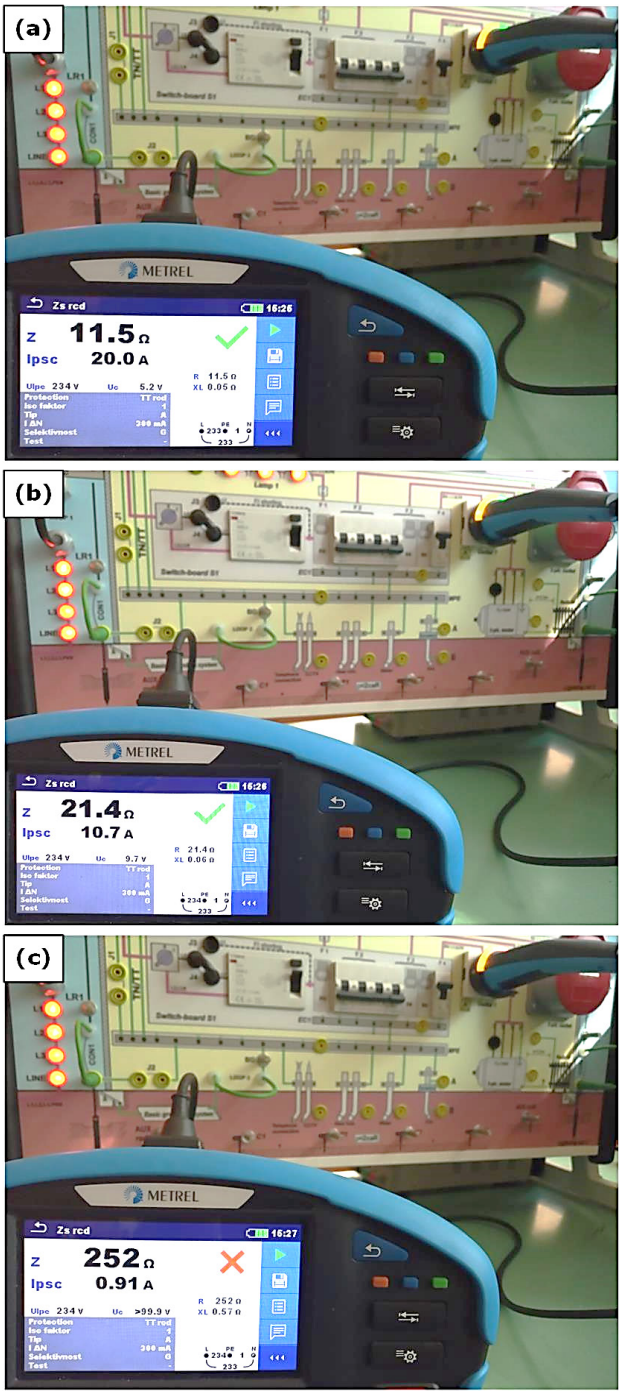

Figure 5. *Results of fault loop impedance measurement at the socket outlet 1 in TT system for case:* ***(a)*** *without error (Z_{loop}=11.5 Ω);* ***(b)*** *with error - caused by phase conductor impedance increase (Z_{loop}=21.4 Ω);* ***(c)*** *with error - caused by installation earthing resistance increase (Z_{loop}=252 Ω).*

Although prospective fault current is higher than the rated residual operating current of RCD, it creates an unacceptably high value of the contact voltage

$$U_{C(c)} \approx R_{A(c)} \cdot I_{psc,TT(c)} = 250 \cdot 0.91 = 227.5 \text{ V},$$

where $R_{Eh(c)} \approx 250$ Ω is the resistance of protective earthing with simulated error.

If a circuit breaker type B 6A were to be used to protect the socket outlet 1, there would be no condition for protection for all three analyzed cases. Then the condition from expression (3) is not satisfied because

$$Z_{loop,TT(a)} = 11.4\ \Omega > \frac{U_0}{I_{a(B6A)}} = \frac{230}{30} = 7.67\ \Omega.$$

A scheme of electrical installation on the demonstration board for fault loop impedance measurement at socket outlet 1 is shown in Figure 6. In the scheme, the red solid arrows show the test current flow during the loop impedance measurement in the TT system. The red dashed arrows show the test current flow during the loop impedance measurement in the TN system.

3.2 Example of fault loop impedance measurement in TN system

Figure 7 shows the results of fault loop impedance measurement at socket outlet 1 in the TN earthing system. To select TN system jumper J1 must be set. In the TN system, the circuit of socket outlet 1 is protected by a circuit breaker with rated current I_{n0} = 6 A and B tripping characteristic (B 6A). For this type of circuit breaker, the trip-out current has a value

$$I_a = 5 \cdot I_{n0} = 30\,\text{A}.$$

The maximum value of the fault loop impedance in the case of using the overcurrent protective device (circuit breaker B 6A) determined by the expression (6) is

$$Z_{loop,TN,\max} = \frac{U_o}{I_a} = \frac{230}{30} = 7.67\,\Omega.$$

For the fault loop impedance measurement in the TN earthing system, the "Zs rsd" option must be set. These settings take into account the existence of RCD in electrical installation. Also, for the type of protection system in the instrument settings "TN" was selected. In that case, only the overcurrent protection (current breaker with B, C and D trip characteristics or fuse) is active for checking. An example of fault loop impedance measurement on the board in a TN system without error is shown in Figure 7-a. Then, the measured impedance is $Z_{loop,TN(a)}$ = 1.14 Ω < 7.67 Ω, so condition (6) is satisfied. With error simulation by increasing the phase conductor impedance (in practice, increasing the length or decreasing the cross-section area of a conductor), the measured value of the loop impedance is $Z_{loop,TN(b)}$ = 11.2 Ω > 7.67 Ω, and the condition given by expression (6) is not satisfied (Figure 7-b).

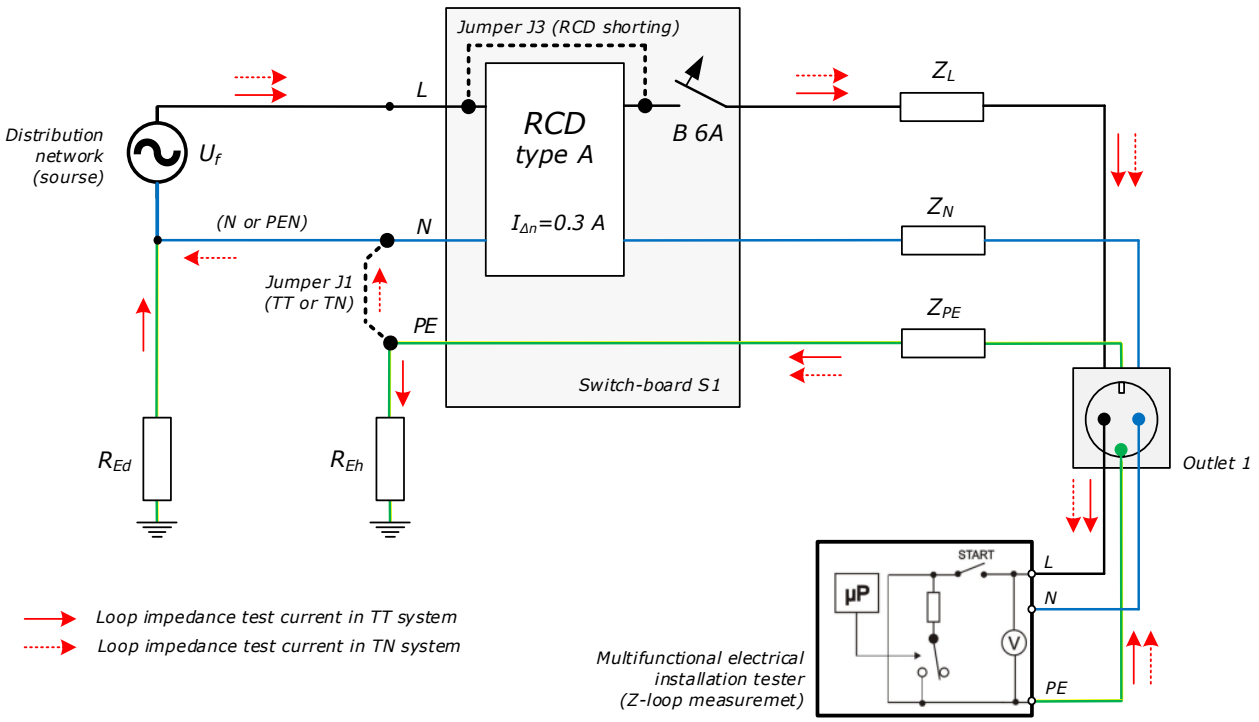

Figure 6. *Principle of loop impedance measurement on the demonstration board (socket outlet 1) in TT and TN system.*

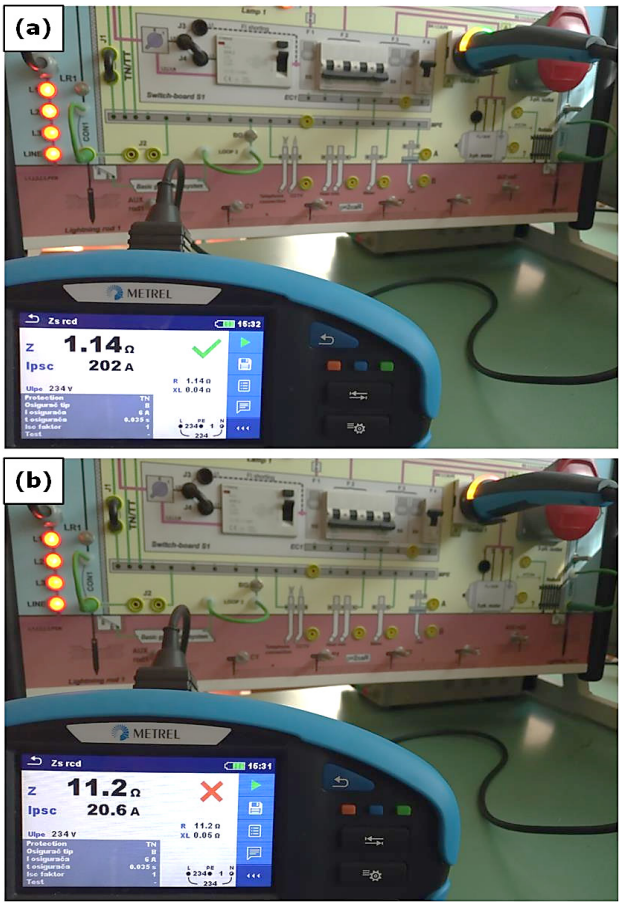

Figure 7. *Results of fault loop impedance measurement at the socket outlet 1 in TN system for case: ;*

(b) *with error - caused by phase conductor impedance increase (Z_{loop}=11.2 Ω).*

It should be noted that for this type of fault loop impedance measurement, it is necessary to use the "Zs rsd" option, because there is a RCD for the protection circuit of socket outlet 1. If this option is not used, the RCD would trip-out unnecessarily and measurement would not be successful. The reason for this unwanted tripping is the existence of a test current which becomes a differential current that causes RCD to react (red dashed arrows in Figure 6).

4. CONCLUSION

The implementation of laboratory exercises for testing low-voltage electrical installations contributes to a better understanding of the theoretical content that students learn in classes (in lectures and calculation exercises). During laboratory exercises, students have the opportunity to gain experience in working with new equipment for electrical installations safety testing. It is especially important to explain protective measures against electric shocks. That is one of the reasons why the paper presents examples of fault loop impedance measurement in TT and TN earthing systems. In the future, an increase in the number of exercises will be considered, as well as worktime student spend in the laboratory. All of this is aimed at gaining students experience in working with new measuring equipment and more practical knowledge.

ACKNOWLEDGEMENTS

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Protection against electric shock in electrical engineering didactic laboratories

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Abstract: *In order to rise safety level of the users in real laboratory environment related to the courses of electrical engineering the description and application examples of cover for laboratory screw terminals for use in research laboratories and experimental electrical systems and equipment is depicted in this paper. The main advantage of the described covers is the protection of laboratory personnel and students against direct contact to metal parts of terminal, which are under high voltage potentials. The paper points out the necessity for protection measures and contains examples of use of different covers for electrical machines, power converters, electric meters and other laboratory equipment.*

Keywords: *electric shock protection; cover; insulator; electric screw terminals; laboratory accessories*

1. INTRODUCTION

During still actual global health crisis caused by Covid-19 virus a huge number of teaching activities is dislocated to online platforms using different online didactic resources [1]. Moving student's practical laboratory exercises to online world was serious challenge with very attractive results and outcomes [2,3]. Implementation of the remote laboratory experiments have faced its creators with numerous challenges in solving real-time synchronised video streaming, experiment booking time slots, protection against unallowed actions, steps, etc. Contrary to this completely user friendly and save environment for students and other online users, traditional approach in real laboratory demands precautions related to electric shock protections and protections of laboratory equipment. Coming back from online resources to the real laboratory premises demands increased caution since online work tend to rise inattentive and careless approach during performing laboratory exercise [4]. Having that in mind this paper presents various electric shock protection applications aiming to prevent potential hazard caused by accidentally contact with high voltage potential points in electrical engineering laboratories.

The most exposed high voltage points in laboratories are screw terminals used to connect the circuits between the wirings of electrical machines, the terminals of meters, the terminals of supply transistor converters and the terminals of supply electric power grid according to delivered scheme by teacher or the scheme drawn by students or by researcher. The screw terminals are widely used in the research and the didactical laboratories such as: in the laboratory of numerical control [5], in the laboratory of the mechatronics [6], laboratory of the electrical engineering and informatics [7], laboratory of the industrial engineering [8], laboratory of superconductive materials [9], laboratory of agriculture [10], laboratories of electrical and computer engineering [11], laboratories for automatic electrical drives [12], laboratory of electrical machines [13], laboratories of the power electronics [14], laboratory of electrical engineering and electrotechnology [15], and in laboratory of mechanics [16]. The screw terminals are used in research laboratories in experimental set up for series connections of supercapacitors [5], for the connections to the electrical machines [9], [11], [12], [13], [17], in laboratory adjustable autotransformers [18], in the isolated measurement system connected to the computer and in the main distribution research table [6], for safety connections [10]. The screw terminals are utilized in different kinds of devices such as: in the meters [9], in the laboratory programmable DC power suppliers [8], [11], [14], in the prototyping devices [7], [12]. The screw connections are also used in a plasma reactor [15], for electromagnet in laboratory set-up for testing [19] and for three phase diode rectifiers in marine energy conversion system [20].

The screw terminals are not only used in the laboratory equipment, but they also can be used in the industrial devices like the welders, the battery chargers, and in domestic devices like sets of loudspeakers to connect with amplifier, etc.

The wide use of the screw terminals is the result of its basic advantage, that is difficult to disconnect accidently the electrical circuit. The electrical and mechanical connection of screw terminals is assured even using the strong mechanical forces when accidently pulling the cable. This basic advantage is very important especially in the laboratory of electrical machines, because it allows to prevent from many unwanted phenomena. The excitation current of separately excited DC motor or separately exited synchronous motor cannot be interrupted rapidly. The rapid interruption of the machine excitation current causes the overload current in the main armature circuit. The interruption of excitation current of DC motor can cause high and dangerous motor speed even hazardous burst of the rotor due to high centrifugal forces.

The current rapid interruption can also cause the dangerous electrical arc burning insulators and melting metals especially in circuits especially with devices like electrical machines. The electric arch in devices can cause the electrical surge between disconnected terminals originated form machine winding inductance. The electrical surge can damage semiconductor devices supplying electrical machines, e.g. diodes of rectifiers or even can cause electrical shock of surprised laboratory personnel. The application of screw terminals ensuring high quality connection prevents laboratory devices and personnel from current rapid interruption and all unexpected phenomena mentioned above.

The screw terminals for use in laboratory are shown in Fig. 1. In order to connect a circuit, the fork terminal *1* ending cable *2* with terminal handle *3* is put under the handle *5* of the screw terminal *4* and then is tightened by screwing the handle *5*. The handle *5* is made of isolation material, which do not conduct the electrical current. The application of isolation material allows the personnel to tough it safely and to screw terminal and to unscrew it. The disconnection of the fork terminal *1* from screw terminal *4* is obtained by unscrewing the handle *5* and pulling back the fork terminal *1*.

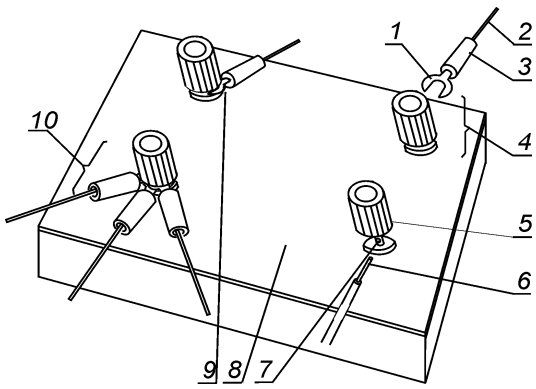

Figure 1. *The screw terminals on mounting plate*

The screw terminal *4* can be also used for connection with bare end *6* of wire with removed isolation. The screw terminal *4* has a whole *7* in its screw in order to put inside the bare end *6* of wire.

All the screw terminals *4* are mounted on mounting plate *8*, which is made of isolating material which do not conduct electric current.

The main disadvantage of using screw laboratory terminal is that, the metal basis *9* of screw terminal and the metal part of fork terminal 1 are exposed, and there is a possibility to touch the metal parts 1 and *9* clamped in the terminal *4*, as shown in Fig. 1. Amount of available active metal components under high voltage rises, when a single laboratory terminal tightens several fork terminals, as indicated by reference numeral *10* in the Fig. 1. Continuing, in accordance with electrical standards it should not occur access to active metal components conducting an electrical current after the connection of an electrical circuit.

2. COVER AGAINST DIRECT CONTACT WITH LABORATORY TERMINALS

The essence of the technical solution is the apply the cover made of not conductive material of appropriate shape enclosing screw terminal *4* (Fig. 1) with clamped fork *1* or clamped the metal end *6* of the cable. The proposed cover of laboratory screw terminals is shown in Fig. 2.

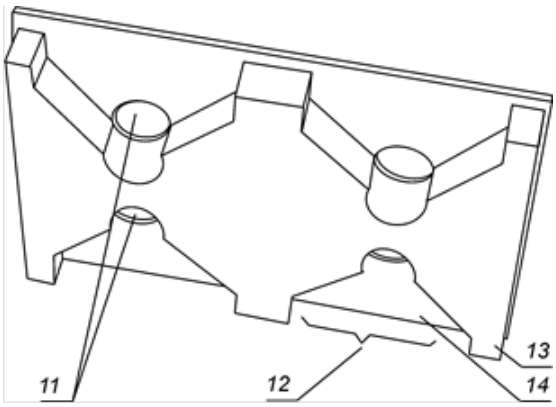

Figure 2. *The bottom view of cover for four laboratory crew terminals*

All potentially dangerous parts of connection of an electric circuit: a screw terminal *4*, a bare end *6* of the wire without insulation, a metal active part *9* of the terminal laboratory screw, are covered by cover shown in Fig.2. As the result, the main advantage is that, the cover protects student and laboratory personnel against direct contact with active bare metal parts of laboratory terminals after the connection of the circuit.

Cover has a hole *11* in the middle, for the handle *5*, and the empty spaces *12* in it, for restoring in: the terminal *4* and one, two or three fork terminals *1*, as it is depicted in Fig. 2. The empty space *12*

may be obtained by cutting the space in the thick plate element *14* made of insulating material do not conducting electricity. The empty space *12* for the fork terminal *1* is covered by an insulating material plate *13* with holes *11* on handle *5* of terminal *4*. Cover allows, without removing it, clinching and disconnection the fork terminal *1* or metal cable end *6* from screw terminal *4*. In other words, the handle *5* can be turned on and off when the cover is placed on the terminal *4*.

Another advantage of the protection solution is a simple construction of the cover. The cover is made of two pieces of plexiglass plates, one *13* is thick and the other *14* is thinner. Thicker plate element *13*, which is shown in Fig. 3a, has a cut *12* for fork terminals 1. Thinner plate element *14* has holes *11*, which are shown in Fig. 3b. The holes *11* are there in order to allow for a handle *5* to protrude over the cover, and to allow for a user to grip the handle 5 and to screw it and to unscrew it, as shown in Fig. 3c. The result of installation of a cover *15* on a set of screw terminals with an insulated handle *5* on mounting plate *8*, is shown in Fig. 3c. The cover of the laboratory screw terminal can be made of any insulating material: transparent or opaque.

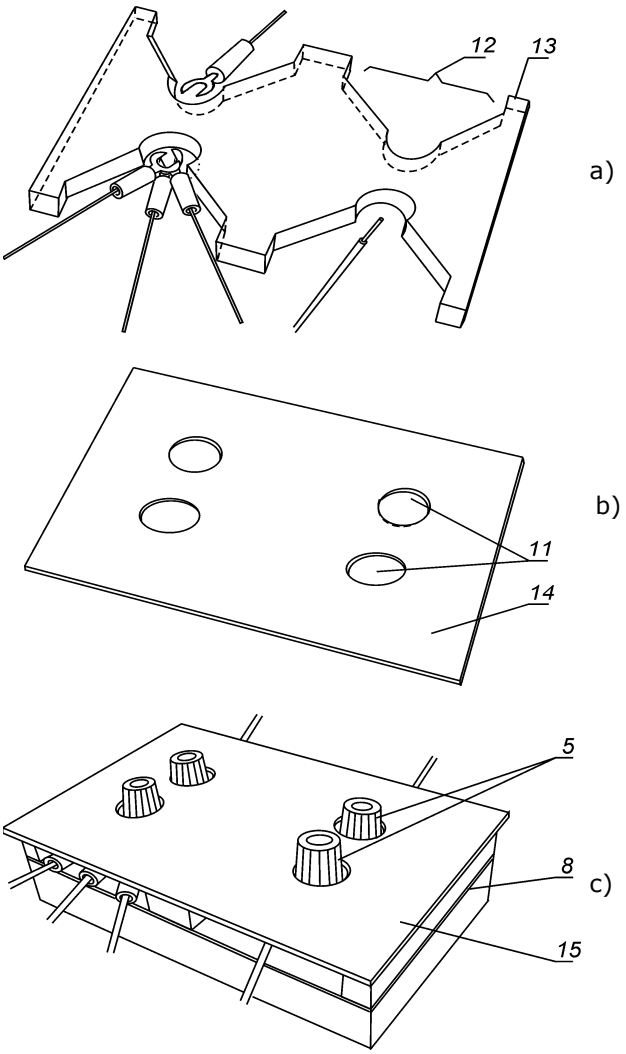

Figure 3. *The set of the screw terminals:* thicker plate (a), thinner plate (b), cover (c)

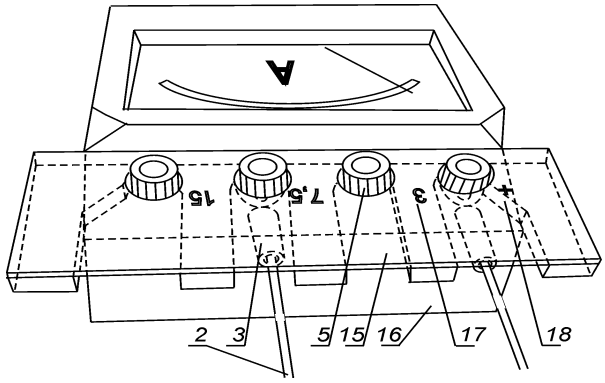

Figure 4. *The set of the screw terminals and the cover*

The example of the cover, which is made of a transparent material such as acrylic glass used for laboratory meter is shown in Fig. 4. The material transparency is critical to the cover functionality, especially when using it to cover the set of screw terminals of the laboratory electric meter *16*. The use of a transparent material for the cover has such the advantage that the markings of the measurement ranges *17* and the markings of the polarity *18* are visible under the cover *15*. In the case of application of transparent cover, the user will see not only the textual descriptions *17* or the graphic signs *18*, but also the schemes of electrical circuit under the cover.

One laboratory screw terminal can tighten several fork terminals *10* in Fig. 1. Therefore, the cover of laboratory screw terminal may be designed to cover one or several fork terminals *1*. Fig. 5 contains the perspective view of the bottom of the terminal cover designed for the electric meter (Fig. 4). In Fig. 5 cover has two empty spaces: whole *11* and empty spaces *12*. The empty spaces *12* can be used for one and for two fork terminals that can be connected to the screw terminal.

The terminal cover can also be used not only for the laboratory equipment, but also for industrial equipment, or household appliances. The example of embodiment of the covers *15* of screw terminal *4* for battery rectifier *19*, autotransformer, welding inverter, column loudspeaker is shown in Fig. 6. Screw terminals and the cover are also used in sets of electrical machines. The embodiment of covers *15* of terminals *1* and *4* for three phases induction motor *20* and for DC tacho-generator are shown in Fig. 7.

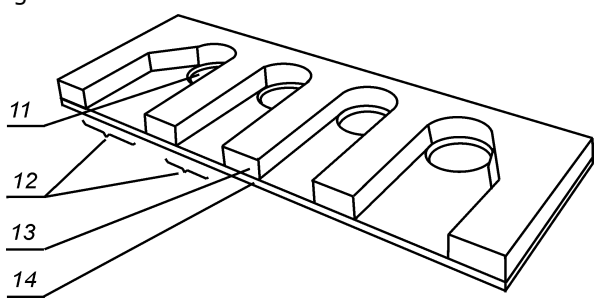

Figure 5. *The view of the bottom of the cover for the laboratory screw terminals*

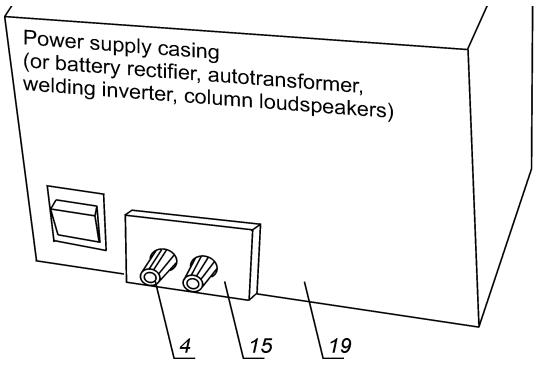

Figure 6. *The cover of screw terminals of industrial device or household appliance*

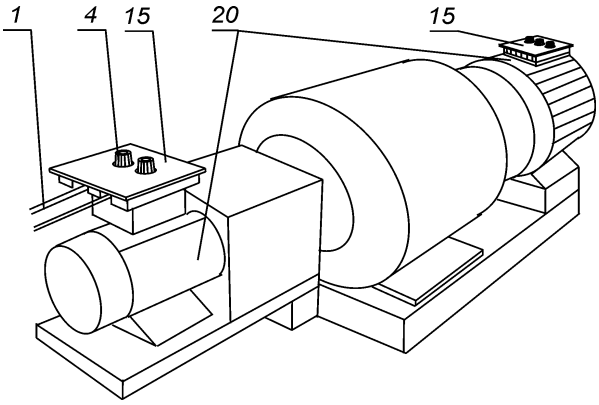

Figure 7. *The cover of screw terminals for electrical machines*

3. THE EXAMPLES OF APPLICATION

The examples of covers for different applications are descried in this chapter. In Fig. 8 covers for laboratory meters are shown, which are manufactured by company Mera Gostynin: for wattmeter *21*, voltmeter *22* and amperemeter *23*.

All covers are made of transparent material plexi-glass. Because of cover transparency, the descriptions of wattmeter *16* rangers *17* and wattmeter voltage coil polarity 18 are visible for user, like it is shown in Fig. 9. Cover *15* allows to connect one fork terminal *3* to one screw terminal *4* of wattmeter *16*, as it is shown in Fig. 9. However, cover *15* can have wider zone *12* for connection many fork terminals to one screw terminal, like is shown in Fig. 12 and in Fig. 14. Cover is narrow enough to make possible for user to take with ease isolated part 3 of fork terminal with fingers, like is show in **Error! Reference source not found.**.

Covers are composed of three layers. In previous figures **Error! Reference source not found.** – Fig. 7 the only two layers *13* and *14* are shown. The third layer *25* is glued to the bottom of cover *15*, as it is shown in Fig. 10. The templates of all layers *13*, *14* and *25* of cover for amperemeter are shown in Fig. 11. The cover *15* assembled from those three layers *13*, *14* and *25* are shown in Fig. 12. The third layer *25* was applied for two reasons.

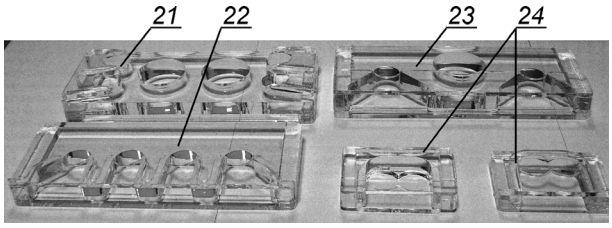

Figure 8. *The examples of covers for different laboratory electrical devices*

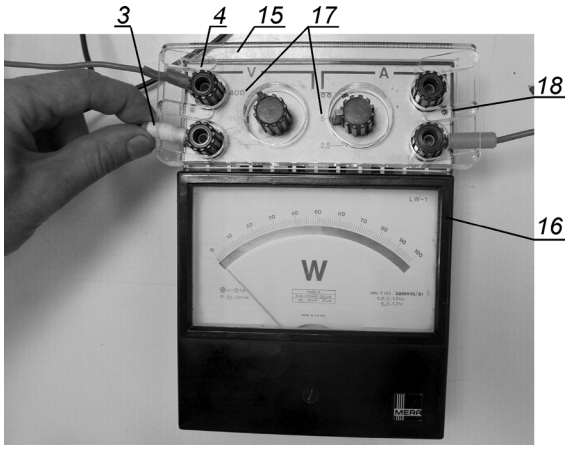

Figure 9. *The application of cover for power meter terminals*

Firstly, to prevent cover from dropping down when meter is turned upside down. In **Error! Reference source not found.** 10, when voltmeter *16* is reversed the fork terminal with cable do not allow the cover *15* to drop down.

Secondly, the third layer is applied in order to prevent user putting finger into zone *12* and to prevent touching the metal parts of connection under high voltage, like is shown in Fig. 12**Error! Reference source not found.**. The finger can not pass through the zone *12*, because height of zone *12* equal 10 mm is lower than average width of a grown human finger. The zone *12* does not prevent from contact with using special thin conductive elements that can be put inside this zone. However, it should be understood, that the cover protects user only from unconscious and accidental touch of metal parts of connection.

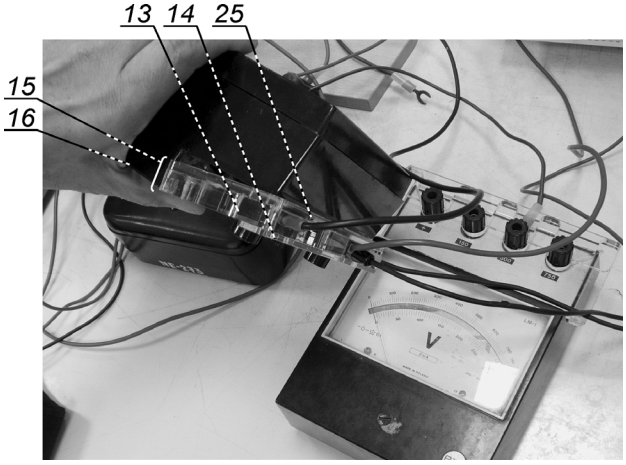

Figure 10. *The view of terminal when meter is tuned upside down*

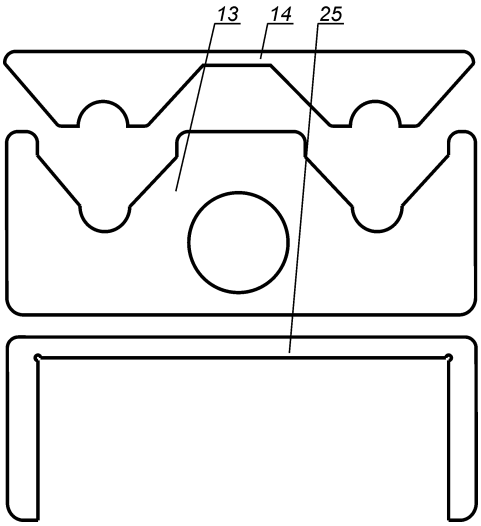

Figure 11. *The templates of all layers of cover for amperemeter*

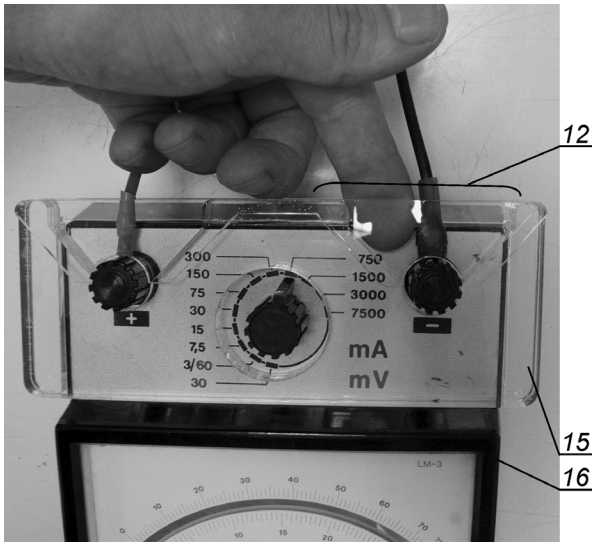

Figure 12. *The view of cover for laboratory amperemeter when trying to put a finger into the zone 12*

The covers *15* in application to laboratory autotransformer *26* are shown in Fig. 13. The fork terminal *3*, screwed in screw terminal *4*, blocks cover *15*. As the result, taking back cover *15* is not possible, because of the existence of the third layer *25*.

The application of the cover to the electrical machines are shown in Fig. 7 and in Fig. 14. In Fig. 7, the sets of screw terminals and the covers *15* are mounted directly on the electrical machines. In Fig. 14, the sets of electrical machine terminals are mounted on the laboratory table *28* away from the electrical machine. The main advantage of application terminals away from electrical machine is that, all the singular connections are done on the laboratory table and any cables does not hang from table towards electrical machine. As the result, user has no possibility to accidently tie himself with these cables. The case *7* with screw terminals *4* are connected to electrical machine with cable *27*. As it was mentioned before, the transparency of cover makes the scheme *29* of DC machine wirings and the symbolic names of terminals visible.

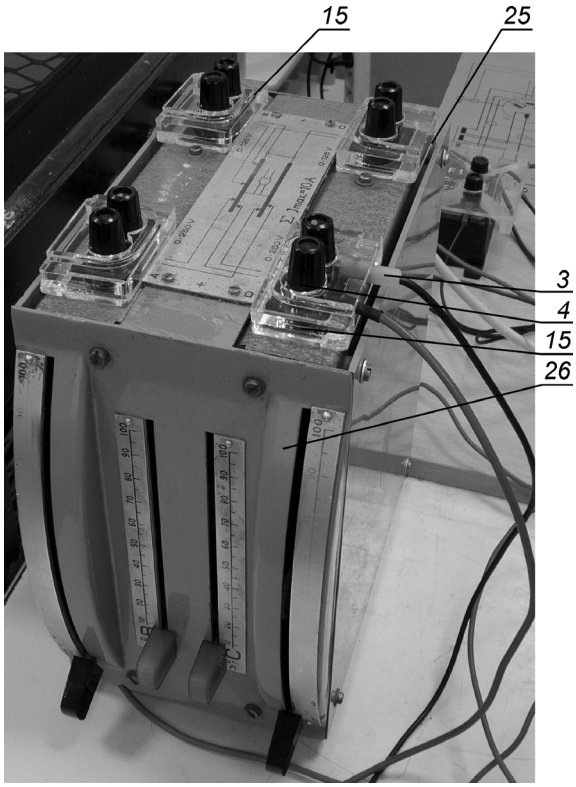

Figure 13. *The application of the cover for the laboratory transformer terminals*

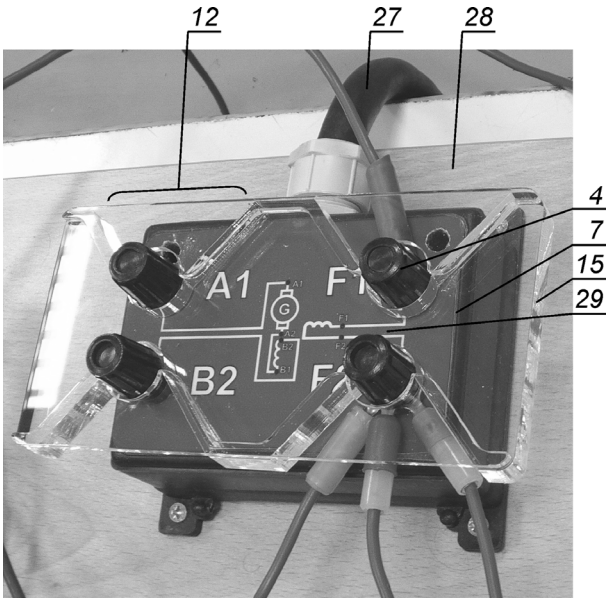

Figure 14. *The cover application for the electric DC machine terminals*

The cover can be used for terminals of other electrical equipment of research laboratories, for example, for the resistor, in Fig. 15. The cover 15

is mounted on the mounting plate *7* of the resistor *30* with screw *31* as it is shown in Fig. 16.

The cover can be used with screw terminals of different sizes. The application examples of cover for screw terminals with durability of 30 A and 100 A are shown in **Error! Reference source not found.** and **Error! Reference source not found.**. respectively.

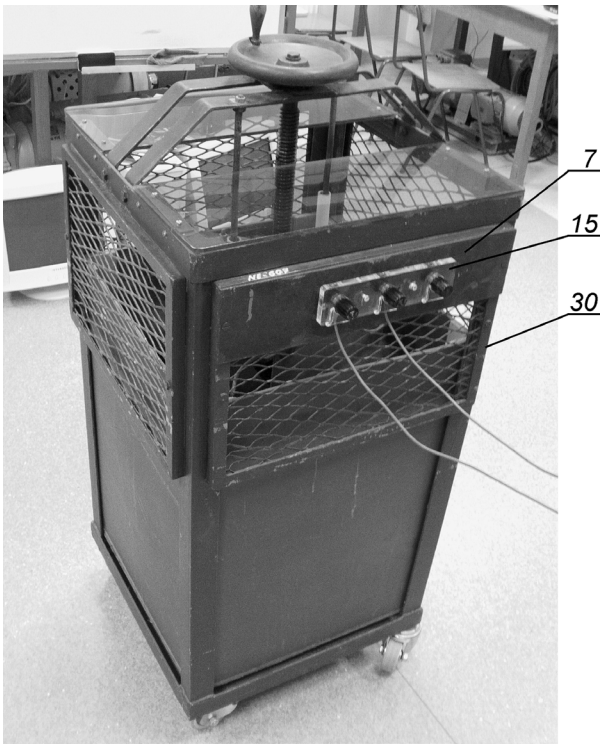

Figure 15. *The application of cover for a adjustable resistor*

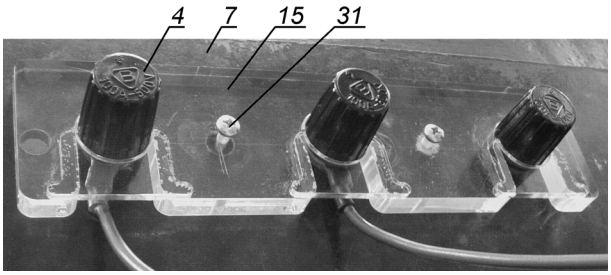

Figure 16. *The application of cover for an adjustable resistor*

4. CONCLUSION

The paper arose as an answer to emerging need to rise safety level of the electrical engineering laboratory environment in terms of prevent possible dangerous and hazard situations caused by laboratory staff and students. The paper presents various types of covers of the laboratory screw terminals can find its use in variety devices such as: sets of electrical machines: motors, generators, transformers, power electronics devices, electric meters (e.g. amperemeters, voltmeters, wattmeter), and in an industrial devices like welders, as well as in a house hold devices like column loudspeakers or battery chargers, laboratory resistor etc. The cover can assure protection of laboratory personnel against the direct and accidental contact to metal parts under high voltage of the screw terminals leading to potential electric shock.

The cover has many additional functionalities such as transparency, can protect connections with one or with many fork contacts, can be applied with screw terminals with different sizes. After application additional third layer the fork terminal block cover from removal. It is important, because after connection the circuit it is not possible to remove the cover and the protection of laboratory personnel is ensured.

The simple cover design solves not only technical problems, but also sociological problems. The basic advantage of cover design is easy mounting without additional expensive devices for plastics forming by injection. The cover simply consists of three plate elements, which are cut from plexi-glass and fixed each other with glue. Because of easy mounting with glue, the cover can be mounted by differently enabled people. It is very important, because this feature allows to solve employment problem of those people a little bit and delivers opportunities for a tolerant society of people with different and full abilities.

ACKNOWLEDGEMENTS

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Improvement of Student's Engine Room knowledge and operational skills during Simulator training

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Abstract: *One of the most important tools for maritime student education is the use of simulators, which provide practical instruction under controlled conditions. This article analyzes the behavior of Marine Engineering students at the Faculty of Maritime Studies in Split and their progress in knowledge and practice achieved through training in the Kongsberg Engine Room Simulator. The research was conducted by the instructors of the Kongsberg training simulator with the students of the third (last) year of the undergraduate study of Maritime Engineering. The progress was observed during the last semester of their studies on the practical problem of manual parallel connection of diesel generators. The obtained results clearly show that the training on the simulator helped the students to combine the learned theory from several subjects into one complex and that this happens gradually during the training.*

Keywords: *simulator training; STCW; Kongsberg; engine officer; synchronization*

1. INTRODUCTION

The distinctive feature of maritime universities compared to other universities is that their curriculum is largely governed by international regulations, in this case mainly the Seafarers' Training, Certification and Watchkeeping Convention (STCW) [1]. The Faculty of Maritime Studies at the University of Split, as one of the maritime higher education institutions, falls under the same rules, which determine, among other things, the training of students in simulators as well as practical training on ships.

The Department of Marine Engineering has several simulators for different courses, including the Kongsberg K- SIM ERS -L11 MAN B&W-5L90MC VLCC Simulator [2].

Figure 1. Kongsberg Simulator Control Room

This Simulator consists of three separate rooms, two where the training is conducted (Engine Room and Engine Control Room) and an instructor's station for supervision of the exercise. The training is designed to teach students to solve practical tasks using the knowledge they have acquired. In the Simulator, students are introduced to their future profession as an Officer in charge of an engineering watch. The Officer in charge of an engineering watch (Marine Engineer or Engineering Officer) must have a good knowledge of the various machinery and technical systems, be familiar with the environment, always follow the correct procedures and react quickly to various situations, challenges or dangers to themselves or the equipment. All these qualities are taught to the students during the Simulator training and are required from them during the final exam. The situations and machinery problems (various malfunctions) they face are very similar to real-life situations and, most importantly, everything happens in real time.

In order for Simulator training to have the greatest possible effect, students must be familiar with various machines and engineering systems. Therefore, the simulator courses are held in the sixth semester (third year of study), when the students are in the final phase of their studies. Simulator training should "*contribute to the students' efficiency and experience and increase their confidence in simulated situations*" [3], or, to quote another researcher, "*to instill adequate skills to handle normal and abnormal situations*" [4]. The

training and education should create the necessary difference needed for their future work.

There are two categories of engine watchkeeping personnel, divided by level of responsibility and understanding of the "bigger picture" of operating principles and potential problems. These categories are Engine ratings and Engineering officers. Their main difference lies in the level of education and thus certification [5].

Engine ratings, especially well-experienced ratings can have a good insight into daily operations and can offer good solutions to the problems at hand. In addition, they usually can successfully perform a variety of actions successfully on their own and without supervision. At the same time, engine rating's understanding of the whole process they are performing is very limited, they know how to do it, but he does not know why.

Engineering Officers should also should be able to perform a variety of actions independently and successfully without supervision. In addition, because of their education and training, they must know in detail the entire process they are dealing with and know at all times what the consequences of their actions may be. Engineering Officers must apply the skills and knowledge they have learned during their education and training in their daily work.

Because of the different training and skills, the Engineering Officer is the one who makes the decision, deals with the consequences and finally takes responsibility.

2. SYNCHRONIZATION EXERCISE

Students (trainees) are required to learn and perform a multitude of exercises during Simulator training. The most common exercises are starting various machinery systems like starting air, cooling fresh water cooling, sea water cooling, lubricating oil, fuel oil supply, ventilation and air conditioning, …, and the most important system on any ship, the generation of electrical power. Without this system, no other system on the ship works and the ship cannot perform its function. Electrical energy on ships is generated by generators, usually powered by diesel engines. Each ship must have several generators in order to be able to respond to changes in energy demand and to have redundancy due to the importance of the system. Depending on the requirements of the ship's network and the consumers, one or more generators run, connected to the ship’s busbars. Today, the monitoring of the entire system and the execution of all steps is done automatically. When the computer decides that another engine is needed, an engine is started, synchronized and connected to the ships' busbars. If a human operator wants to start an additional generator engine, he can give the computer the command to do so remotely. The whole process is relatively short and simple, especially if the automatic system is working properly, and can easily be done by either by Engine ratings or an Engineering Officer. The difference between the two is noticed when problems occur and when the system starts to function abnormally.

As described in the introduction, simulator training can be seen as a bridge between practice and theory. Assuming that students have learned the theoretical part and are ready to face the challenges of the practical simulator, the training is conducted in a way where students actively participate in various operations and problem-solving classes.

In this method of training, students are given standard ship checklists and are encouraged to carry out the exercise themselves under the guidance of an instructor. Any problems they encounter along the way can be considered learning checkpoints, because at these moments the students have to draw on their theoretical knowledge and use it to solve the problem. This is the foundation on which they will build their future experience.

The Simulator exercise recreates extraordinary situations where education and training should be beneficial. In the first part of the exercise, the computer system has failed and the monitoring of the generator and load should be done by a human. When the student determines that an additional generator is needed, he has to start a generator, synchronize it and connect it manually to the busbars.

To perform this task manually, the student must be familiar with the three conditions required to synchronize a generator (only three which the operator can change):

- The incoming generator voltage and the mains voltage must match,
- the frequency of the incoming generator and the mains should be almost the same,
- the phase sequence and phase position of the incoming generator and the mains should match.

Only when the student knows these conditions, he can perform the manual synchronization [6] of the generator.

2.1. Synchronization procedure

After connecting one generator to the ship's grid and starting and warming up another generator, the student should proceed with the process of synchronization. After turning on the synchroscope on Synchronizing Panel (Figure 2), the student must select the generator to be connected to the network (the incoming generator).

At this moment, the displays at the top of the Synchronizing Panel start to show the correct values. The first thing the students have to check

is that the two voltages are the same. The voltages of the incoming generator and the mains are fixed by the manufacturers and normally do not need to be adjusted. If the student needs to perform an adjustment, they can do so by setting the AVR (Automatic Voltage Regulator).

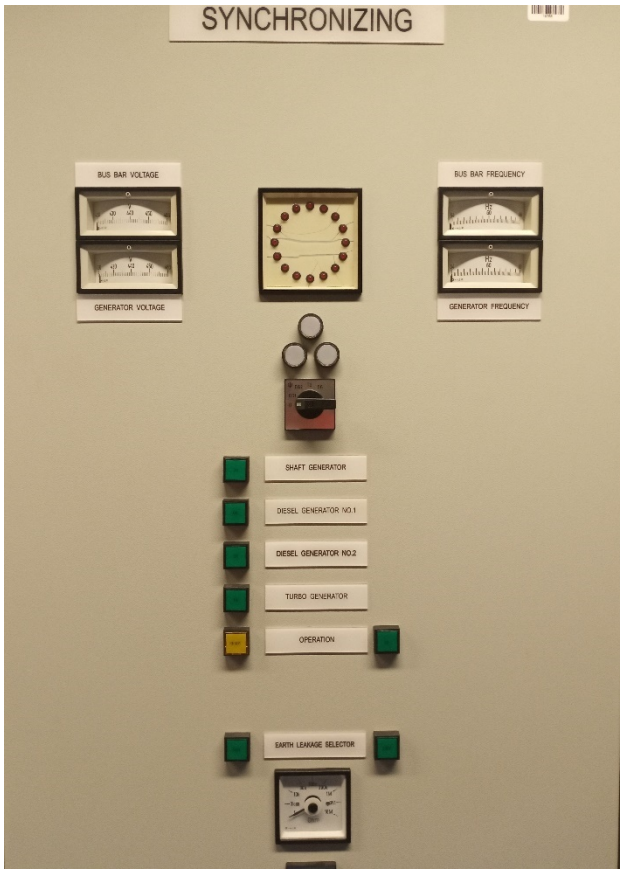

Figure 2. Simulator Synchronizing Panel

After checking that the voltages are equal in the upper left part of the Synchronizing Panel (Figure 2), you need to check and set the next condition, which is that the frequency is almost equal.

The frequency meters are in the upper right part of the panel and both frequencies should be almost the same. If an adjustment is required, you should operate the frequency adjustment handle (Figure 3) to achieve the correct results.

Figure 3. Frequency adjustment handle

The frequency of the incoming generator can also be checked by means of the rotating lights (upper part, in the middle), which indicate the difference in frequency between the generator and the mains. If the lights rotate too fast in either direction (clockwise or counterclockwise), it means that the incoming frequency should be adjusted until the rotation slows down. Once you have adjusted the frequency of the generator, you can move on to the last part of the synchronization, which is to adjust the phase and connect the generator to the mains.

The rotating lights should turn slowly clockwise, which means that the frequency of the incoming generator is slightly higher than that of the mains and the generator will start generating electricity after being connected. The generator can also be connected also if lights rotate slowly counterclockwise, which means that the incoming generator has a lower frequency than the mains. Connecting the generator in this condition will make the generator run like a motor (consuming electricity instead of generating it) and can trigger a reverse power protection trip if the power is too high or the time for such work is too long.

Another mistake students can make is connecting the generator when the rotating speed is too high. This action can lead to an aggressive connection and cause damage to the engine and generator.

After getting everything ready, the student should wait until the rotating lights arrive just before the 12 o'clock position and then connect the generator to the mains. When making the connection, the student should ensure that the load of all generators is evenly distributed [7].

3. STUDENTS' PROGRESS

The first assessment was conducted when the instructors determined that familiarization with the simulator was complete, i.e. after 16 hours of instruction. During this time, the students learned about the simulator set-up, functioning and operation principles of the simulator and performed several exercises and tasks. One of the normal tasks was to remotely connect another generator in automatic mode. They performed this task several times and were familiar with the procedure. The assessment consisted of the synchronization process after a computer failure, i.e. manual synchronization, where the students had to answer several questions to show that they understood the background of the process. At the end of the practical demonstration, the students had to answer a questionnaire with 10 questions to check their theoretical knowledge about actions.

The results of the first assessment are shown in Table 1.

Table 1. *The first assessment success rate*

Practical	Answers	Questionnaire
7/23	4/23	17/23
30%	17%	74%

Despite familiarization and theoretical knowledge, very few students managed to pass the assessment. The only area where the results were acceptable was the questionnaire, which 74% of the students passed, all other results were very poor.

At the end of the semester, the students were tested again using the same approach. The test was repeated and this time the pass rate was 100%, which can be explained by the consequences of failing the first assessment. After this part, the students are tested again, only this time the questions and tasks have been adjusted to a higher level. Besides the computer failure, there was an additional failure of the governor motor, which made it impossible to use the frequency adjustment handle. This largely complicated synchronization process, which required local manual adjustment of the governor to the value at which the incoming generator frequency is too high compared to the mains, followed by an increase in the mains frequency, creating the synchronization conditions. After synchronization and connection of the generator, the mains frequency should be set to a normal value, resulting in load sharing to the newly connected generator with a faulty governor motor.

Table 2. *The second assessment success rate*

Practical	Answers	Questionnaire
21/23	19/23	22/23
91%	82%	95%

As shown in Table 2, the vast majority of students succeeded in passing the assessment despite the relatively complex scenario. The assessment results clearly show the great progress made by the students during the Simulator course. The same results have been reached by many researchers in the maritime industry [8, 9, 10] as well as in other industries [11, 12].

4. CONCLUSION

From the assessment results, it is clear that the students have improved significantly since they started the Simulator training. The Simulator training allowed the students to apply their theoretical knowledge for the first time and "connect" it with practice.

When the parallelization problem was first presented to the students, many of them knew the definition from the textbook and the conditions for parallelization (almost 75% of the students), but did not know how to perform the operation. Only a small number of students were able to perform the required task on the first assessment, showing that theoretical knowledge alone is not sufficient. After mastering the operation procedure, theoretical and practical knowledge were merged and students were not only able to perform this and many other exercises, but also to understand the whole background of the process. This moment represents the point at which the students transform from being Engine room ratings to future Engineering Officers.

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Integration of virtual instrumentation in marine electrical engineering education

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Abstract: *Virtual instruments have wide application and they are used not only for measurements and control but also as an excellent tool in engineering education. They can be utilized in real and actual laboratories. They present huge support for individual learning and distance learning. This paper presents an example of using virtual instruments in the education of future Electro Technical Officers, actually the present students enrolled in the study program of Marine Electrical Engineering at Faculty of Maritime Studies Kotor, University of Montenegro. With the aim of promoting practical exercises for the subject Ship's Measurements as a part of the undergraduate study of Marine Electrical Engineering, the paper proposes examples of laboratory exercises with belonging schemes of connection and experimental set up.*

Keywords: *engineering education; virtual instrumentation; practical teaching; ship's measurements; LabVIEW*

1. INTRODUCTION

A number of measurements of physical values (the process values) of non-electric values are carried out on a ship for the purpose of managing ship and ship processes. Among these measurements, of special importance are measurements of temperature, pressure, flow, and level [1]. Due to the importance of process measurements in shipping, the education of seafarers should be enhanced with the subjects dealing with ship measurements so that the students can get familiar with the modern methods of measurement and acquire the knowledge and skills for independent work and future career. Practical education is a significant domain of the education process and learning and has a significant impact on seafarers' education. Therefore, laboratory exercises are very important part of engineering education, especially in the field of the ship's measurements principles [2]. With the development of e-learning, there is a considerable need for new methods of organizing laboratory work that are being under examination [3]–[5].

Virtual instrumentation connects sensors, hardware, and software technology with the aim of creating flexible and sophisticated instruments for process control and measurements [6]–[9]. Virtual instrumentation has defined a methodology for projecting measurement instruments that use a standard computer of general purpose, special hardware components for acquisition and digital conversion of the signal, and computer programs that provide collection, process, sign, and display of signal at the computer [6]. This universality introduces one key feature of the virtual instruments, enabling the user to modify desired functions in order to fit the wide spectrum of applications.

A review of the literature shows that LabVIEW is one of the primary software in designing applications and analytical solutions in different fields in engineering technology and education, such as biomedical engineering [10], electrotechnics [11]–[13], chemistry and chemical engineering [14], physics [15], mechanical engineering [16] and other.

Virtual instrumentation has a great role in the teaching process [17], in different fields of science: mathematics, physics, chemistry, biology, etc., improves the research process and increases the base of knowledge in other domains [18]. It also enhances learning in the laboratory, reduces the risks of the laboratory equipment, and enables the approach to expensive laboratories via the Internet connection [19]. From the aspect of distance learning [20]–[22], virtual instrumentation can be used to improve engineering courses, and the fact that it can be used with the aim of simulation of a physical phenomenon, to generate signals and read the results in real time [23], [24].

The use of educational tools the personal computer (PC) in the laboratories has become common in many training centers providing courses in the domain of engineering and technology. The research was conducted with the aim of acquiring virtual tools that resemble real surroundings for the purpose of motivating students' work [25]–[29].

In this paper, virtual instrumentation will be applied for creating several laboratory exercises for the subject Ship's Measurements which is conducted at the Faculty of Maritime Studies Kotor, University of

Montenegro, at the study program Marine Electrical Engineering.

The designed laboratory exercises presented in this paper will contribute to a better understanding of the contemporary methods of measurements of the process values and acquiring the practical knowledge necessary in the process of seafarer's education.

The paper is composed of the following sections. The first section presents the introduction. In the second is shown the importance of measurements in the process of education of the future Electro Technical Officers through the introduction of the new laboratory exercises within the subject Ship's Measurements of the study program at the Faculty of Maritime Studies Kotor, University of Montenegro. The concept of virtual instrumentation is shown in section three. A review of the laboratory exercises is given in section four.

2. MARINE ELECTRICAL ENGINEERING EDUCATION

Nowadays, the Electro Technical Officer (ETO) role became one of the more and more popular professions in the maritime industry [30]. The role of the Electro Technical Officer is defined by changes in the Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) from 1978. with amendments added in 2010 (Table A-III/6 STCW) [31]. Electro technical officers are responsible for supervision of systems and components in the fields of electrical engineering, electronics, communications, automatic control, and other on board in order to increase the operational safety and efficiency of the ship under the supervision of the Chief Engineer.

The ETO officer is one of the most important roles on board modern ships, especially when it comes to the expertise of handling important and complex electrical and electronic systems, without which is not possible to process some of the basic operational functions of the ship itself. On contemporary passenger ships which are equipped with diesel electric propulsion, the list of responsibilities and tasks of the Electro Technical Officer is even greater because it is necessary to maintain: air conditioning and heating systems, computer and communication systems, elevators, electric propulsion motors, generators and high voltage motors, main switchboards with transformers and high voltage distribution, automatic alarm and monitoring system (Machinery Automation System - M.A.S.), propulsion and steering machinery with converters, emergency lighting converter and associated emergency batteries, UPSs with batteries, complex navigational and communication equipment, etc.

The role of the ETO onboard a ship is extremely important, bearing in mind the trends in the technology of the production and use of modern ships, as well as the fact that the important ship's functions are increasingly under the supervision of automation systems and even artificial intelligence.

Future ETO officers are being educated in the study program of Marine Electrical Engineering, Faculty of Maritime Studies Kotor, University of Montenegro [32]. Within the framework of this study program, students have the opportunity to gain proper knowledge in all areas of marine electrical engineering which is necessary for quality training of future ETO officers. In the education of ETO officers and preparation for work onboard a ship, a very important segment is a practice as well as practical exercises in high-voltage and electrotechnical laboratories. The integration of virtual instrumentation into the teaching process through the subject Ship's Measurements represents the improvement of practical teaching.

The objectives of the Ship's Measurements course are to familiarize students with basic electrical and electronic measurements and instrumentation, and also to show them the principles of basic non-electrical measurements of physical quantities such as temperature, pressure, flow, level, etc.

3. VIRTUAL INSTRUMENTATION

The application of the concept of virtual instrumentation is of exceptional importance in measurements. The creation of instruments "per measurements" gives users the possibility of wide applications, and a variety of sophisticated sensors, modern design technology, enable the application in different fields of science and technics. Its application has special importance in the education process.

The concept of virtual instrumentation refers to the transition from traditional hardware measurement devices to modern software-oriented measurement systems [6].

Virtual instrumentation is a concept meaning integration of hardware and software, encompassing the processes of measurement, acquisition, processing, and display of the obtained data, representing the trend in technics and science due to the rising complexity of engineering jobs, the growing need for specialized and sophisticated instruments and software solutions, as well as the need for highly skilled personnel for work with the instruments. The application ranges are from the simple laboratory experiments to the complex applications for automation purposes [6], [8].

The company National Instruments has implemented a specialized software package LabVIEW enabling the program devices that will perform the role as conventional measurement instruments where the complete analysis and data processing is simultaneously performed on the personal computer. Therefore, personal computer takes over the role of the conventional instrument whereas the graphical user interface programmed in LabVIEW may represent the real instrument and that's where it comes from the title virtual instrumentation [6].

The purpose of the virtual instrument is identical as the function of the classical instrument. The difference is that the virtual instrument may change and adapt to the measuring process compared to a classic instrument which has unchangeable functionality stated by the producer. Representation of measured data is usually in graphical form, functions, and controls, of a graphical interface that resembles real measurement instruments. The interface is active and has possibilities of the control of measurement process, defined by the signal parameters which are generated [6], [8]. The measurement-acquisition system based on PC computer is shown in Figure 1.

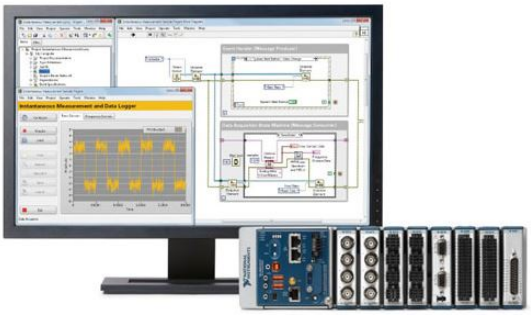

Figure 1. *Measurement- acquisition system based on PC computer* [33]

4. PERFORMING THE EXPERIMENTS

The laboratory exercises simply presented in this section show the application of virtual instrumentation in the implementation of practical classes in the field of ship's measurements. It is possible to easily create virtual instruments that enable the measurement of basic electrical and non-electrical quantities.

To implement the exercises, it is necessary to have a computer on which the LabVIEW software is installed, a power source, various sensors, acquisition cards etc. The advantage of such laboratory exercises is the simplicity of the hardware (DAQ-data acquisition, sensors, power supply) and the possibility of creating creative solutions in the LabVIEW program. The acquisition card (DAQ) is controlled via LabVIEW for generating and obtaining physical signals in the laboratory environment. The obtained results can be processed in different ways within the LabVIEW software package.

In this section, four laboratory exercises are presented, two for measurement of electrical quantities and two to the measurement of non-electrical quantities. Laboratory exercises 1 and 2 refer to the measurement of voltage and current. The goal of these laboratory exercises is to gradually introduce students to the use of virtual instrumentation, the connection of all elements in the measurement system, and especially the use of acquisition cards and the creation of virtual instruments through basic measurements in electrical engineering, which include current and voltage measurements. Laboratory exercise 3 shows temperature measurement. The goal of this exercise is to show students how to measure signals from thermocouples using a measuring system based on a PC. Mass measurement, including calibration of the measuring cell, is shown in laboratory exercise 4.

4.1. The laboratory exercise 1

A laboratory exercise related to voltage measurement is shown in this section.

To perform this laboratory exercise, the necessary equipment consists of an acquisition card NI 6009, a potentiometer (BK5), and an experimental board. The connection set up scheme of this laboratory exercise is shown in Figure 2.

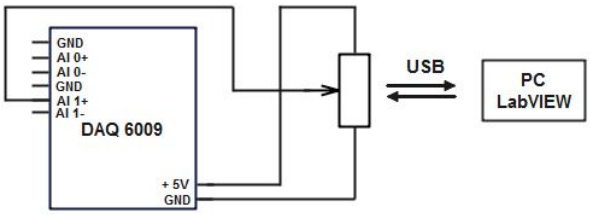

Figure 2. *Connection scheme for laboratory exercise of the voltage measurement*

First, it is necessary to connect the NI 6009 acquisition card to the computer via a USB cable. As shown in Figure 3, the potentiometer is connected to the experimental board. One end of the potentiometer is connected to the digital input of the acquisition card (GND), while the other end is connected to the digital input (+5V). The middle output of the potentiometer is connected to one of the analog inputs.

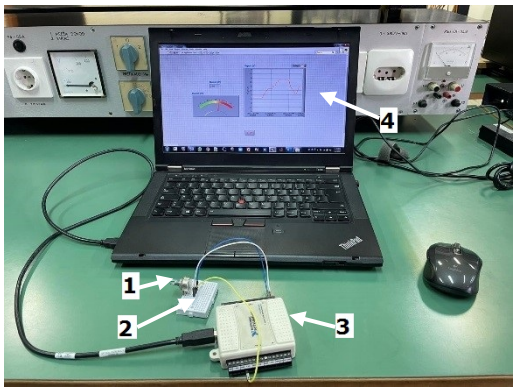

Figure 3. *Experimental set up for laboratory exercise of the voltage measurement*

In Figure 3, the following are marked with numbers:

1- potentiometer;

2- experimental plate;

3- acquisition card NI 6009, and

4- computer with installed LabVIEW software.

Front panel of the laboratory exercise related to voltage measurement in the LabVIEW 2021 software is shown in Figure 4.

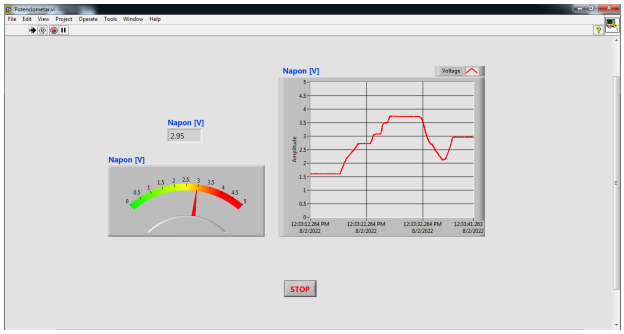

Figure 4. *Front panel of the laboratory exercise 1.*

4.2. The laboratory exercise 2

This section shows laboratory exercise related to the measurement of current through a shunt resistor.

To perform this laboratory exercise, the necessary equipment consists of an acquisition card NI 6009, a shunt resistor with power of 40 W and resistance of 1 Ω, and a light bulb with a power of 100 W. The connection scheme of this laboratory exercise is shown in Figure 5.

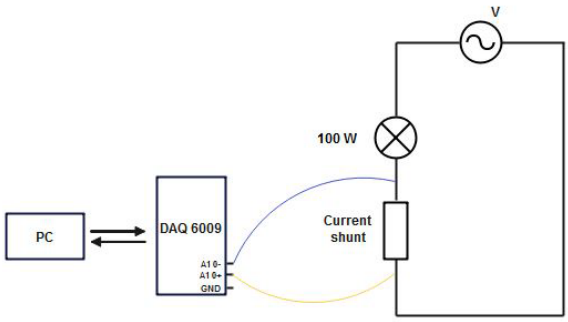

Figure 5. *Connection scheme for laboratory exercise of the current measurement*

The voltage from the autotransformer is applied to the serial connection of the light bulb and the shunt resistor (low resistance). An NI 6009 acquisition card is connected parallel to the shunt, which is connected to a computer via a USB cable, as it is shown in Figure 6.

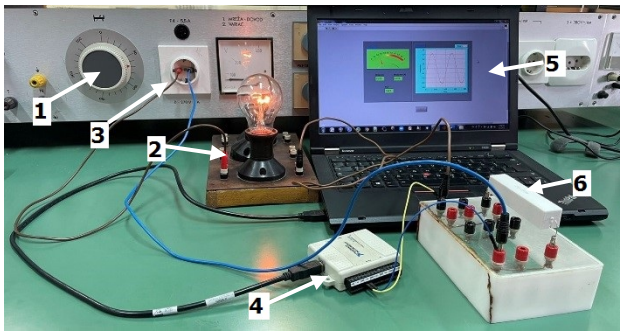

Figure 6. *Experimental setup for laboratory exercise of the current measurement*

In Figure 6, the following are marked with numbers:

1- autotransformer;

2- board with light bulb;

3- power supply;

4- acquisition card NI 6009;

5- computer with installed LabVIEW software and

6- shunt resistor.

Front panel of laboratory exercise 2 related to the measurement of current through a shunt resistor in the software LabVIEW 2021 is shown in Figure 7.

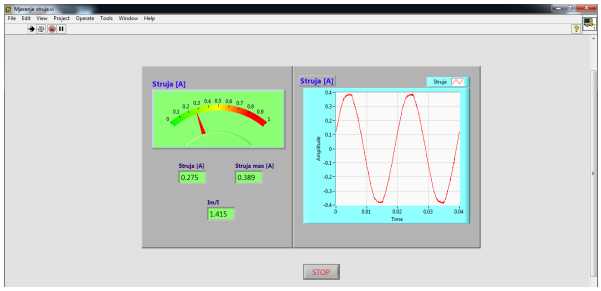

Figure 7. *Front panel of the laboratory exercise 2.*

4.3. The laboratory exercise 3

A huge number of non-electric quantities are measured on ships for the purposes of managing ship processes, among which a special place belongs to temperature measurements. There is a variety of temperature sensors which have application onboard, but the thermocouple is the most commonly used sensor for temperature measurement due to its low price, wide measurement range, ease of installation, and easy application [6], [13].

Thermocouples are based on the thermoelectric effect (Seebeck effect). According to the Seebeck effect, a voltage differential can be created between two electrical conductors or semiconductors by varying their temperatures. The Seebeck voltage depends on the type of material and the temperature difference between T_1 and T_2 (Figure 8) [17].

$$U_{AB} = K_A\,(T_2 - T_1) - K_B\,(T_1 - T_2) = \alpha\,(T_2 - T_1) \quad (1)$$

where K_A and K_B are the thermoelectric constants of two conductors, and the coefficient α is the thermoelectric Seebeck proportionality constant that depends on those two conductors [17].

Figure 8. *Thermoelectric circuit* [13]

This section shows laboratory exercise related to temperature measurement.

In order to perform laboratory exercise related to the temperature measurement with a thermocoule, it is necessary to have the following equipment: a thermocouple (J type), a personal computer with

LabVIEW software and NI cDAQ-9178 chassis with an NI 9211 data acquisition card and two cups (with hot and cold water).

Experimental setup for temperature measurement is shown in Figure 9.

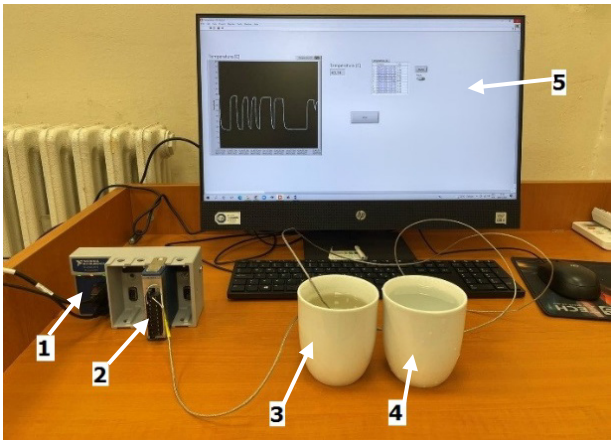

Figure 9. *Experimental setup for temperature measurement*

In Figure 9, the following are marked with numbers:

1- NI CompactDAQ Four-Slot USB Chassis (cDAQ-9174);

2- acquisition card NI 9211;

3- cup with hot water;

4- cup with cold water, and

5- computer with installed LabVIEW software.

In Figure 10 is shown the connection scheme for thermocouple binding with an acquisition card.

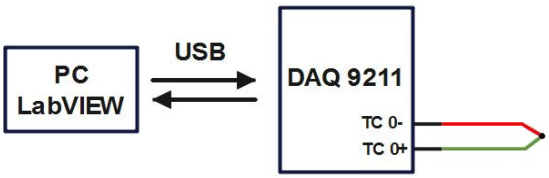

Figure 10. *Connection scheme for thermocouple binding with an acquisition card*

The process of temperature changes, increase and decrease, while the thermocouple is transferred from one cup to another, is monitored on the LabVIEW 2021 front panel shown in Figure 11. All measured temperatures are stored in Excel format and in this form gained results are ready for further processing.

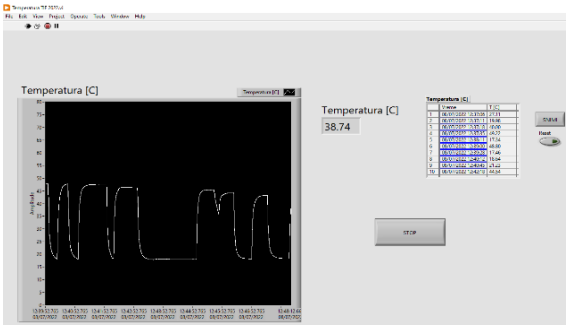

Figure 11. *Front panel of the temperature measurement in LabVIEW software*

4.4. The laboratory exercise 4

A laboratory exercise related to the mass measurements, including the calibration of load cell is shown in this section.

The load cell belongs to the group of resistance sensors for the load measurements. It is made of aluminum which is weakened in the middle part to enables elastic bending. Strain gauges are placed on the upper and lower sides. They are arranged so that two are placed on the top of the opening of the load cell, and two at the bottom [34]. This arrangement allows the strain gauge to be connected to the Wheatstone bridge circuit as shown in Figure 12.

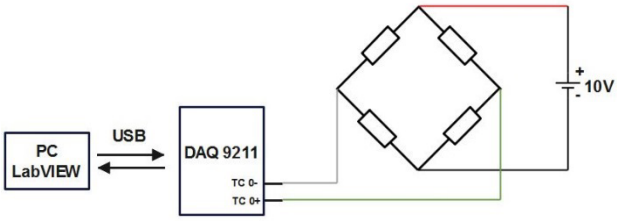

Figure 12. *Connection scheme of the measuring cell and acquisition card*

When the load cell is loaded, it bends, the strain gauge tightens and leads to a change in its resistance. Before starting the mass measurement with the load cell, it is necessary to determine its characteristic or clarify the relation between input and output quantities. This characteristic of the load cell with strain gauge represents the correlation between load cell output voltage and load itself. To determine this characteristic, it is necessary to calibrate the measuring cell. This procedure can be performed by measuring the output voltage U of the measuring cell for different values of the known mass m. In this way, the characteristic of the measuring cell is obtained as a set of measured points *(m, U)* [34].

Experimental setup for mass measurement is shown in Figure 13. The measuring system consists of a load cell (CZL602 3 kg), 10 V battery, NI-9211 data acquisition card manufactured by National Instruments, and load.

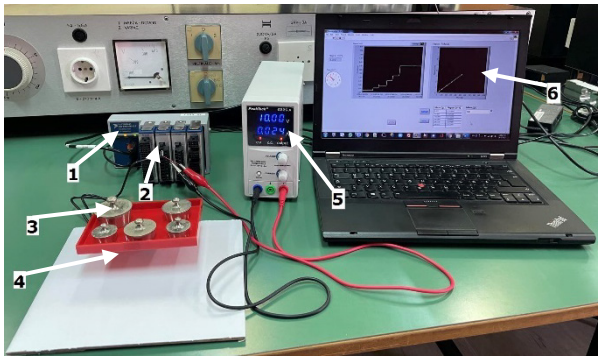

Figure 13. *Experimental setup for mass measurement*

In Figure 13, the following are marked with numbers:

1- NI CompactDAQ Four-Slot USB Chassis (cDAQ-9174);

2- acquisition card NI 9211;

3- load 50 to 500 [g];

4- load cell CZL608 3 kg;

5- 10 V battery, and

6- computer with LabVIEW software installed.

Figure 14 shows the calibration procedure. The beginning of the calibration starts with the measuring cell without load and this initial state must be recorded and output voltage must be measured. The measured output voltage will be of non-zero value due to system imperfections. It is possible to override this voltage by using the software. After the zero point for voltage measurement is set up, it is necessary to fill in the initial values in the table in the front panel of the LabVIEW software, which will be displayed graphically at the same time [34]. After this first step, it is necessary to add additional load to the measuring cell of 50 g and save the obtained results in the table. Each following load placed on the load cell should be greater than the previous one, and procedure should be carried out until the nominal load is exceeded. When the calibration is finished (by clicking the "Stop" button), the calibration program will be stopped.

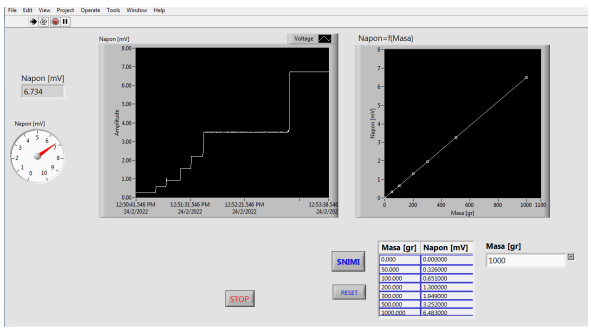

Figure 14. *Front panel of the laboratory exercise for load cell calibration in LabVIEW software*

After the calibration process, an application for measuring unknown masses was created and it is shown in Figure 15.

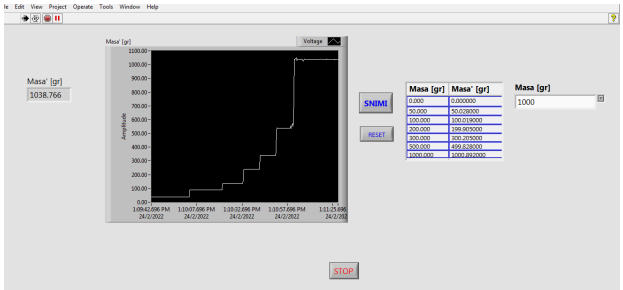

Figure 15. *Front panel of the laboratory exercise for measuring an unknown mass*

Numerical data of the load cell calibration is given in Table 1. Calibration has been performed for different loads up to 1000 g.

Table 1. *Measurement results of load cell calibration*

m [g]	***U [mV]***
0	0
50	0.326
100	0.651
200	1.300
300	1.949
500	3.252
1000	6.483

Using the created program, measurements were made with known masses and the measured deviations are presented in Table 2.

Table 2. *Results of measurement of mass and absolute and relative deviations*

m [g]	***m' [g]***	$\Delta m = \lvert m' - m \rvert$	$\delta m = \frac{\Delta m}{m} \cdot 100$ ***[%]***
0	0	0	0
50	50.028	0.028	0.056
100	100.019	0.019	0.019
200	199.905	0.095	0.047
300	300.205	0.205	0.068
500	499.828	0.172	0.034
1000	1000.892	0.892	0.089

CONCLUSION

The paper presents a few examples of laboratory exercises that represent the beginning of the application of virtual instrumentation in the teaching process at Faculty of Maritime Studies Kotor. These exercises represent the improvement of practical teaching within the subject Ship's Measurements. The schemes and the experimental setup for four

laboratory exercises related to voltage measurement, current measurement, temperature measurement with thermocouples and mass measurement with the previous calibration of the measuring cell are presented.

Future directions of research refer to the creation of virtual instruments for more complex temperature measurements on one of the systems used on board ships, as well as the survey students' satisfaction with this type of experiments.

ACKNOWLEDGEMENTS

This paper has been prepared within the framework of the ERASMUS+ CBHE project titled "Sustainable development of blue economies through higher education and innovation in Western Balkan Countries - BLUEWBC". Also, the research presented in this paper is supported by the Ministry of Education, Science and Technological Development of the RS, contract no. 451-03-68/2022-14/200132, which is implemented by the Faculty of Technical Sciences in Čačak - University of Kragujevac.

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Field reversal DC machine braking with DCM drive

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Abstract: *This paper gives a detailed description of implementation of braking by field reversal at laboratory setup of DC machine with modern Siemens DCM drive. The main focus of the paper is implementation of braking procedure of the DC machine using field reversal through didactic approach suited to students of electrical engineering within the course of the electric drives at Faculty of Technical Sciences Čačak. The laboratory test bench allows students to upgrade parts of the setup and test different operation regimes of DC and AC machines, as well as gaining experience of tuning and optimization of the overall motor-load system.*

Keywords: *DCM drive; Braking; Field reversal; Laboratory setup; Siemens sinamics;*

1. INTRODUCTION

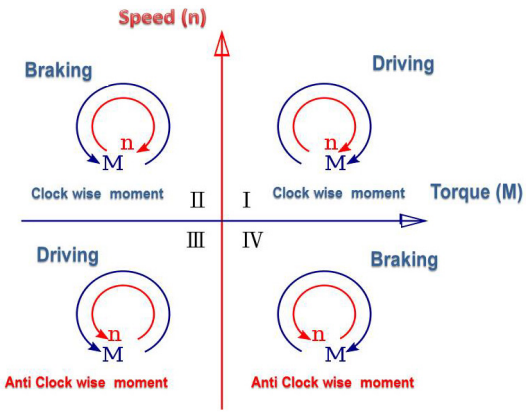
DC machine is an unavoidable part of electric drives in industry. In the past they were used for industry processes that require a wide range of power and speed as well as high accuracy in terms of torque, speed and position control.

Nowadays the majority of all electromotor drives in industry are AC drives, but even today there are obsolete or even new implemented DC drive running. Retrofitting those existing DC drives with AC machines and AC drives sometimes can be more expensive than just repairing and adding new DC drive, making economically unjustifiable a change it to AC drive [1]. Because of this reason, the principles of operation and control of DC drives are still studied in courses of electrical machines and drives at universities around the world.

The software capabilities of modern converters and drives with the development of power electronics are becoming more complex and sophisticated. Different control principles and various states of electric drive systems are today accompanied by numerous parameters that can be set on the modern converters and drives, prior electric drive commissioning and operation. For this reason, EMPA laboratory of Faculty of Technical Sciences Čačak [2], has developed laboratory setup with four-quadrant (4Q) operation of conventional DC and AC (induction) machines [3]. The system is dedicated to practical laboratory exercises where students can get familiar with different operation regimes of motor-load system, defining configuration, setting various converter parameters, testing possibilities and drive dynamics gaining in that way necessary practical knowledge.

2. THEORETICAL BACKGROUND

Electric machine can operate in motor or generator regime, depending on the energy flow, that is direction of speed and torque of the machine shaft. Accordingly, machine operating point can be positioned in one of the four quadrants on machine torque-speed characteristic. In the odd quadrants (I and III) the machine works as a motor, while in the even quadrants (II and IV) it works as a generator [4].



In odd quadrants the direction of power is positive (electric power is converted into mechanical power - driving), while in even quadrants the direction of power is negative (mechanical power is converted into electric power - braking). Depending on the type of electrical machine and accompanying power converter, the electric drive can be one-quadrant, two-quadrant and four-quadrant drive. One-quadrant (1Q) operation of the electric motor means that the electric machine can only work in motor mode (energy flow from grid to drive) for

only one direction of rotation, which is a consequence of the control system that the drive has. In the case of two-quadrant (2Q) operation of electric drive works in motor mode (energy flow from grid to drive) but with the choice of direction of rotation. In that case, energy during generator regime cannot be sent to the grid but it should be spared on the braking resistor. In the case of four-quadrant (4Q) operation of electric motor drive electric machine can work in all operating modes (energy flow in all directions) and in both directions of rotation thanks to the ability of power convertor to send the generated energy to the grid.

Since each electric machine can work both as a motor and as a generator according to the fulfilled working conditions, the quadrant operation of the drive is usually determined by the characteristics of the accompanying power converter (its ability provide energy flow from the machine to the grid). In that sense, user, prior drive installation, should anticipate possible working regimes of the drive and subsequently chose 2Q or 4Q taking into the account all economical aspects.

2.1. Braking using field reversal

In 4Q DC drive operation in all 4 quadrants during the normal motor operation or during the braking is possible without the need to change the direction of the field circuit. On the other hand, when using a 2Q unit (with only one armature current flow direction) operation in additional quadrants of the speed-torque characteristic is possible (direction of rotation reversal and braking) by reversing the current in the excitation winding of the DC motor (field reversal).

Braking using field reversal also known as braking by changing the polarity of the inductor field or reverse current braking or plugging. Theoretical background of reverse current braking relies on the rule of 4 factors, which says that change in any of 4 factors of DC machine requires consequent change of one another factor. This means that following 4 factors are changing in pairs.

Rule of 4 factors includes:

1. Machine regime - motor or generator,
2. Direction of machine rotation – clockwise or counterclockwise,
3. Direction of machine armature current,
4. Direction of machine field current.

As mentioned, the rule says that the factors change in pairs, change of one of the four factors causes the inevitable change of another.

By adding an electric circuit for manipulating the direction of current through the field circuit, the role of the machine (motor) is directly affected. Since the direction of current through the armature and the direction of rotation are the same for this type of braking, by changing the direction of current through the field circuit (field reversal), the only factor that can be changed is the role of the electric machine (from motor to generator).

The machine enters the generator mode in terms of changing the polarity of the electromotive force (EMF) caused by field reversal, while the motor speed and armature current keeps their directions same as before braking. The armature voltage during the braking is changing in such way that maintains the required value of the armature current necessary for developing the defined deceleration ramp.

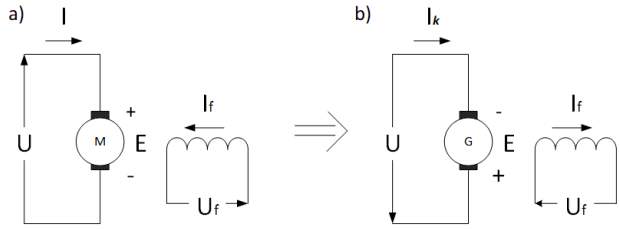


Figure 2. *Equivalent scheme of DC drive in a) motor mode and in b) braking mode*

From the picture above it can be concluded that the flow of energy through the power converter is always in one direction, which is a characteristic of two-quadrant drive due to the retention of the same direction of the armature current.

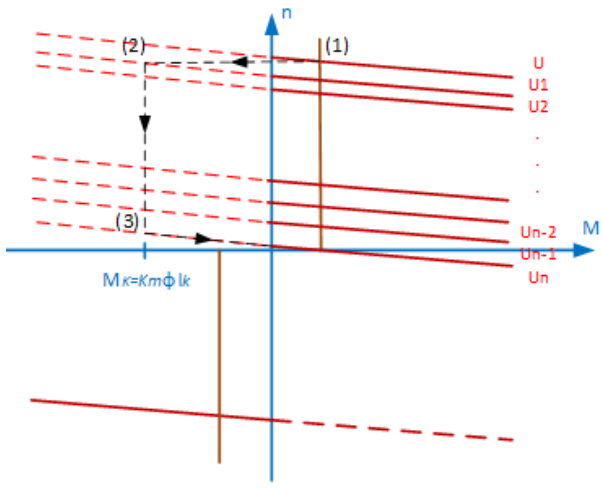


Figure 3. *Change of torque/speed characteristic during field reversal braking sequence*

The Fig. 3 shows step by step the braking of DC machine using field reversal. At a first the DC machine operating point (position 1) defines motor mode operating point prior braking. By changing the direction of current through the field circuit the machine tends to reach a new intersection point (position) on torque-speed characteristic depending on the armature voltage, motor speed and load intensity. Keeping the appropriate armature current intensity, armature voltage is accordingly reduced with motor deacceleration. At the end of braking period when machine reaches zero speed the controller (drive) turns OFF itself.

$$U > U_1 > U_2 > \dots U_{n-2} > U_{n-2} > U_n \qquad (1)$$

This transition from point 1 (motor mode) to the coordinate beginning takes place gradually through several iterations of mechanical characteristics of different armature voltages, since the speed and direction of rotation cannot be changed instantaneously. Therefore, to avoid high braking torque and thus high braking current that could damage the armature circuit, the power controller during each iteration of mechanical characteristics takes care that the braking (armature) current is always within the allowable limits. This limit depends on the defined values of the acceleration and deceleration ramps in the converter.

The consequence of this gradual lowering of the mechanical characteristics by changing the armature voltage is braking of the DC machine during which back electromotive force (EMF) (2) and speed are reduced rapidly.

$$E = k_e \, \varphi \, n \qquad (2)$$

3. REALISATION FIELD REVERSAL BRAKING WITH SIEMENS DCM DRIVE

In order to realise braking by filed reversal, two contactors Kf and Kr are needed in the field circuit of DC machine in order to change the direction of the field current. The contactors are controlled by a Siemens DCM drive whose digital outputs (DO 0 and DO 1) had been programmed to constantly send excitation (control signal) to the Forward field contactor (Kf). Start of braking is associated with a digital input DI 3. When DI 3 is activated, the controller turns OFF the Forward field contactor (DO 0) and turn ON the Revers field contactor (Kr) using another digital output (DO 1).

The electrical scheme is given in the Fig. 4, where the change of direction is provided through the H bridge realized with the NO contact of two independent contactors (Kf and Kr). The contactors Kf and Kr are mutually locked by means of respective NC contacts in their excitation circuits as it is shown in Fig. 5.

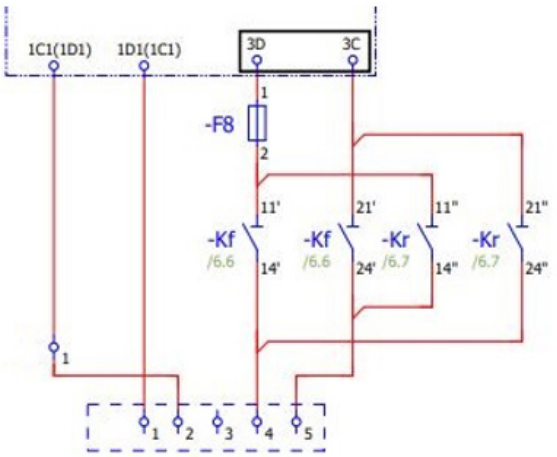


Figure 4. *Electrical scheme of H bridge circuit*

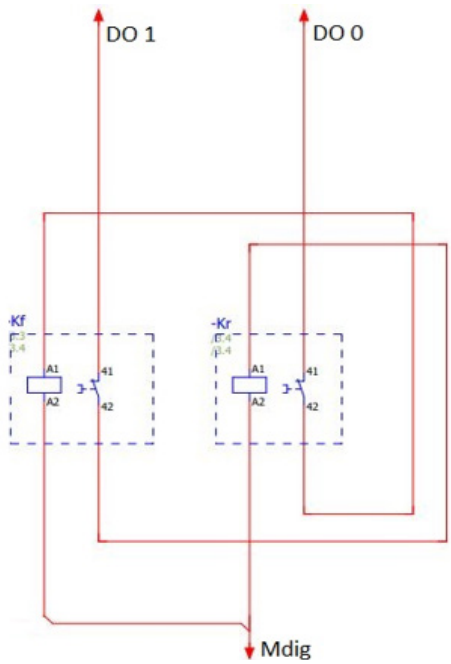


Figure 5. *Electrical scheme of control circuit*

3.1. Definition of digital outputs of SIEMENS DCM DRIVE

Parametrizing of the DCM drive prior commissioning is done through STARTER software [3, 5]. Before starting the braking by reversing the machine field, it is necessary to assign functions to the digital outputs DO 0 (r53195.0) and DO 1 (r53195.1), which are used to control the field contactors.

- r53195.0 - state (read) parameter of positive filed polarity and
- r53195.1 - state (read) parameter of negative filed polarity.

These states should be assigned to the digital outputs DO 0 and DO 1 as it is shown in Fig. 6.

CUD input/output terminal > Digital outputs → CUD DO 0 и CUD DO 1:

r53195[0] → DO 0 → X177.19 → Excitation signal for positive polarity filed contactor Kf.

r53195[1] → DO 1 → X177.20 → Excitation signal for negative polarity filed contactor Kr.

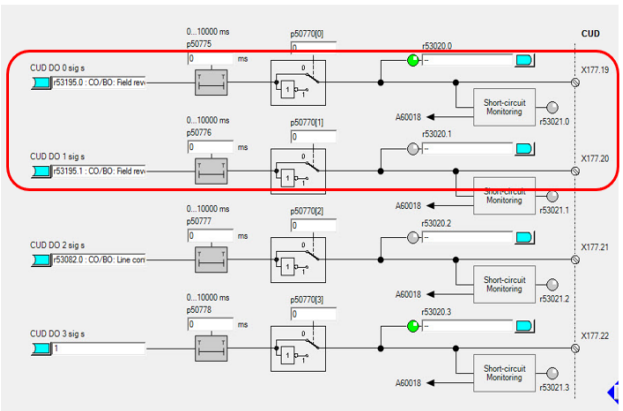


Figure 6. *Setting up digital outputs DO0 and DO1*

3.2. Definition of digital input of SIEMENS DCM DRIVE

In order to initiate the braking function of the digital output DI 3 should be assigned to parameter p50581 (Fig. 7) and physically connect it to a push button or switch that activates braking process.

- p50581 [0] - parameter setting the start of braking by field reversal.

CUD input/output terminal > Digital input → CUD DI 3:

X177.14 → DI 3 → p50581[0]

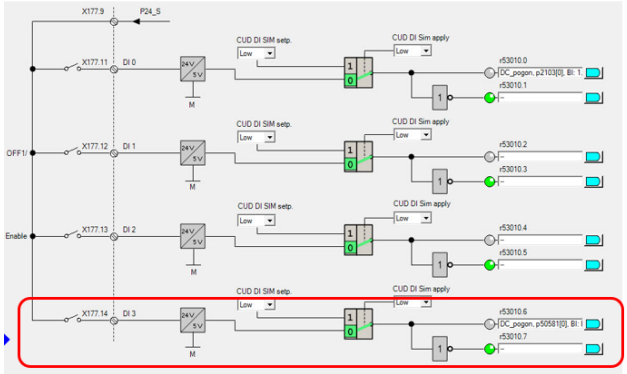


Figure 7. *Definition of digital inputs*

3.3. Defining time intervals of the field reversal braking process

In order to achieve fast and dynamic braking to the input command of the digital input DI 3, it is necessary to further define the time constants and delays related to braking procedure. Fig. 8. shows the shape of armature and field current with corresponding residual values and time delays related to filed contactor excitations timings (r53195.0 and r53195.1).

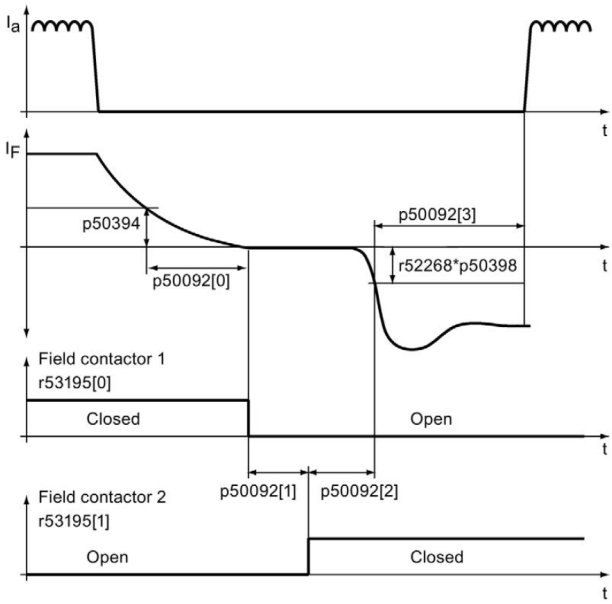


Figure 8. *Shape of the armature and filed currents with the filed excitation signals during the braking transient process.*

In Siemens DCM drive user has the ability to observe and define all the parameters of the power converter within the *Expert list* section, as shown in Fig. 9 and Fig. 10 belove.

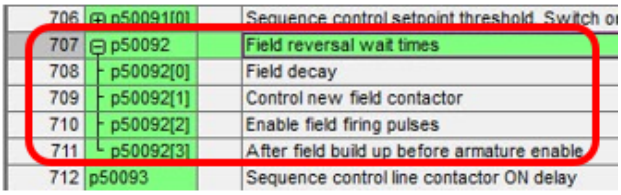


Figure 9. *Seething up parameters of braking procedure*

The following parameters of braking must be set:

a. p50394 = 3 [%] - value of residual field current prior to switching OFF Kf contactor
b. p50092 [0] = 0,1 [s] - time delay of Kf switch-OFF
c. p50092 [1] = 0,1 [s] - dead time between operation of two contactors Kf and Kr
d. p50092 [2] = 0,1 [s] - time delay between switching ON contactor Kr and turning ON field current and
e. p50092 [3] = 0,1 [s] - settling time of field current before switching ON the armature current.

In order to achieve the most dynamic response of the controller in the process of braking, it is necessary to define the parameters time delays to the lowest possible value. However, these values should be in respect with machine armature and field currents dynamics in order to avoid possible short circuit during the field reversal procedure.

In order to define maximum braking torque of the Sinamics DCM drive, it is necessary to define the limiting acceleration and deacceleration parameters as it is shown in Fig.9:

f. p50303 [0] = 3 [s] - acceleration ramp (irrelevant in our case of braking)
g. p50304 [0] = 1.2 [s] - deceleration ramp (braking speed)

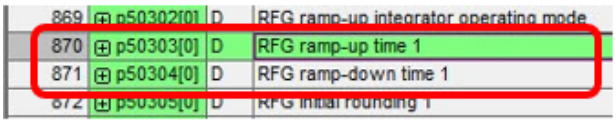


Figure *10.* Acceleration and deceleration ramp parameters

3.4. Field reversal braking procedure with SIEMENS DCM drive

The sequence of operations and events during process of braking using field reversal is as follows:

1. The DC motor rotates clockwise,
2. By pressing the start braking button (activation DI 3) for time period longer than 30 ms,
3. The armature current is turned off,
4. The field current starts to decrease,

5. At the moment when the field current is less than the set reference value - parameter r50394, the process of reversing the polarity of the inductor field begins,

6. Wait time according to p50092[0], after which both contactors r53195[0]=0 and r53195[1]=0 are turned OFF,

7. Then there is a moratorium of time period defined by parameters r50092[1] and r50092[2],

8. Control new field contactor, r53195[1] = 1 contactor Kr is turned ON,

9. After the time r50092[3] has elapsed, the armature current is switched ON back

10. At the moment of stopping the motor (speed close to zero) the DC drive is switched OFF completely.

4. Laboratory experiment and results of measurement

The laboratory setup with DCM converter is described in detail in [2] while DC machine parameters are given in the appendix at the end of the paper.

The obtain result of the laboratory experiment and result of measurements are shown in this chapter. The main idea of this laboratory experiment is the realization and adjustment of parameters of the driver itself in order to achieve the shortest and most dynamic braking of the DC drive. During the braking characteristic motor values will be monitored, recorded and subsequently analysed with respect to parameter values set in chapter 3.3.

The laboratory experiment consists of three parts:

- Stopping the motor based on the set reference (deacceleration ramp),
- Braking motor using field reversal with the set deceleration ramp 2 seconds and
- Braking motor using field reversal with the set deceleration ramp 1 seconds.

The following drive quantities were recorded using the *Device trace* STARTER software option:

- Speed - actual value - r63 [1],
- Armature current actual value - r50019,
- Feld current controller actual value - r50035 and
- Active power actual value - r82 [0].

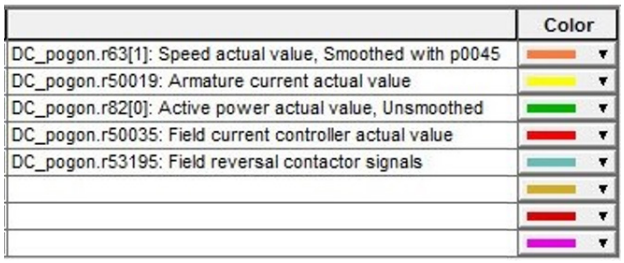
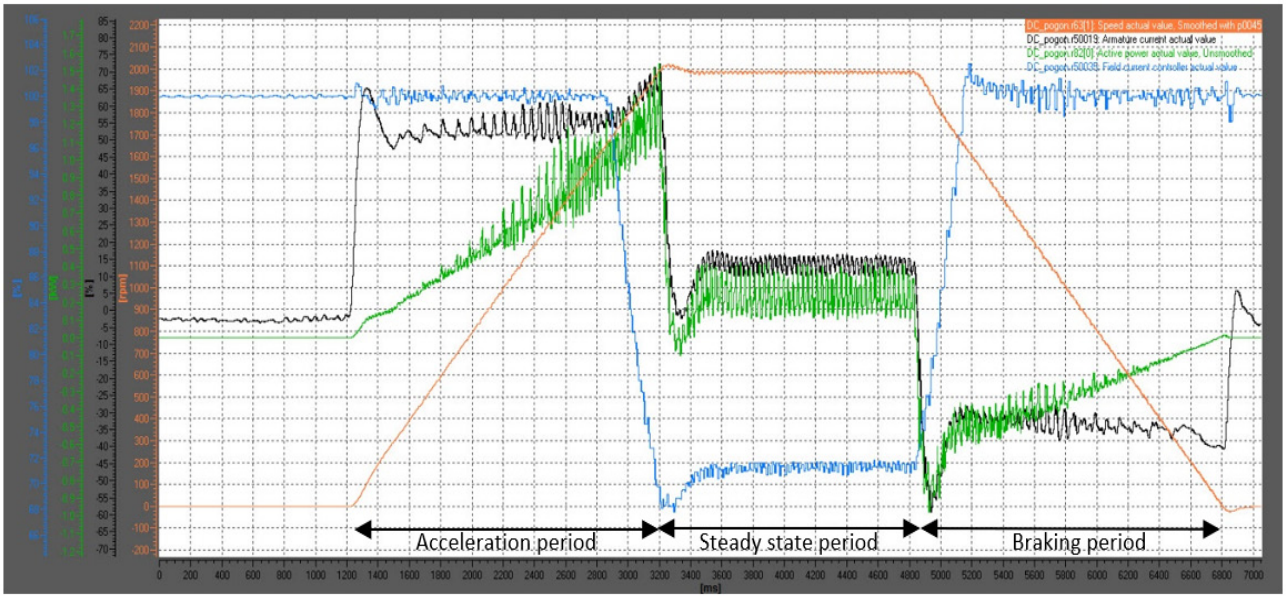


Figure 11. *Recorded characteristic quantities*

4.1. Braking motor based on the set reference

Fig. 12. shows the motor operation at set speed reference value of approx. 2000 rpm at defined acceleration and deceleration ramps of 2 seconds. The motor operation frame consists of the acceleration period, the steady state period and the deacceleration period as it is shown in Fig. 12.



Since the motor rated speed value is 1540 rpm, during the acceleration to 2000 rpm motor enters field weakening regime at the end of acceleration period which is characterized by field current less than nominal - about 70%), as can be noted in Fig. 12. The motor reaches the set speed (2000 rpm) in 2 sec with an overshot of 40 rpm, and selling time of 0.2 sec with the help of integrated PI controller.

After reaching the reference motor is in a steady state regime characterized by lower active power consumption and lower armature current (which varies between 10 [%] and 15 [%] rated values) and is only responsible for covering friction and ventilation torque.

The active power released during the braking is negative, because SIEMENS DCM drive brakes with regenerative generator braking and returns energy directly to the grid. During the braking, the active power is highest at the beginning transient period and its intensity depends on braking dynamics i. e. deacceleration ramp (0.8 kW for 2s ramp and 1.5 kW for 1s deacceleration ramp). It can be noted that during the stationary period active motor power is only 0.25kW responsible for friction, ventilation and active power losses in the machine.

4.2. Braking using field reversal with the set deceleration ramp of 2 s

The results obtained during the realized field reversal braking with deacceleration ramp set to 2 sec are shown in the Fig. 13.

Fig. 13, as previous one, also show period of acceleration, steady state period and braking period. This time braking is realised through described field reversal procedure allowing us to track field current decreasing, change of field direction and braking dynamics with different intensities of armature current. The zoomed part of Fig. 13 during the braking is shown in Fig. 14.

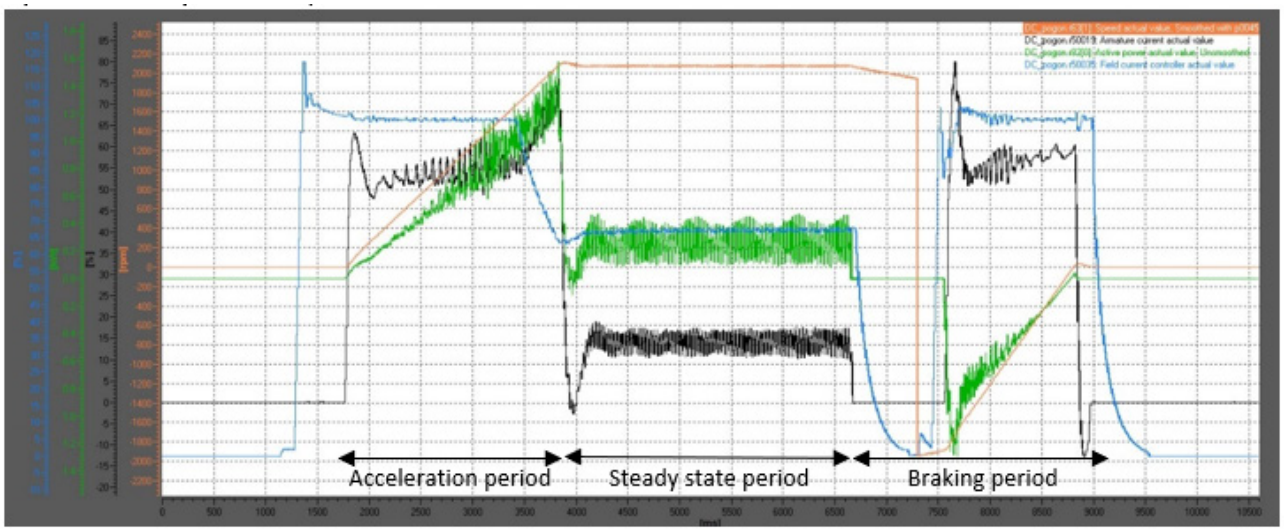
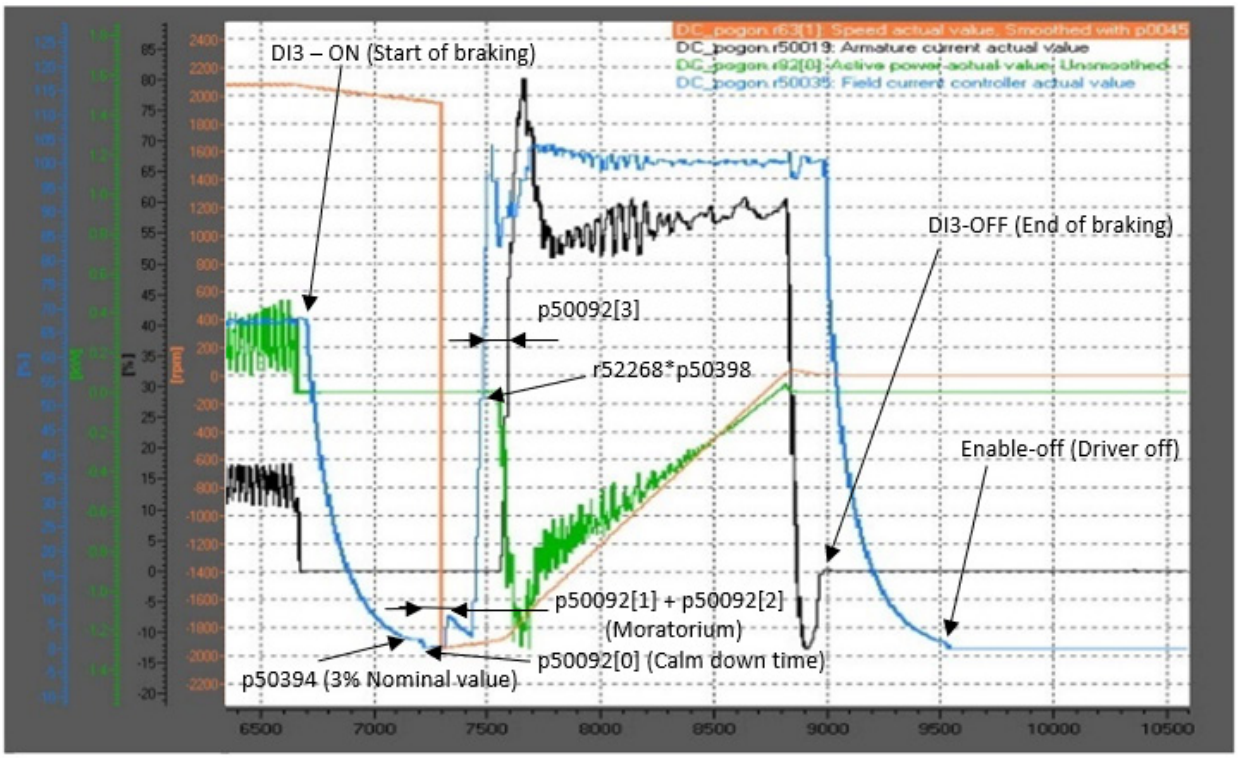


Figure 13. *Braking period by field reversal with 2 seconds deacceleration ramp*



After a start braking command, at the 6.7 second, controller turns OFF armature current and begins to reduce the field current, at 7.2 second the condition is met that the field current is less than 3% of nominal value (p50394) and process of reversing polarity of field begins. The field contactor Kf is turn OFF after set time of 0.1 sec (p50092[0]). Then delay time of 0.1 sec (p50092[1]) starts at the end of which field contactor Kr (for the negative filed polarity) is turned ON. After another 0.1 sec (p50092[2]) the opposite direction of field current is lets through the field coil. Time delay of 0.1 sec necessary for filed current to establish its rated value and settle is defined by (p50092[3]) after which controller lets armature current back on. In a moment when armature current is back braking begins. It lasts 1.4 sec as can be seen in the *Device Trace* diagram shown in Fig. 14.

By defining different deacceleration ramp braking torque (armature current) get limited accordingly. If shorter deacceleration time is defined armature current will be higher during the braking with maximal limit of rated armature current enabling high speed braking. This limitation of maximal armature current can also be modified in controller parameters but the users should be careful in setting higher values of maximal armature currents because it can jeopardise machine brushes and armature circuit.

Field reversal braking with the set deceleration ramp of 1.5 sec and 1 sec are shown in Fig. 15. and Fig. 16 respectively.

It can bean noted that braking is obviously quicker with 1s acceleration ramp with higher armature current (saturated at 100% of nominal value) as expected. Also, the corresponding active braking power is higher with a higher braking current (inductor) and follows machine speed (EMF) dynamics as expected during the constant machine field.

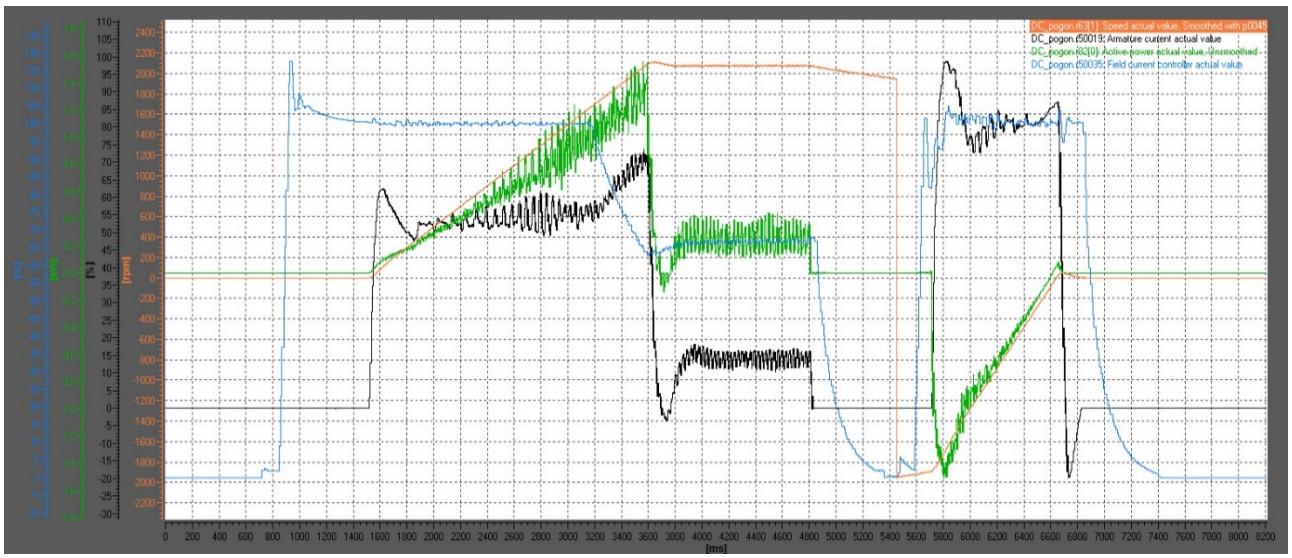


Figure *15*. *Braking period by field reversal with 1.5 seconds deacceleration ramp*

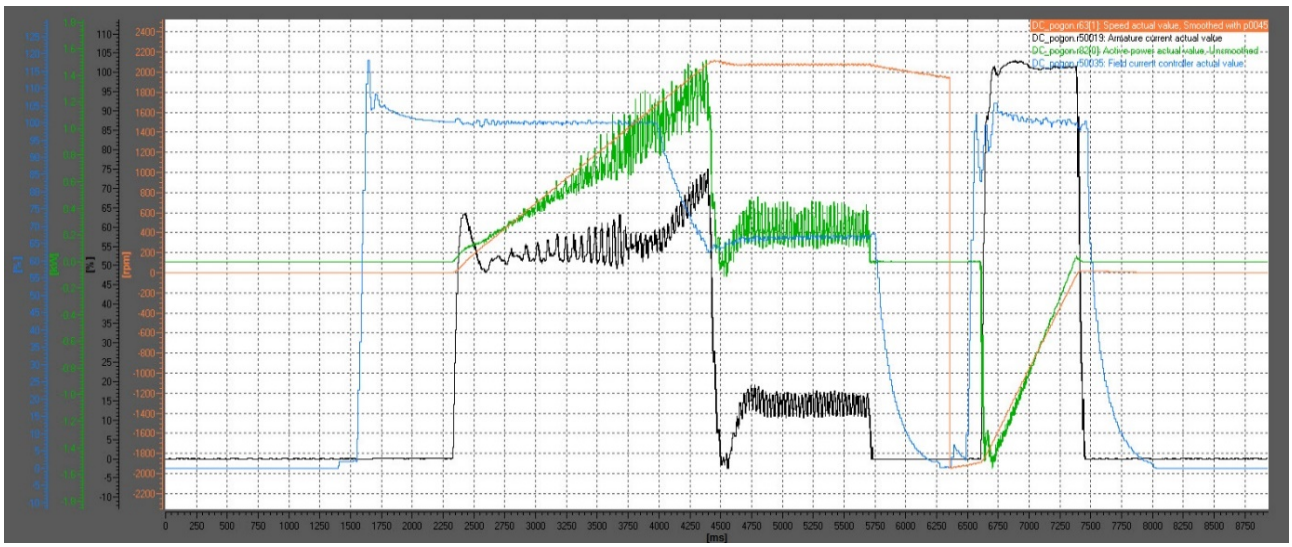


Figure *16*. *Braking period by field reversal with 1 seconds deacceleration ramp*

5. CONCLUSION

This paper presents filed reversal breaking procedure of DC machine with Siemens DCM drive. Short theoretical background is given at the beginning after which hardware configuration of experimental setup and parametrisation of DCM drive is presented. A detailed description of field reversal procedure is shown with description of important parameters necessary to be defined in order to adequately realise field reversal braking. At the end experimental results with recorded characteristic motor quantities are presented followed by proper discussion of critical time frame during the machine braking. Influence of set parameters of DCM drive in braking dynamics is analysed as well.

This laboratory exercise gives students the necessary overview of modern drives parametrisation procedure and help them to understand the basic principles of control of the DC machine, and its dynamics during various operating regimes.

ACKNOWLEDGEMENTS

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APPENDIX

Table 1. *DC machine SEVER ZIN.112N.S parameters*

I_{an} [A]	12	n_n [rpm]	1540	P_n [W]	1500
U_{an} [V]	150	R_a [Ω]	0.504	L_a [H]	16.56
U_{fn} [V]	200	R_f [Ω]	276.1	L_f [mH]	37.832

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Use of electronic design automation tools in computer engineering courses

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Abstract: *Electronic Design Automation (EDA) tools are widely used semiconductor industry to support the ever-growing complexity of computer design, and they became an important skill which is required by computer engineers. In this paper, we present the usage of the EDA Playground web platform for practical exercise in the Digital systems design course at the computer engineering department of the Faculty of technical sciences. This platform was used in process of designing and testing of program counter register of a simple processor.*

Keywords: *EDA; Verilog; design; simulation; HDL*

1. INTRODUCTION

Computer engineering is a branch of electrical engineering which integrates knowledge from the field of computer science to design new computer hardware and software. This discipline is responsible that the software part of the computer system being integrated seamlessly with the hardware part of the computer system. To achieve this goal, computer engineering requires a solid foundation in computer architecture, programming languages, operating systems, electrical engineering, electronics, and a variety of subdisciplines [1].

Due to the high complexity of current computer systems, which include billions of transistors and millions of lines of code, computer engineering relies on a set of automated tools which significantly increase design productivity. In the case of computer software, programmers write the programs in high-level languages, which syntax is very abstract for the computer hardware to be executed directly. Therefore, a set of tools is developed which automatically translates this high-level code into machine executable code. These tools include compilers, linkers, debuggers and assemblers.

The design of computer hardware relies on a set of EDA (Electronic Design Automation) tools which are used through the various design phases. These tools are used in the design and testing of integrating circuits, automating the placement of logic elements and interconnections on silicon wafer of integrated circuit, as well as designing PCB (Printed Circuit Boards) boards which are found in almost every computer system.

Different software tools are used for designing and simulating of digital circuits where some of the most common are Logisim, LogicWorks, LOGiX, Digital-ProfiLab, Cedar Logic Simulator, Deeds-DcS and Proteus. These simulators represent design in form of the schematic diagram, which is very convenient for simple designs, and can only stimulate design signals with values manually set by the user. On the other hand complex designs are today mostly represented using the HDL (Hardware Description Language) in which the structure or functionality of digital circuits are represented by a specific type of program language with a high level of abstraction.

EDA Playground is a free web platform that provides the possibility of designing, simulating, and verifying hardware described in HDL language. It supports most HDL languages such as Verilog, VHDL, C++, and SystemC, which can be run on various free and commercial simulators. This platform enables easy design and development of functional tests for small prototypes. Easy sharing of project code and simplified access to simulators and libraries makes it especially suitable for educational purposes.

EDA Playground platform is used as a tool for practical exercises for two computer engineering courses at the Faculty of technical sciences: Digital systems design [2] and VLSI systems design [3]. In this paper, we present a design and testing methodology for the practical exercise of a program counter register of a central processor of Hack computer [4]. This design is used as part of the design of the digital systems course.

2. PROGRAM COUNTER DESIGN

The program counter (PC) is one of the most important registers of the central processor. Its role is to point the address of the next instruction to be

executed. When the computer is powered on for the first time or rebooted, the value of the program counter is set to zero, so this register points to the first instruction in the program located at the address 0. When the current instruction is executed, program counter is incremented for the length of the current instruction to point to the address of the next instruction. The only exceptions to this rule are the branching instructions, for which program counter can point to the address of jump instruction, depending on the certain condition.

The most widely used HDL languages in the industry are VHDL and Verilog. In Verilog circuit is represented as a block, called a module which implements certain functionality between its input and output interfaces, called ports.

The final circuit, called the top module, can be composed of lower-level modules which are embedded inside the top module of it and the top module communicates with them using their input/output ports. This kind of design hierarchy enables module reuse and helps the designer in tackling with the design complexity.

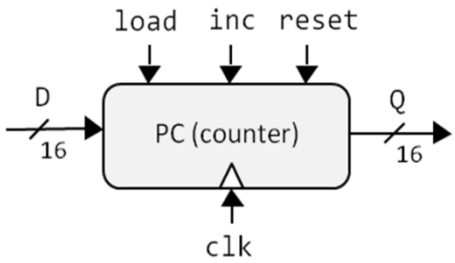


Figure 1. *Interfaces of program counter module*

Interfaces of the program counter include the following ports:

- Q – represents 16-bit wide output value of program counter which points to the address of the next program instruction.
- clk – represents the input signal which oscillates between a high and a low state and is used to coordinate actions of digital circuits.
- inc – represents the input signal used to increment the current program counter value after every positive transition of clk signal. In this design, each instruction has a length of one word, so inc input is represented by the one bit wide signal.
- D - represents 16-bit wide input value of address of the jump instruction.
- load – represents the input signal which loads the value of input in to program counter when jump condition is true.
- reset – represents the input signal which resets the value of the program counter to zero.

The structural view of the program counter module is composed of several lower-level modules. Register module r0 is responsible for holding the current 16-bit program counter value. This value can be reset by the reset input, or it will always load the value from the output of the adjacent multiplexer m1 at the positive transition of clk signal. This multiplexer selects one of two 16-bit inputs depending on the value of the Select input which is connected to the load signal. This multiplexer will load the address of jump instruction present at D input or the output of the adjacent multiplexer m0. Multiplexer m0 will select the current value of the program counter or the value of the program counter incremented with one by the adder a0, depending on the value of inc input.

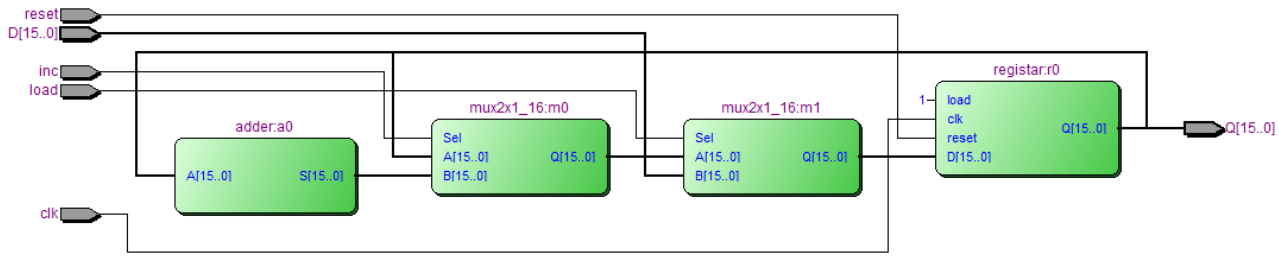
3. EDA PLAYGROUND PROJECT

The EDA Playground platform requires the creation of a user account, for which it is recommended to use an institutional e-mail address, to be able to use all types of simulators [5]. Within its account, the user has a personal directory for storing the active projects. For each project, the user can adjust its visibility on the EDA Playground platform. The project can be

- private – project is invisible to other EDA Playground users.
- public - project is visible to users which are provided with the project URL.
- published - project is visible to all users of the EDA platform via the search.

The EDA Playground workspace, shown in Fig 3. is divided into 4 main areas:

1. Language, libraries and simulator settings
2. Testbench editor
3. Design editor
4. Log output panel



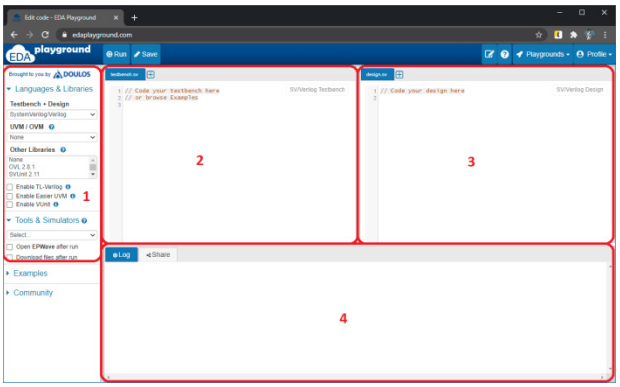


Figure 3. *Layout of EDA Playground workspace*

The right part of the EDA Playground workspace, marked with 3 in Fig 3., is reserved for the design editor in which the digital component is described by Verilog HDL code. The design can include several components that can be found in single or multiple files, whereby the largest component in the hierarchy must be in the mandatory design.sv file. Additional design files must be appended to the design.sv file using the include command. The structural description in Verilog HDL of the program counter module, called PC, is shown in Fig 4. The top-level module includes several lower-level modules which are also described in the Verilog HDL code.

```
module PC (input [15:0] D,input
inc,load,clk,reset,output [15:0] Q);
   wire [15:0] S;
   wire [15:0] Q_inc;
   wire [15:0] Q_load;
   supply1 vcc;
   adder a0 (Q,S);
   mux2x1_16 m0 (Q,S,inc,Q_inc);
   mux2x1_16 m1 (Q_inc,D,load,Q_load);
   registar r0(Q_load,vcc,clk,reset,Q);
endmodule
```

Figure 4. *Verilog PC module of program counter*

The left part of the EDA Playground workspace, marked with 2 in Fig 3., is used for writing the tests which are used to check design functionality. These tests are known as testbench and are placed in the testbench.sv file. The testbench is represented as a module without external interfaces and its role is to instantiate the top-level design component, called DUT (Design Under Test). The main role of the testbench is to generate test signals for a certain scenario, pass these signals to the top-level design component, collect design output and present it to the user in the output log panel of the EDA Playground workspace marked with 4 in Fig 3.

In this exercise, testbench generated several test signals of register type, which all have the suffix "_t" which indicated that they are generated by the testbench. The top-level module PC is instantiated as a dut component and connected with test signals, while the output of dut is connected to the Q_t signal.

```
module testbench;
  reg [15:0]D_t;
  reg clk_t,load_t,inc_t,reset_t;
  wire [15:0]Q_t;
  PC dut(D_t,inc_t,load_t,clk_t,reset_t,Q_t);
  .......
endmodule
```

Figure 5. *Internal signals of testbench module*

The following step is the generation of test signals, which are carried out in discrete time instances. First, clock signal clk_t is generated, using the initial statement when is set to zero, after which is inverted every 5 ns throughout the simulation. After the generation of the clock signal other signals are generated in the initial block where a certain time delay is added between changes of a certain signal as shown by the testbench code represented in Fig 6.

```
initial
   clk_t = 0;
always
   #5 clk_t = ~clk_t;
initial
   begin
         D_t=16'h0000;
         load_t=1'b0;
         inc_t=1'b0;
         reset_t=1'b1;
   #10 inc_t=1'b1;
         reset_t=1'b0;
   #20 D_t=16'h0100;
         load_t=1'b1;
   #10 D_t=16'h0000;
         load_t=1'b0;
   #10 reset_t=1'b1;
   #10 reset_t=1'b0;
   #50 $finish;
   end
```

Figure 6. *Generation of test signals for testbench module*

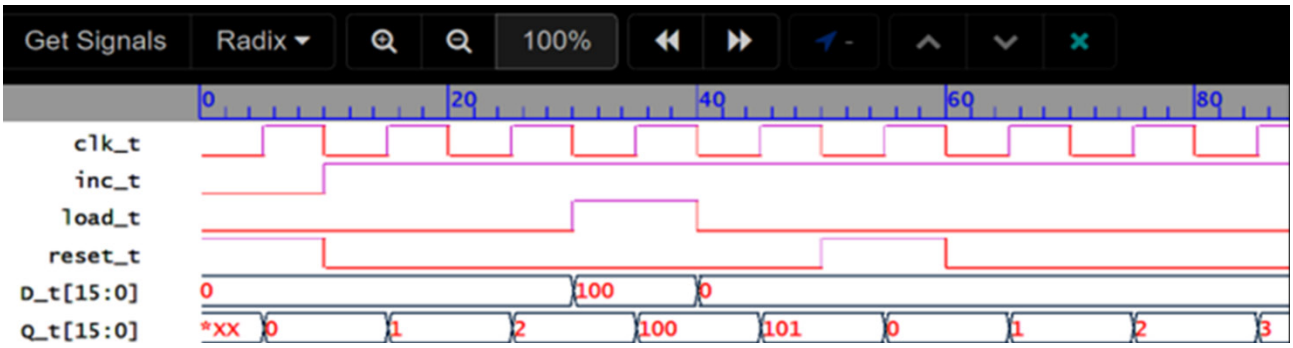


Figure 8. *EPWave testbench waveform for program counter example*

Simulation is ended after the 50ns of the last change in test signals. The simulation starts by resetting the program counter by the reset signal, after which it begins to increment its value by one at every positive transition of the clock signal. After three successive instructions, the program counter loads the jump address 0100_{16} from the D input and continues to execute the next instruction at address 0101_{16}. Next, a reset is performed after which the program counter continues to increment its value.

```
initial
  begin
        $dumpfile("dump.vcd");
        $dumpvars(0);
  end
```

Figure 7. *Collecting signals for EPWave diagram*

Results displayed in Fig 8, show that the design behaves as expected by the functional description of the program counter. Observation of program counter output, shows that is first reset to 0, after which starts to increment twice to value 2, after which it jumps to address 010016, then increments by one. Then, reset returns the value of the program counter to 0, after which it starts to increment. A manually driven testbench is only sufficient for testing simple designs. Complex design requires the use of test automation that can be loaded using test-vector files, or by using constrained random verification. EDA Playground also provides several verification methodologies, the most useful of which is UVM, which ensures complete automation of verification processes.

4. CONCLUSION

Usage of EDA tools significantly increases the productivity of the design of computer systems. These tools are becoming an important piece of technology with which future computer engineers should be familiar. Usage of EDA tools in education significantly improves the quality of practical exercises and improves students' skills which will be needed in further professional development. In this paper, we presented the methodology of design end testing of the program counter using the EDA Playground platform.

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New Challenges in Computer Architecture Education

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Abstract: *This paper provides a brief overview of the development of computer architecture and its impact on approaches to the presentation of appropriate information and computer education. The relative constancy of the concepts that were applied in the architecture of the computer influenced that the classical approaches to the appropriate education are kept until today. The changes that occurred in architecture during the development of computer technology, in conjunction with technological development, required a corresponding adjustment in the sphere of education. The turning point was the advent of the microprocessor, which introduced the x86 architecture into education. The beginning of the new century was marked by the ARM architecture. And today, the RISC-V architecture is emerging more and more as a new design challenge.*

Keywords: *computer architecture, microprocessors, x86, ARM, RISC-V*

1. INTRODUCTION

With the development of computer science, computer architecture has somewhat gone out of the view of the wider population of those whose work is related to the computer. This was also reflected in the education of computer science engineers in terms of computer architecture. Instead of a generalized approach, students are mostly introduced to computer architecture through concrete examples of computer architecture. Today, these are mainly microprocessor architectures on which the development of modern computers is based.

The beginnings of computer development are related mainly to university environments, primarily in the United States of America, Great Britain, and Germany. Intensive research was started on the eve of World War II and continued immediately after its end. The largest number of experts were concentrated in the universities, so they were a natural environment for the development of the new science from which so much was expected. The hint of a new world conflict was enough justification for powerful countries to finance the development of computers.

New momentum in the development of computer technology was brought by the appearance of companies that offered the market computers based on their architecture. Until the end of the seventies of the last century and the advent of microcomputers, the computer market was dominated primarily by American companies, such as IBM, DEC, Honeywell, Burroughs, CDC, NCR, General Electric, RCA, and Sperry Rand. In addition to them, we should also mention the British companies Ferranti and ICL, the French Bull, and the Italian Olivetti. Computers were also developed in other countries, but they were placed on the world market on a smaller scale.

In principle, each company based its computers on its own development. First of all, that meant defining one's architecture on which the work of those computers was based. On the other hand, computers from that time were offered as complete units. In addition to complete computer hardware, companies also offered customers appropriate system software: operating systems and tools for program development. This meant primarily making compilers available to users. This was a logical consequence of the fact that operating systems and compilers depended directly on the architecture of the computer on which they were used.

Following the state of the computer market, universities began to try to link teaching in fundamental computer disciplines to the computers that dominated the market. In this respect, the architecture of the IBM computers from the 360 and 370 series [1], [2] is the most used computer architecture. In the 1970s, computer architecture education focused more on DEC computers and their PDP-11 [3] and VAX-11 [4] systems. Given that some companies had computers with a very specific architecture, they were used as an educational platform for pointing out advanced techniques in computing. In this respect, Burroughs computers were particularly characteristic.

Although the development of computers was dominantly linked to large computer companies,

research at universities in the field of computing did not abate. Considering that computers were becoming more and more important for military needs, especially large countries gave great support to research at universities in the field of computing. On the other hand, many companies have also invested in university research intending to create ideas in those environments in which computing will rest in the future. It has proven particularly successful in areas such as programming languages and operating systems. From the MULTICS project [5], [6], which was realized at MIT University, the concept of a multiuser operating system was designed, on which all later known operating systems were more or less based. As far as programming languages are concerned, the example of the ADA programming language [7] whose development was financed by the United States Department of Defense can be mentioned.

As far as computer architecture is concerned, the universities mainly engaged in research in the field of advanced architectures. With a special emphasis on the development of parallel computer systems.

2. MICROPROCESSORS BRING CHANGE

The development of semiconductor technology and the emergence of microprocessors represented a turning point in the development of computing [8]. But also, education in terms of computer architecture. The emergence of 8-bit microprocessors is of particular importance for the development of computing. Table 1 provides an overview of the 8-bit microprocessors that were most commonly used. And thus influenced the changes in computer education in the following decades.

Behind the contents of Table 1 hides the important fact that, except for Motorola, the companies that offered microprocessors to the market were, so to speak, newly founded companies. Intel was founded in 1968, MOS Technology in 1969, and Zilog in 1974. Gordon Moor and Robert Noyce left Fairchild and founded Intel because in the previous company there was no sense in making highly integrated circuits.

Table 1. *The overview of 8-bit microprocessors*

Micro-processor	Manufacturer	Year	Technology
8080	Intel	1974	NMOS
8085	Intel	1976	HMOS
6800	Motorola	1974	NMOS
6809	Motorola	1978	NMOS
Z80	Zilog	1976	NMOS
6502	MOS Technology	1975	NMOS

Not neglecting other microprocessors, at the beginning of the new era in computing, microprocessors 8080/8085 from Intel [9] and 6800 from Motorola [10] had a dominant position.

The advent of the microprocessor brought a major change to the computer design process. Computers are now designed around microprocessors, as ready-made components, which could be bought, like any other electronic component. Accordingly, computer designers had to know the characteristics of microprocessors, first of all, their architecture and the way of connection with the environment. At the same time, this also meant the need for changes in the education of computer science engineers. Manufacturers of microprocessors had to provide all the necessary documentation to the designers of the new class of computers, which are called microcomputers due to the use of highly integrated components. Consequently, it was natural that the introduction to microprocessors and microcomputers should be based on the original literature.

On the other hand, knowledge of microprocessor architecture was important from the aspect of developing system software for computers, which were based on microprocessors. Given that the first computers based on microprocessors were not general purpose, the necessary system support for them was usually provided by microprocessor manufacturers. Classic examples are the PL/M programming language [11] and the CP/M operating system [12]. Considering that it was mainly about 8-bit microprocessors with limited resources, the operating systems developed for them did not contain elements of multiprogramming.

2.1 Personal computers - heralds of the new age

A new revolution in computing was brought by the so-called personal computers. The biggest contribution to this change was made by the IBM company with its microcomputer, which they gave the shortened name PC from Personal Computer [13]. Even before 1981, when the IBM PC appeared, there were similar computers on the market. However, the new computer brought for the users, and these were primarily people who already used computers, the way of usage they were used to. This largely explains the popularity that this type of computer will have in the future.

Thanks to the success of the IBM PC computer, Intel microprocessors from the 8086 series dominated the market. These were 16-bit processors that Intel offered to the market in 1985. They were the progenitors of a new family of computer architectures that is still known as the x86 architecture [14]. In the meantime, this architecture of 16-bit microprocessor realization was realized through 32-bit microprocessors, whose designations were 80386, 80486 and Pentium. The latest processors from the company

Intel carry the codes Core i3, i5, i7, i9 and Xeon [15].

The success and popularity of the x86 architecture caused many companies to "clone" it. The most successful "clone" of x86 architecture was made by AMD (Advanced Micro Devices). Thanks to this, personal computers compatible with IBM PCs are a serious competitor to corresponding computers based on Intel microprocessors. The current generation of AMD processors is codenamed Ryzen [16]. In addition to AMD, the company Cyrix also dealt with "cloning" of the x86 architecture [17].

The last quarter of the last century brought the appearance of a large number of new microprocessors. Many of them were more advanced in their architecture compared to the x86 family. However, Intel's dominance in the personal computer segment meant that most of them did not get full commercial satisfaction. To the greatest extent, they have found application in the design of the so-called graphic workstations. It was about computers intended for designing in various fields of technology. With such computers, extensive and fast calculations and graphical presentation of information were required. Also, computers with good graphics capabilities have found wide applications in the field of graphic design. In this regard, the company Apple particularly stood out with its family of Macintosh (MAC) computers, which were originally based on microprocessors from the Motorola 680x0 series [18]. Later, Apple, in cooperation with IBM and Motorola, will develop a new PowerPC microprocessor family, which will be incorporated into new versions of MAC computers. Interestingly, Intel and Motorola remained competitors in the domain of 32 microprocessors (80386 versus 68030). Although Motorola offered a more advanced architecture, commercial success was on Intel's side. Table 2 provides an overview of microprocessors developed during the last two decades of the 20th century. It was a time when 32-bits dominated, and 64-bit microprocessors were emerging. The latest 64-bit microprocessors were intended for very powerful computers. Servers, workstations, and supercomputers were developed on their basis.

In 1995, DEC (Digital Equipment Corporation) developed the Alpha 21164 microprocessor, which implemented the Alpha RISC architecture [19]. The idea was for the microprocessor to be a replacement for the 32-bit VAX architecture. As well this RISC (Reduced Instruction Set Computers) enabled DEC to be competitive in the field of UNIX workstations. In a way, DEC wanted to make up for not accepting personal computers during the 1980s.

Table 2. *The overview of 32/64 – bit microprocessors*

Micro-processor	Manu-facturer	Word length	Usage
68040	Motorola	32	Workstation
PowerPC 601,750	Motorola, IBM, Apple	32	RISC processor, Notebook
PowerPC 620	Motorola, IBM, Apple	64	Workstation
Alpha 21164 21264	DEC	64	RISC processor
ULTRA SPARC	SUN	64	RISC processor
MIPS	MIPS	64	RISC processor, workstation
PA 8500	Hewlett Packard	64	Workstation, servers

2.2 CISC and RISC architectures

The beginning of the eighties of the last century brought the RISC (Reduced Instruction Set Computers) concept [20], [21], [22] to be strongly opposed to the previous CISC (Complex Instruction Set Computers). Although it seems that CISC, thanks to the commercial success of the x86 architecture, is still dominant, the architectures of practically all new microprocessors are based on the RISC concept [23]. It can also be seen in Table 2.

The dominance of microprocessors as components for computer development has influenced computer education to be increasingly turning to familiar with specific microprocessor architectures. In the beginning, the x86 architecture dominated, and later other microprocessor architectures found their place in the educational process. First of all, MIPS. This orientation, as well as all recent approaches in education regarding computer architecture, followed the trail of the RISC concept. The importance of familiarizing future experts in the field of computer hardware can best be seen in the books by David Patterson and John Hennessy [24], [25].

Until the eighties of the last century, the development of microprocessors was tied to companies that were simultaneously the carriers of the development of semiconductor technology. A typical example was Intel and AMD. However, with the development of HDL (Hardware Description Languages) [26] and other VLSI (Very Large-Scale Integration) design tools [27], there have been major changes in this area. Thanks to this, many companies declared themselves as microprocessor manufacturers, even though they were essentially just their designers. While manufacturing was serviced by companies that exclusively specialized in that business.

3. ARM TAKES PRECEDENCE

The company whose family of computer architectures will mark the transition between centuries was created under the auspices of the British computer manufacturer Acorn Computers. This company entered the world of VLSI at a time when, in addition to the microprocessors themselves, the development of various coprocessor components began massively. Most often, it was about mathematical and graphic coprocessors. It was while looking for the best option for the graphics subsystem of the BBC Micro family [28] of computers that Acorn came up with the idea of developing a processor with its own architecture for these needs. As a result of cooperation with integrated circuit manufacturer VLSI Technology, the first ARM processor, ARM1, appeared in 1985. Already the following year, a serial processor was available, which bore the name ARM2.

At the beginning of the nineties of the last century, Acorn formed a new company, Acorn RISC Machine, from the processor design team, which will later change its name to Advanced RISC Machines, known by the abbreviation ARM. During the subsequent development of new architectures in ARM, they tried to make the processors based on them to have fewer transistors than typical microprocessors. The goal was to reduce energy consumption, reduce heating, and of course obtain a price-competitive product. The stated goals of ARM coincided with the requirements set by mobile devices oriented towards battery power at the beginning of the 21st century. The relative simplicity of its ARM processors is also due to the absence of microprogram memory.

The importance and possibilities of the philosophy applied by ARM in the specification of architectures have been noticed by many companies. One of the companies that has the longest cooperation with ARM is Apple. In addition to Apple, ARM-based systems are also implemented by nVidia, Qualcomm, Samsung, and Texas Instruments. It is almost difficult to list all the companies that have developed their processors around one of the ARM cores. Suffice it to say that ARM cores are dominant in processor solutions for smartphones and laptops. In the case of mobile phones, over 90% of them use processors based on the ARM architecture. However, we should not forget the multi-core processors based on ARM architectures, which are intended for the implementation of servers and supercomputers. Also, ARM architectures have become dominant in the development of microcontrollers.

ARM is one of the world's largest companies that deals with the specification of computer architectures. However, it does not manufacture processors as integrated circuits itself. Instead, ARM sells its architecture and integrated circuit design solutions to other firms. Based on them, these companies develop their products. First of all, it is about processors, but also about the so-called SoC (System on Chip). On them, memory, communication interfaces, and even radio components are integrated around the processor with ARM architecture. In addition to a complete description of the hardware cores, ARM provides its partners with translators, debuggers, and development tools.

Despite the dominant position of ARM processors in mobile devices, most computers in use are based on CISC processors. However, there is a growing trend to use ARM processors for these computers as well. In 2017, Microsoft and Qualcomm announced the symbiosis of the Windows 10 operating system and devices based on ARM processors. At the same time, Hewlett-Packard, Asus, and Lenovo produced laptops based on the Snapdragon 835 processor.

Thanks to the wide application of ARM architectures, they have also found their place in educational activities. More and more courses in which ARM architectures are studied are found in the curricula of world universities. Accordingly, chapters in many textbooks, even entire textbooks, are dedicated to familiarizing readers with ARM architectures, [29], [30], [31], [32].

The main advantages of ARM architectures are:

- Accessibility and low cost in terms of processor development;
- Low power consumption;
- Since operations are performed in one cycle, processors work faster;
- They are suitable for the realization of multi-process systems;
- Operations are performed on the contents of registers, which reduces interaction with memory.
- ARM processors are very simple so due to their compactness they can be used for small devices.

In addition to all the good features that have imposed themselves as a good basis for the development of modern processors, the ARM concept also has its drawbacks:

- Due to incompatibility with the x86 architecture, they have not been used in the Windows environment until recently;
- Some ARM processors have speed limitations;
- Correct execution of instructions depends on the programmer, which can affect the overall performance of the processor. This means that programming ARM processors requires highly skilled programmers;
- Finally, the ARM architecture is based on a closed concept.

4. RISC–V – SOMETHING NEW IS COMING

Microprocessor architectures arose and developed on the wave of changes brought to computing by semiconductor technology. The University of Berkeley pioneered the semiconductor realization of the RISC concept. At the University of Berkeley, the first integrated processor based on the RISC concept, RISC I, was realized in 1981 [33]. Under the direction of Professor David Patterson, the integrated processor was designed and implemented by students. The project was implemented to check the possibilities of reducing the hardware for decoding and managing instructions, a large set of registers, and the realization of 32-bit address space. Also, the idea was to check the possibility of executing instructions with overlapping phases (pipelining). The realization of RISC I was motivated by the ideas presented by Andrew Tanenbaum in his 1978 paper [34]. In doing so, he showed how a complex program written in a high-level programming language can be represented using a simple instruction architecture. RISC I had a little over 44 thousand transistors, it was made in 5-micron NMOS technology on a 77mm^2 board. It worked with a clock of 1MHz. Already in the next year, a new version of the RISC II processor was created. It had about 40 thousand transistors, it was made in 3-micron NMOS technology on a 60mm^2 board. Its operating clock speed was 3MHz [35].

After almost three decades of continuous research in this field and four generations of RISC processors, in 2010, work on the project of a new computer architecture called RISC-V was started in the Parallel Computing Laboratory (Par Lab) of the University of Berkeley. The research team consisted of Krste Asanović and Ph.D. students Yunsup Lee and Andrew Waterman. The development took place as part of a project whose goal was to improve parallel computing, and which was financed by Intel and Microsoft. It should be emphasized that the projects carried out in Par Lab were in "open source" mode. Their results are distributed under the Berkeley Software Distribution (BSD) license. At the same time, Par Lab developed Chisel, a new HDL (Hardware Description Language) that was intended for hardware implementation within the RISC-V project [36].

As a rule, previous instructional architectures (ISA) entailed the possession of a license for their use. Instead, RISC-V is available under an "open source" license. Although it has no technological implications, the appearance of RISC-V represented a real small revolution in computing. The architecture specification can be obtained for free; the desired measurements can be made; the hardware and software can be developed and finally, the corresponding processors can be realized. To popularize this concept, the RISC-V Foundation was formed in 2015, bringing together more than 20 companies. The foundation was renamed RISC-V International in 2020 and today gathers more than 2000 members in over 70 countries. Some of the founders of RISC-V International are Google, Qualcomm, Western Digital, Hitachi, Samsung, and others.

The main features of the RISC-V architecture are:

- The specified ISA follows RISC design principles;
- Instructions are executed in one cycle;
- Execution of operations is based on the load/store principle;
- The project is software oriented;
- The architecture is modular and scalable, which means that it can be used for a wide range of applications, from microcontrollers to personal computers to supercomputers;
- It has 32-bit and 64-bit variants and plugins for working in floating-point;
- It is supported by different compilers and Linux operating system;
- Offers hardware support for the development of microcontrollers, SoM and SoC circuits, as well as FPGA circuits;
- Through cooperation within the RISC-V community and the possibility of reusing ready-made IP (Intellectual Property) solutions, the time needed to get from the project to the market is shortened.

The novelties offered by the RISC-V concept to the expert computing public have received a lot of attention. And not only companies that have been on the computer market for a long time, but also new companies that have based their solutions on the RISC-V architecture. All those interested have extensive literature available based on which they can get involved in the realization of processors and systems based on the RISC-V architecture [37 - 40].

The growing popularity of the RISC-V concept among computer hardware manufacturers has also found its response in the educational community. An increasing number of universities in the United States of America, but also around the world, are supplementing their programs in the field of computer architecture with topics related to RISC-V architecture.

5. CONCLUSION

Using a computer, primarily from the point of view of system software development, is practically impossible without detailed knowledge of computer architecture and organization. This was particularly evident with the advent of the microprocessor. It would be practically impossible, without detailed knowledge of the architecture and organization of the microprocessor, to develop a computer around it as a central component.

On the other hand, computer architecture represents one of the pillars of computer science. This implies that education in this segment of computer science is impossible without adequate literature. At first glance, the basic postulates of computer architecture have not changed much since the very beginnings of computer technology. However, the changes that took place, in conjunction with technological development, required adequate adaptation to computer education. Through this work, an attempt was made to draw a parallel between the changes in computer architecture and the approach to the presentation of appropriate information concerning the requirements of education in this area. The emergence of new architectures, such as RISC-V, presents a new challenge in this regard.

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ECG Sensor Measurements with Arduino in Biomedicine Education

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Abstract: *This paper presents the system for electrocardiogram measurements (ECG) using an Arduino microcontroller and AD8232 ECG sensor. The paper gives the basics of human heart anatomy and electrical activity which is enough for understanding the basic principles of ECG measurements. The hardware and software components are presented, as well as the given results. This system can be effectively used as an ECG measurement device and in biomedicine students' education.*

Keywords: *Arduino; ECG; human heart; measurements; sensor*

1. INTRODUCTION

The use of computers in biomedicine has made a revolution in this field since it greatly facilitated diagnostic procedures, as well as the analysis of the obtained results.

Electrocardiography is certainly one of the pioneers of this field. Starting with bulky and heavy devices for registering heart activity, today it has come to the point that for some basic identification of the heart rhythm, it is enough to have a small and cheap sensor plate.

Of course, the question of the accuracy of such sensors remains, but they can be used for research, education, and even initial diagnostics. One of such sensors is also presented in this paper. How the sensor is integrated into a system that can successfully register the human heart is also described.

Authors of [1] and [2] used ECG sensor as wireless wearable device to be used in portable form. In [3], the authors showed the potential of medical-grade ECG sensor in medicine, sports, veterinary, etc. The development of wireless sensor network for ECG monitoring is given in [4]. ECG sensor and transmission of its data via Bluetooth LE is presented in [5]. A wearable system with wireless low power ECG sensor is given in [6].

The anatomy of the human heart is presented in Section 2. The heart's electrical activity is given in Section 3. Section 4 shows the electrocardiography methods. The hardware and software components of the system for heart activity detection are given in Section 5. Section 6 shows the results and corresponding discussion. Section 7 gives the concluding remarks, as well as the possibilities for system upgrades.

2. ANATOMY OF THE HUMAN HEART

The human heart is a muscle about the size of a man's fist weighing about 300 g. It consists of two separate, but mutually similar parts, which together act as a blood pump. The heart is divided by a muscular wall into left and right sides. Each side is divided into two parts - the smaller is the atrium, and the larger is the ventricle. Heart valves regulate the passage of blood from the atrium to the ventricle. They have the role of a valve: they let blood flow in one direction, from the atrium to the ventricle. The flow of blood passing from the atrium to the ventricle closes the heart valves, so the return of blood is not possible [7].

Between the atrium and the chambers of the heart, there are valves: mitral (which has two valves) and tricuspid (which has three valves). The valves function as sophisticated non-return "valves" that prevent blood from the ventricles from returning to the atria. The anatomy of the heart is shown in Fig. 1.

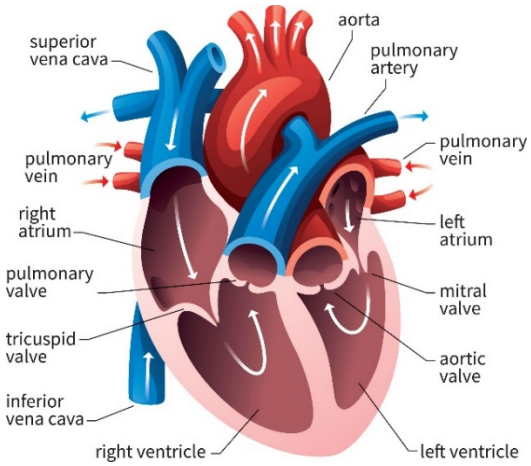


Figure 1. *The anatomy of the human heart [8]*

The left side of the heart pumps blood into the whole body, in all body cells. The right side of the heart pumps blood into the lungs. The blood of poor oxygen enters through the superior and inferior vena cava to the right atrium, crossing the right ventricle, and is squeezed into the pulmonary artery. The pulmonary artery is a large blood vessel, which later branches and flows the blood to the entire lungs. In the lungs, blood is re-enriched with oxygen and returned to the left side of the heart [9].

3. HEART ELECTRICAL ACTIVITY

All events that occur from the beginning of one beat until the beginning of the following are called a heart cycle [10]. Each cycle is caused by the spontaneous generation of action potential in the sinus node. The sinus node (often called a sinoatrial node) is a small flat ellipsoidal tape of the specialized heart muscle. It is located on the upper posterolateral wall of the right atrium just below and slightly lateral from the opening of the superior vena cava (Fig. 2).

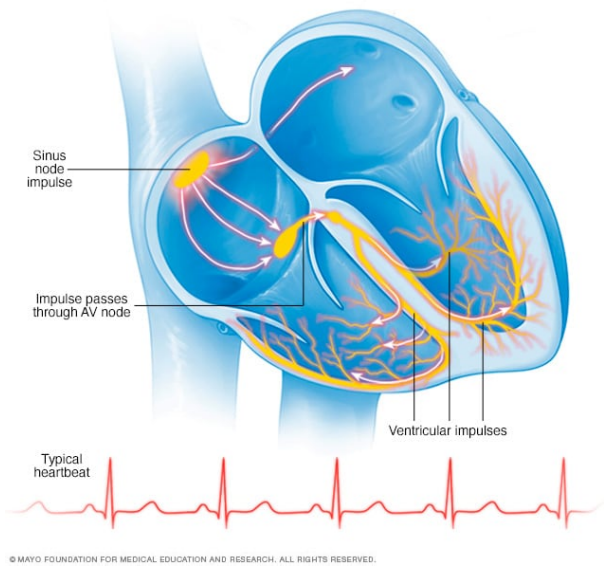


Figure 2. *The location of the sinus node [11]*

The muscle fibers of the sinus node are directly connected to the fibers of the atrium so that each action potential starting in the sinus node is momentarily spreading throughout the atrial muscular wall. For this reason, a sinus node controls the heartbeat.

Under normal circumstances, potentials are conducted only through a specialized conducting system called the "A-V" beam of conducting fibers.

All events that occur from the beginning of one beat until the beginning of the next are called heart cycle. Each cycle is caused by the spontaneous generation of action potential in the sinus node [9 – 12].

4. ELECTROCARDIOGRAM

When the heart impulse goes through the heart, the electricity is also spreading through the heart to the tissue surrounding it. A small part of that current comes to the surface of the skin. If the electrodes are put on the skin from the opposite side of the heart, the electrical potentials generated by the heart can be recorded. Such a recording is known as an electrocardiogram (Fig. 3).

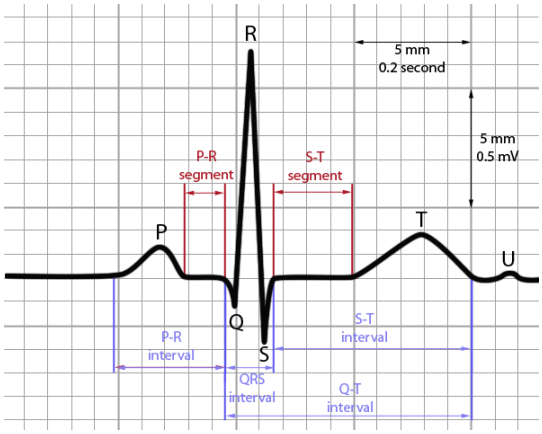


Figure 3. *Electrocardiogram [13]*

The characteristic parts of the ECG signal are P, Q, R, S, and T waves, and are shown in Fig. 3. QRS complex consists of Q, R, and S waves [9 – 13].

The P wave is an electric activity of contractions of both atria. The QRS complex is an electric impulse on the road from the A-V node to myocardial cells. The QRS complex represents the electrical activity of stimulated ventricles. The Q wave is the first descending part of the QRS complex and it is important to know that the Q wave is often not present at the ECG. The first rising wave followed after the Q wave is the R wave. After the ascending R wave follows the descending S wave. The difference between Q and S is that there is no rising wave in front of Q waves, and there is a rising wave in front of the S wave.

The T wave represents the repolarization of the ventricles so that they can be re-stimulated by electric impulse. This wave can be understood as a "reset" of heart cells. One heart cycle consists of a P wave, QRS complex, and T wave. This cycle is constantly repeated [9 – 13].

The U wave comes after the T wave and usually has the same direction. It may not be present always on ECG measurements, and its origin is still unknown [14].

5. SYSTEM FOR HEART RATE DETECTION

The backbone of this system is a heart rate detection sensor. On one side, it is connected by electrodes to the human body at exactly certain points, and on the other hand, with a microcontroller, which has the possibility of receiving data from the sensor. The schematic

representation of the given detection system and the view of the heart rate is given in Fig. 4.

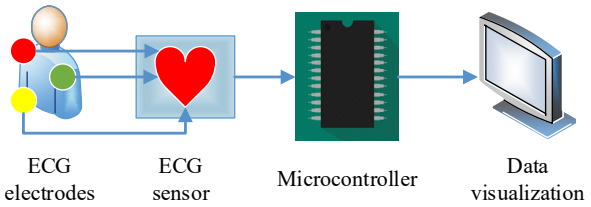


Figure 4. *Schematic representation of the system for heart rate detection*

As an ECG sensor, the AD8232 sensor is used [15]. The Microcontroller is an Arduino Pro Mini based on the ATmega 328 chip, which operates at a frequency of 8 MHz and a voltage of 3.3 V. It has 32 KB of flash memory, of which 2 KB is used for bootloader, as well as 16 input-output pins which can be used for different purposes.

5.1. AD8232 ECG SENSOR

The AD8232 is designed to extract, amplify, and filter weak biopotential signals in the presence of noise, such as noise from movement or distant electrode placement. This design allows the analog-to-digital converter or microcontroller to easily reach the output signals. The layout of this tile is shown in Fig. 5.

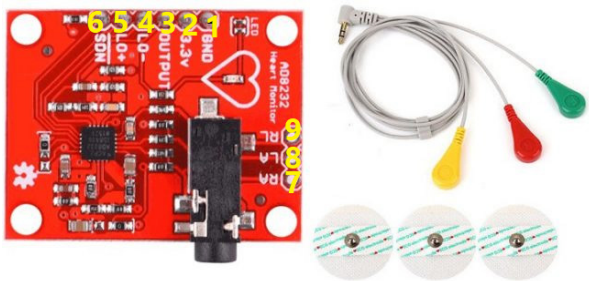


Figure 5. *The AD8232 ECG sensor plate with electrodes [15]*

The use of the corresponding pins on the AD8232 sensor board is shown in Table 1. In addition to the pins for connecting individual electrodes, there is also an input for connecting a cable with combined electrodes.

Table 1. *The use of the corresponding pins on the AD8232 sensor board [16]*

No.	Pin	Usage
1	GND	Ground
2	3.3V	Power supply
3	OUTPUT	Output ECG signal
4	LO-	The negative end of the circuit for detection of working interruptions (*Leads-off Detect*)
5	LO+	The positive end of the circuit for detection of working interruptions
6	/SDN	*Shutdown*
7	RA	*Right Arm* electrode
8	LA	*Left Arm* electrode
9	RL	*Right Leg* electrode

The AD8232 has a two-pole high-pass filter that removes noise due to movement and the very potential of the electrodes. This filter is connected to the instrumentation architecture of the amplifier which enables high gains and high-pass filtering in one step, thus reducing the cost and also the space on the chip. This ECG board also has a three-pole low-pass filter, which removes additional noise, as well as a circuit for quickly detecting interruptions in the signal due to the removal of electrodes from the body [16].

5.2. ECG ELECTRODES PLACEMENT

The electrodes that came with the ECG sensor are colored yellow, red, and green. The place of connection of these electrodes on the body is given in Fig. 6.

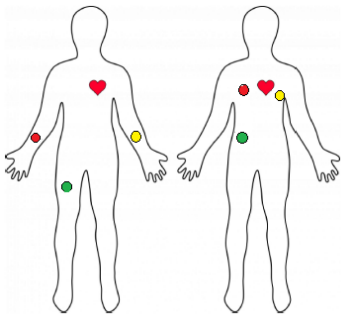


Figure 6. *Points of connection of ECG electrodes to the body [17]*

As can be seen from Fig. 6, the yellow electrode is attached to the left hand, but it can also be on the left side of the heart. The red electrode is attached to the right hand, and can also be attached to the right side of the heart. The green electrode is attached to the right leg, and can also be placed under the heart on the right side.

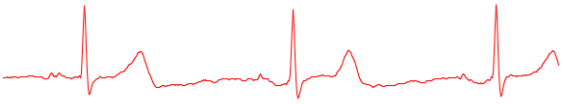
Based on all of the above, Fig. 7 shows how heart activity was measured by placing electrodes in appropriate places.

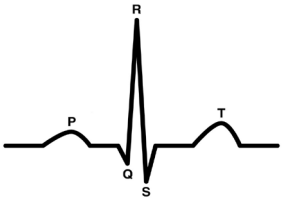
Figure 7. *Position of ECG electrodes on the patient's body*

6. RESULTS AND DISCUSSION

The software part of the system consists of an Arduino program and a Processing sketch [17] that draws ECG waves on the screen.

By starting the Processing program, data from the ECG sensor was obtained, which is shown in Fig. 8a. To compare the obtained results with the theoretical appearance of the ECG signal, Fig. 8b shows the ECG signal and its elements again.





b)

Figure 8. *a) The obtained ECG signal; b) The ECG signal elements*

By comparing the obtained result, one can notice the clear appearance of R and T peaks, as well as S valley, while the P peak is a little harder to see, but it is present. Based on the obtained results, the Q valley cannot be differentiated.

To show the effect of movement on the results, measurements were taken while the patient was moving. Those results are shown in Fig. 9.

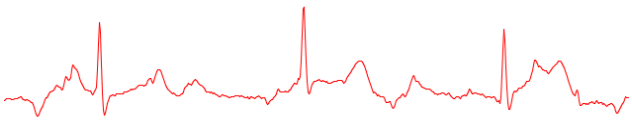


Figure 9. *The ECG signal while patients movement*

From Fig. 9, it can be noticed significant disturbances in the signal received from the sensor, which is mostly reflected in the instability of the P and T peaks.

If the places of the green and red electrodes are changed, an ECG result is obtained as in Fig. 10. It can be noticed that the peaks have become valleys and vice versa, therefore, an inverted ECG recording along the y-axis is obtained.

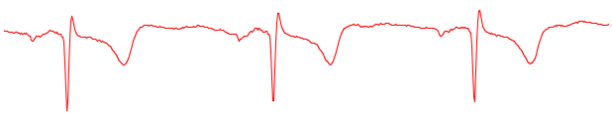


Figure 10. *ECG recording when replacing the green and red electrodes*

7. CONCLUSION

This paper describes a heart rate detection system based on an AD8232 ECG sensor and an Arduino Pro Mini microcontroller system. How the hardware elements of such a system are connected, as well as the software part that is used to detect the heartbeat and send data, is shown. In addition to the practical implementation of the realized system, a theoretical overview of the anatomy and physiology of the heart muscle, as well as all the details of the detection of its work, is given.

The implemented system is a single unit, but additional upgrades are possible. Since the connection is made on the connection board, it is possible to complete the system by making a printed circuit board with the possibility of further expansion.

It is possible to add a real-time clock to the system, to obtain precise time results for further data analysis. Also, it is possible to add an independent power source in the form of a battery and thereby be freed from being tied to a computer. Of course, the display of data itself could be realized on the connected LCD screen or the data could be sent wirelessly to a computer for processing.

It is also possible to add a place for an SD card, on which the data would be stored so that there would be no need to send them to the computer, i.e., offline data analysis could be performed.

As a possible wearable device, this sensor system can be followed with battery pack and some type of wireless communication. Preferable type would be Bluetooth Low Energy, and the power could be generated from bodily sources, by harvesting electrical potential of the human body.

On the software side, it is possible to implement an algorithm for pulse detection. Also, it would be interesting to implement some of the algorithms for the analysis of the QRS complex in real-time, so that preliminary analyzes of ECG signals could be performed, using wavelets or artificial neural networks [18 – 27].

This relatively simple system for ECG measurements can be an excellent exercise for biomedicine students. The biomedical engineers can learn the basics of human heart anatomy and electrical activity, while medicine students or professionals can analyze the given ECG measurement and provide the necessary incites.

ACKNOWLEDGEMENTS

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Introduction to non-contact temperature measurement procedures using the Python programming language

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Abstract: *Learning temperature measurement procedures is extremely important for students of the technical professions. The previous practice was mostly based on the study of contact methods of measurement, however, due to the progress of technology, there is a need for a more detailed introduction to non-contact temperature measurement procedures, such as thermovision. When studying thermovision, in addition to the thermovision camera, the software supplied with it is also used to analyze the obtained thermograms. However, in most cases this software is not suitable for use in a teaching process. Due to this, the paper presents a solution based on the use of a different type of software compared to the traditionally used software during the introduction to thermovision procedures. The entire code for the software was developed in the Python programming language using elements of computer vision, image analysis and other capabilities that Python offers through its various modules. The entire environment intended for learning was implemented using virtualization techniques. An adequate virtual machine was implemented using free software and open source software.*

Keywords: *Engineering education; Image processing; OpenCV; Python; Thermovision*

1. INTRODUCTION

Temperature measurement is one of the most common measurements performed in process techniques [1]. The mentioned measurement procedure can be implemented in two ways: contact, when we make direct contact between the sensor and the measurement object, and non-contact, when there is no direct contact between the sensor and the measurement object [2]. Typical representatives of contact temperature measurement, in the field of process techniques, are resistance temperature sensors and thermocouples, while in the area of non-contact temperature measurement, optical and radiation (infrared) pyrometers, as well as thermovision (thermal imaging) cameras, are the most common.

Temperature measurements have important role not only in measurement systems, they are also important part of other systems such as control systems [3]. In many industrial processes in different systems, the contact type of temperature measurement still dominates, but it is expected in the future that in many places the contact type of measurement will be replaced by non-contact measurement, especially in monitoring systems. This statement is based on the fact that during contact measurement, the sensor does not make contact only with the object it is measuring, but also with the rest of the measuring system in most cases. Also, there is a great influence of the environment, so during contact measurement, the sensor should be well protected, and special attention should also be paid to good thermal contact between the sensor and the object on which the measurement is performed.

In accordance with the above, future engineers will have to be prepared and trained to work, in addition to traditional methods of temperature measurement, with new measurement technologies such as non-contact measurement. That is why it is necessary to upgrade the appropriate curricula of the subjects that students of engineering study with parts related to the field of non-contact measurement, and of particular importance is the realization of both the theoretical part and the practical part.

This is the reason why in the new accreditation cycle (accreditation year 2020) for the subject Process measurement techniques, which is taken in the final year within the basic academic studies (undergraduate studies, level I of studies) of the Mining engineering study program at the Technical Faculty in Bor, there is a special part dedicated to studying the non-contact method of temperature measurement [4]. In addition to lectures, the

lessons that are realized within this course also include a certain number of hours of practical teaching. A certain number of these hours are intended for the realization of exercises in the field of non-contact measurement.

In the following, the implementation of practical exercises in the domain of using thermal imaging, as one of the methods of non-contact temperature measurement, will be shown, with a special emphasis on the implementation of the environment for performing the subject exercises, which was realized, among other things, by using free solutions, open source software and the Python programming language.

2. STRUCTURE OF EXERCISES AND EXPECTED OUTCOMES

Exercises in thermal imaging consist of three connected segments intended for realization in the faculty's interior and exterior space and part of the exercises is also realized through independent work at home. In the following, each of these segments will be briefly presented.

The first segment is realized in the external space of the faculty. It is intended for an introduction to the basic principles of thermovision and working with a thermovision camera. Recording thermograms of various objects, students learn to operate a thermovision camera adjusting the camera to the recording conditions by defining the emissivity for various recording objects, the distance of the recording object and the temperature of the environment in which thermal imaging tests are performed [5][6]. An example of one such recording is shown in Fig. 1.

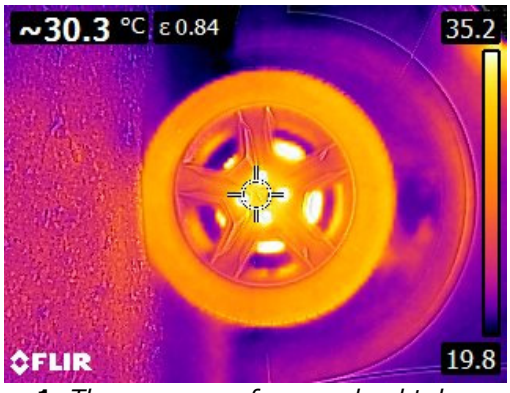

Figure 1. *Thermogram of a car wheel taken on a very sunny day*

Thermograms made in this way are used later in the further work of students in the computer laboratory, as well as at home.

The second segment represents work with a thermovision camera in a computer laboratory. The camera is connected to the computer and continuous thermovision monitoring is performed over a specific observation object [7]. Also, at certain moments of time, thermograms are extracted using a computer. Students learn continuous thermal imaging, as well as optimal indoor recording conditions by monitoring the temperature and relative humidity in the room with adequate equipment (suitable probes) and adjusting the camera to the given conditions [8][9]. Thermograms made in this way, also, are used later in the further work of students.

The third segment is a final part of thermovision excercies which is partly realized in the computer laboratory and the rest of activities are realized according to the principle of working from home. In this part, students are introduced to the analysis of thermograms by processing recorded thermograms obtained through previously realized activities.

3. SOME POTENTIAL SOFTWARE ISSUES

As can be seen from the above, only in the first part the exercises are performed exclusively using a thermovision camera, while in the other parts the exercises involve the use of a computer. This practically implies the use of adequate software.

All manufacturers of thermovision cameras deliver appropriate software along with cameras, however, there are some issues related to the usability of such software in teaching from several aspects. Most of such software are intended for professional use and are not adequate for use in the teaching process. Also, since it is commercial software, its use in teaching is limited by various license conditions. There are limited possibilities regarding the redistribution of the software, which practically means that the software cannot be made available to students at all times, especially not for working from home. Certain softwares have limitations in the number of users, so they cannot be installed on a sufficient number of computers intended for performing exercises.

It should also be noted that most of the software is not multi-platform oriented, so it may happen that it is only partially usable in the implementation of exercises. The situation in which the hardware is controlled by the software is not desirable, but it is necessary to enable the operation of the software regardless of the type of platform on which it is intended to be launched, or at least to make it feasible in most cases.

Certain software that comes with a thermovision cameras also requires an extensive registration process before using the software itself, which can cause a number of problems from the Law on Personal Data Protection point of view. In some cases, certain functionalities of the software are limited in some way (limited by the number of uses, locked in their entirety, etc.) until the software is upgraded, which in most cases is charged additionally.

4. DEVELOPMENT OF AN ALTERNATIVE SOLUTION

Due to the reasons mentioned above, it was decided that the exercises are not carried out using the software supplied with the thermovision camera, but that the exercises are carried out through alternative solution, which will be presented in the following lines.

4.1. Environment

Students use various operating systems on their computers at home. Also in the computer laboratory, although the aim is for all computers to be identical in terms of platform, certain deviations may occur, so we may have a certain diversity in terms of the version of the operating system, versions of certain software, configurations and the like.

The goal is to ensure that the software used for the implementation of the exercises can work identically on Linux, Windows 7/8/8.1/10/11 and macOS systems, because each of these systems can be encountered in real work with students. Of course, it is possible to compile the software separately for each of these systems, but in this case it would not be the most adequate solution.

If the software were to be compiled separately for each of these systems, the focus is again on the student to choose the appropriate installation and to configure it on his computer, as well as to eliminate any errors that may occur during the installation. Also, here again the problem of meeting the minimum requirements for running the software, which can vary significantly even between similar systems, is manifested. For example, compiling software for Windows 10 can be done using the Python 3.9 compiler, but it cannot be used for Windows 7, since the last version of the Python compiler that enables compiling for Windows 7 is 3.7, so the work of compiling for Windows systems becomes even more complicated.

That is why it was decided not to compile the software, but to provide the student with an environment in which the Python code will be run and that the environment be identical for everyone, regardless of the platform used. Anaconda Distribution was chosen to run all the necessary Python programs, since it is an open source platform that integrates everything that is necessary for a student to successfully master the exercises. It integrates the appropriate Python compiler, the necessary libraries, as well as the Jupyter Notebook IDE, and in addition, it offers simplicity of implementation and ease of management, which is important when working in this special case when the focus is on mastering the course material by the student.

However, the installation of Anaconda itself, setting up the environment, installation of all the necessary modules and similar activities can again have a certain amount of complexity for the average student. At the same time, it should be kept in mind that for Mining engineering students focus is not on computer science, but software is an auxiliary tool that contributes to better mastering of professional subjects.

Analyzing the above, it is concluded that students should be provided with a pre-installed environment that the student will only run without any additional installations, settings, etc. Accordingly, the concept of virtualization was introduced into the entire solution, since it shifts the focus of the environment, installation and configuration of the software from the student to the teacher who will prepare and make available that virtual environment.

In accordance with the above requirements, a virtual machine was created that the students will use both in the computer lab and on their computers at home in order to have a pre-defined environment that will be completely identical on all platforms and all computers, regardless of whether it is about faculty computers or personal computers at home.

For the guest OS, Linux Fedora 36 in the Workstation edition was selected, within which the Anaconda Distribution was installed along with all the necessary modules that are necessary to run the software. Linux Fedora was chosen for this task because it can be completely freely used, redistributed and there are no additional limitations. The entire environment is fully configured and tested, so that the student only has to run the specific Python software and realize his intended teaching activities. The student does not have the obligation to download the necessary Python files, since they, together with the entire teaching material, are integrated into the existing virtual machine so that the student does not have to make additional efforts in finding the necessary material.

The operation of the virtual machine is made possible by using the VirtualBox product of the company Oracle. VirtualBox was chosen for the reason that it is implemented as a type 2 hypervisor, which practically means that it runs on the user's operating system and then enables the running of guest OSes on virtual machines using basic virtualization techniques. In addition, VirtualBox exists in appropriate versions for Linux, Windows and macOS systems, it is very easy to implement and to use and is completely free and is an open source software that can be freely redistributed further.

In this way, a functional and complete solution was created that can be launched on any platform in a simple way. At the same time, all elements are always identical: the way of use, display implementation, configuration, paths, files and all

other elements always implement identical properties regardless of the platform on which the virtual machine is launched, which was aimed at from the very beginning of the planning of the subject exercises.

4.2. Code

As already mentioned, the entire code was implemented using the Anaconda Distribution environment. In this case, Jupyter Lab and Jupyter Notebook were equally used as the IDE in which the given code was implemented (that's why the codes have the .ipynb extension instead of the traditional .py extension). The entire code was developed using the basics of the Python3 programming language, and the compiled code itself was compiled using the Python 3.9 compiler.

Two codes were developed for the purposes of mastering the field of thermovision, which is studied within the subject course:

TCam.ipynb for connecting the thermovision camera to the computer and continuous monitoring of the observed object through the thermovision camera and

TTemp.ipynb for computer analysis of thermograms recorded by a thermovision camera.

When implementing the first code TCam, the OpenCV library for Python was used in version 4.6.0, which contains the appropriate functionalities related to the use of computer vision [10]. The connection between the thermovision camera and the computer is achieved through a USB connection, so in essence the access to the thermovision camera will not differ significantly from the access to any other type of camera using OpenCV. Of course, a thermovision camera, unlike others, will emit a thermographic image (thermogram), but it will do so frame by frame (each frame will be one thermogram) as other cameras do. This means that the access to the thermovision camera, with some slight modifications, can be done entirely based on the code that is an integral part of the OpenCV documentation related to the Python programming language [11]:

```
#Capturing signal from thermovision camera
import cv2

video = cv2.VideoCapture(0)

if not video.isOpened():
    print("Nije ostvarena konekcija sa kamerom")
    exit()

while True:
    ret, frame = video.read()

    if not ret:
        print("Greska u prenosu sa kamere")
        break

    cv.imshow('TCam', frame)

    if cv.waitKey(1) == ord('q'):
        break

video.release()
cv.destroyAllWindows()
```

The example of the captured video signal from the thermovision camera by starting the previous code using Jupyter Notebook is shown in Fig. 2.

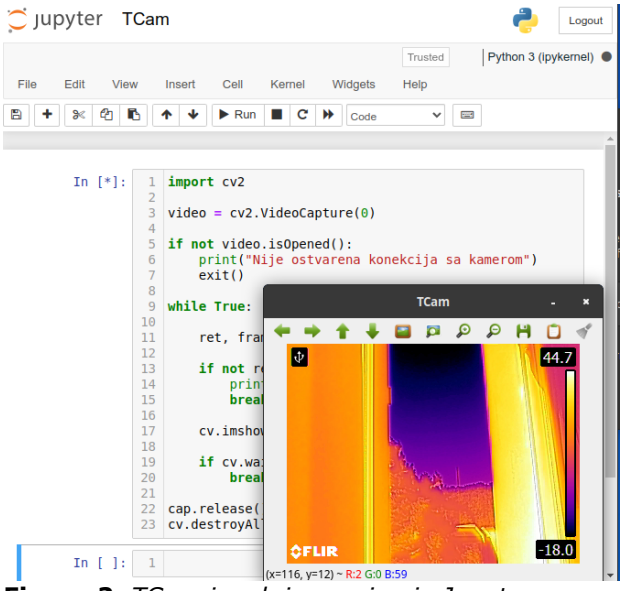

Figure 2. *TCam.ipynb is running in Jupyter Notebook and captures the video signal from thermovision camera*

Each received frame can be saved as a corresponding file on disk. It has already been mentioned that each frame represents one thermogram and in accordance with the previous one, based on the captured video signal from the thermovision camera, the corresponding thermogram can be recorded on the computer disk.

Second code TTemp is a tool for analyzing the obtained thermograms. It can work in three defined ways:

- it can find the maximum temperature recorded on the thermogram and mark the points where the maximum temperature was detected,
- it can find the minimum temperature recorded on the thermogram and mark the points where the minimum temperature was detected and
- for the temperature value provided by the user, it can find all appearances of that temperature on the thermogram and mark appropriate points where the temperature was detected.

The thermogram analysis in this code is based on the use of the Pillow library, which represents a PIL (Python Imaging Library) fork, while the GUI

implementation is based on the use of the Tkinter library, which enables a clear graphic interpretation of the obtained processing results [12].

Regardless of the method of analysis of the existing thermogram, the first step that must be taken is the translation of the given temperature scale [13]. The temperature scale is given in the right part of the thermogram, and on it, the corresponding temperature values are represented by appropriate color representations. The minimum temperature value on the scale is marked at the bottom of the scale, while the maximum value on the scale is marked at the top of the scale. Knowing this data, we can find the representation of other temperature values on the scale by using the following code:

```
def UcitajSkalu():
    global ScalePixel, ScaleTemperature
    Y1=30
    Y2=209
    X=310
    Step=(High-Low)/(Y2-Y1)
    Temperature=High
    ScalePixel=[]
    ScaleTemperature=[]
    for i in range(Y1,Y2):
  ScalePixel.append(loaded_image.getpixel((X,i)))
        ScaleTemperature.append(Temperature)
        Temperature=Temperature-Step
```

X and Y values are determined by the characteristics of the thermovision camera itself. In this case, a FLIR E5 thermovision camera was used, which records thermograms with a resolution of 320x240 pixels. Thus, it was determined that on each thermogram recorded by this camera, the temperature scale is located on 310th pixel on the x axis and from the 30th to the 209th pixel along the y axis.

When you know which color coded which temperature value, you can easily continue with the analysis of the thermogram. The thermogram is analyzed in two passes. In the first pass, the thermogram is read pixel by pixel and to each pixel is assigned a corresponding temperature value. In the second pass, depending on the selected option, the maximum recorded temperature value is found and all positions where these values were detected are marked, or the minimum recorded temperature value is found and all positions where these values were detected are marked, or all positions are detected in which the temperature defined by the user himself, i.e. the student, is recorded. Standard algorithms are used for mutual comparison of values and finding extremes.

At the end of each thermogram processing, the student can record a new thermogram with the corresponding results of processing. Saving process using the filedialog option, while the new thermogram itself is recorded as an image given in JPEG format. An example of a recorded thermogram with marked positions where maximum temperature values were identified is given in Fig. 3 (the rear window of the parked car is analyzed).

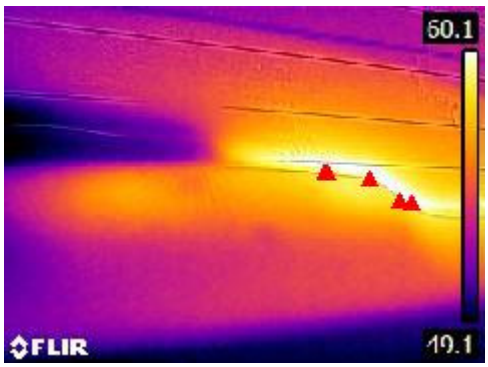

Figure 3. *Example of saved termogram with obtained results after detection of spots with maximum temperature recorded*

It should be noted that at any moment, if any unwanted behavior of the software occurs during thermogram analysis, the student has the option of resetting. The reset option deletes all detected values, re-initializes all parameters and loads the last good known thermogram, so that the student can start again with the analysis of the desired thermogram in order to obtain adequate processing results.

5. CONCLUSION

As can be seen from the above, it is entirely possible to teach students about the basics of non-contact temperature measurement by using some new non-traditional thermal imaging solutions implemented using the Python programming language and its corresponding libraries. In addition, the presented solution frees the student from some secondary activities that he would have to perform using traditional software, such as software installation, system configuration, troubleshooting, which can be an extremely tiring process, especially for students who do not pursue their education in the field of computer science. Also, by uniting all teaching materials, examples, software and other digital contents within one virtual machine, one centralization of the necessary contents is realized with the aim of reducing the time needed to find those contents through various sources.

Various benefits are achieved by implementing the presented approach in the teaching process.

If we look at the financial aspect, it can be said that the implementation can be achieved according to the "zero-cost" principle. The entire software implies the use of free solutions, which practically means that there are no additional investments in

terms of software by the institution that implements the teaching process. There is also no investment by the student side either, since the mentioned virtual machine can be used freely without any compensation, that is, there are no additional licensing costs.

Also, if we look at the legal regulations, it should be noted that there are certain license provisions even when using free software and open source software. However, these licenses are much more flexible than most licenses practiced by various software manufacturers and suppliers. Most of the licenses that are practiced when licensing free software support the free redistribution, which is of great importance when incorporating the software into the teaching process, since the software is installed outside the borders of the institution and on equipment that is the personal property of students. The selection of software that is part of the virtual machine is realized in such a way that it does not require any additional registration or the delivery of any sensitive data to a third party, which may cause certain problems regarding the right to the protection of personal data in accordance with applicable laws. In this way, legal protection was realized at different levels, the institution is protected, the students are protected and the teaching staff are also protected from potentially controversial situations.

From the sustainability point of view, it can be said that significant results are being achieved here as well. The presented environment with all its elements was primarily implemented for the purposes of teaching within the Process Measurement Techniques course, which is taken by students of Mining Engineering, but the use value exceeds these limits. It can be used in the scientific research work of students, which in recent years has been increasingly emphasized in the system of higher education and also it can be useful to students of other technical fields, for example it can realize a very large potential in the implementation of the teaching process in computer science subjects. Through described approach, students can learn the basics of programming in the Python programming language, learn the basics of virtualization, learn the basics of connecting a computer to other devices within measuring systems, gain insight into advanced programming, computer vision, designing and implementing a graphical user interface (GUI), etc. The possibilities are numerous and with slight modifications this solution can realize many other activities in different teaching and learning processes.

The complete learning model described in the paper will be used regularly in the teaching process of the Process Measurement Technique course during the spring semester of the 2022/2023 school year. It is expected that after the above mentioned semester, a proper evaluation will be carried out, and if the results are positive, some other solutions will be implemented in the teaching process of other subjects based on the presented model.

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Construction and programming of the platform for spatial imaging with sensors

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Abstract: *In this paper, the construction solution and the method of programming the platform for spatial imaging with sensors are presented. The mechanical construction of the platform is described in detail, as well as the electrical components needed for movement of the sensor carrier in the horizontal plane. Movement is achieved by two stepper motors, and movement control is obtained by connecting the corresponding Arduino and LabVIEW programs. The movement of the carrier from the initial position, through four arbitrary points, until it is placed again in the initial position was realised. The paper provides relevant technical data about the platform, connection diagrams, parts of the program code and accompanying discussion.*

Keywords: *platform spatial imaging with sensors; mechanical construction; electrical components; Arduino; LabVIEW*

1. INTRODUCTION

Spatial imaging with sensors is done by moving into space, in a plane (two-dimensional space) or volume (three-dimensional space), a sensor or a system whose parameters are measured [1, 2]. This imaging can be realised for different purposes, just by replacing a sensor or the measuring system. Depending on the type of sensor, visible or invisible phenomena can be displayed by the human eye. For example, when current flows across a conductor, the only „visible" appearance that indicates the existence of a magnetic field in the vicinity of the conductor is a mechanical force or torque, which can act on a nearby object that is sensitive to the magnetic field. Real image of the magnetic field can be seen by the sensors and this is exactly what is achieved by the application of the platform [1].

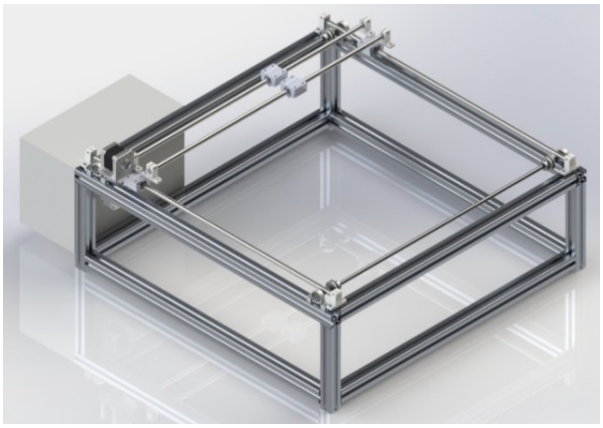
In a similarly way, by using other sensors, other fields, like electric or temperature, can be recorded, or other parameters, dimensions, friction or roughness can be measured.

This paper shows the process of making the platform, its dimensions 700x700x300 mm, mechanical parts, electrical components and parts of the program code for motion control. Also, the paper provides an appropriate discussion of the realized platform and directions for further development.

The platform will be used for teaching at master's studies at FTN in Čačak in the subjects Virtual Instrumentation (VI) and Electrical Measurements of Non-Electric Quantities (EMNEQ), as well as for research that will be carried out by students and teachers of the Faculty in the future.

2. PLATFORM MODEL

Before beginning of mounting mechanics and electrical components, it is necessary to create a model in the 3D CAD design software. A model of a platform for spatial imaging with sensors is created using SolidWorks software and is shown in Figure 1. This is necessary to do before the actual creation of the platform, in order to achieve the desired form on the model itself, through its development, and to spot potential errors that may affect the functionality of the platform in time.



The next step, after developing the model, is to form a list of required parts, which (for the realized platform) are given in Table 1. The table shows the component name and quantity.

A platform is designed to move in the horizontal plane (in two coordinate axes, *X* and *Y*).

3. PARTS OF THE PLATFORM

Table 1 shows the basic mechanical and electrical parts used to build a platform.

Table 1. *Specification of used mechanical and electrical parts*

Name of component	Quantity/ Length
1. Arduino MEGA	1pcs
2. RAMPS 1.4	1 pcs
3. Structural profile 20x20 mm	9 m
4. 10mm aluminium round bar	4 m
5. Aluminium tile	2 pcs
6. Stepper motor	2 pcs
7. 3M Timing belt pulley, tooth pitch 3 mm, width 11 mm/ 16 mm for stepper motor	6 pcs
8. Screw M5	15 pcs
9. Flat washer for screw M5	30 pcs
10. T-slot nut sliding block swivel-in with spring Slot 8 - Type B - M5	100 pcs
11. Mounting enclosure (400x300 mm)	1 pcs
12. Power supply 12V DC (Power supply has huge capacity (30 A) for future upgrades)	1 pcs
13. Timing belt (width 10 mm, pitch 3 mm)	1 pcs
14. Corner connector for profile mounting	25 pcs
15. Optical sensor	2 pcs
16. USB cable, B type	1 pcs
17. Motor driver	2 pcs

To assemble the mentioned parts so that they form a whole that will perform the desired task, it is necessary to use the following tools and measuring instruments:

- electric drill,
- electric grinder,
- screwdriver set,
- hex key set,
- hand saw for metal,
- tape measure and
- digital multimeter.

The supporting structure of the platform is made of aluminum structural profiles 20x20 mm, connected with corner connectors and screws. Mechanical energy is transmitted via timing belts, while stepper motors are used as actuators. Used stepper motors have a two-phase winding and middle derivative leads on the phases. A middle leads are not connected anywhere, because in this way the entire winding of a motor is covered. Limit switches are pass-through optical sensors with three ends. A sensor consists of a photodiode as a transmitter and a phototransistor as a receiver. When a piece of opaque plastic cuts the beam of light, a voltage signal of 5 V is obtained at the ends of the sensor.

After mounting of the mechanical part of the platform, it is necessary to connect the electrical parts in a mounting enclosure according to the wiring diagram shown in Figure 2.

The appearance of the inside of a mounting enclosure after connecting the electrical components is shown in Figure 3. It can be noticed that most of a mounting enclosure is empty, which was the intention, with the aim of later upgrading the platform as needed, that is, the addition of electrical components.

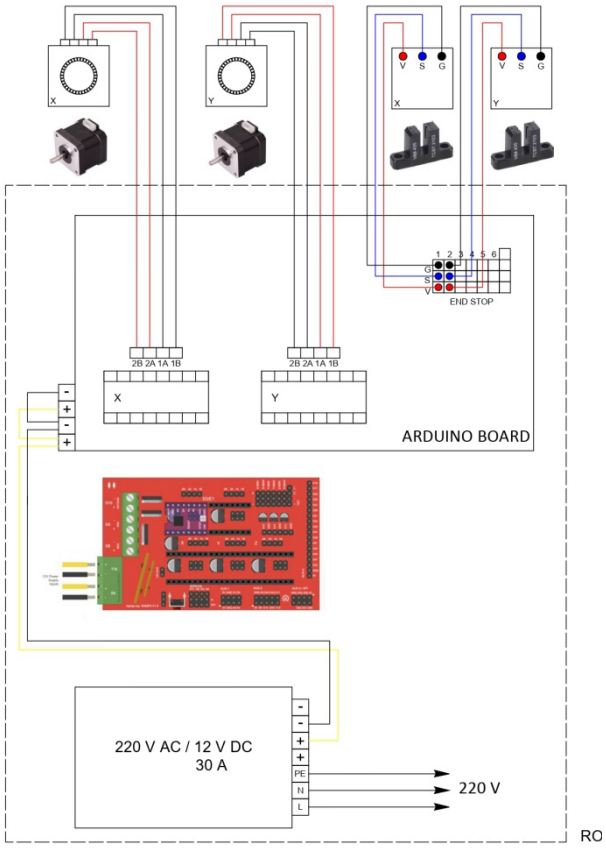


Figure 2. *Wiring diagram of electrical parts*

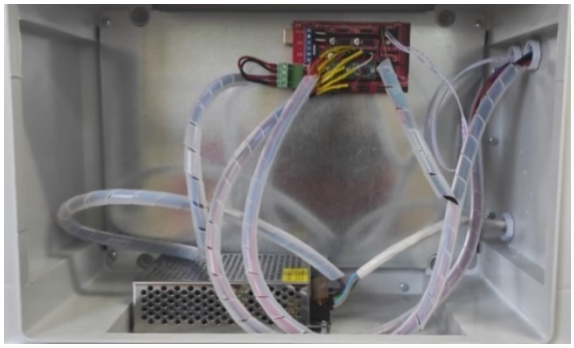


Figure 3. *Inside a mounting enclosure*

To start the stepper motors, the appropriate drivers are needed, which are connected to the RAMPS 1.4 (an additional board for working with motors and sensors), which is previously connected to the Arduino MEGA control board via the appropriate array of pins. The RAMPS 1.4 development board offers advantages when used with already made libraries for use with 3D printers or mini CNC machines. For this platform, the use of already made libraries makes only starting the machine easier, but not its further development. Generally, this project does not require RAMPS 1.4, but the motor drivers themselves require an external power supply which is easiest to connect to the Arduino MEGA board, and the board then routes that power to all the drivers placed on the RAMPS 1.4 board.

Figure 4 shows the stepper motor driver, with the connection ends marked and the connection to the controller and motor.

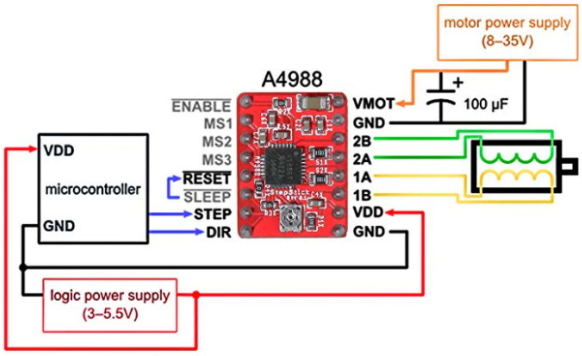


Figure 4. *Driver connection diagram with motor, power supply and* microcontroller

To start the motor, it is necessary to transfer three signals from the Arduino board:

- the first is the ENABLE signal which turns on the driver,
- the second is the DIRECTION signal that defines the direction of movement and
- the third is the STEP signal (an impulse that directly causes the motor to step).

So the platform has two stepper motors and therefore two drivers. It is necessary to determine the six signals that are sent from the Arduino board to the RAMPS 1.4. Picture 5 shows the RAMPS 1.4 with drivers, in a mounting enclosure of the platform.

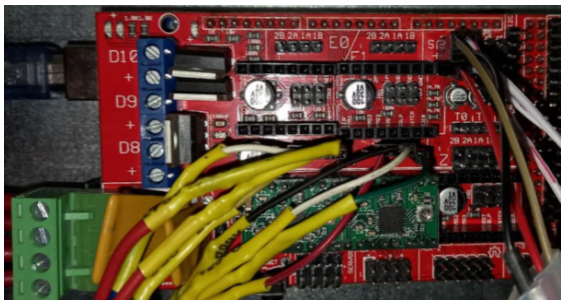


Figure 4. *Layout of the RAMPS 1.4 board in the machine cabinet*

In the cabinet of the machine, the drivers are placed on the bottom two RAMPS 1.4 connectors. It is necessary to remove the drivers from the RAMPS 1.4, and remove the RAMPS 1.4 from the Arduino board in order to examine with a multimeter the connection ends to which the drivers are connected and their connection to the Arduino board. When the RAMPS 1.4 top and bottom connections are found, the pins on the Arduino that the driver is connected to are found. Figure 6 shows the known electrical connection diagram obtained after measuring with a multimeter. Knowledge of these connections is necessary for writing the program code, because it initially defines the connections on which the necessary electrical signals are generated or measured.

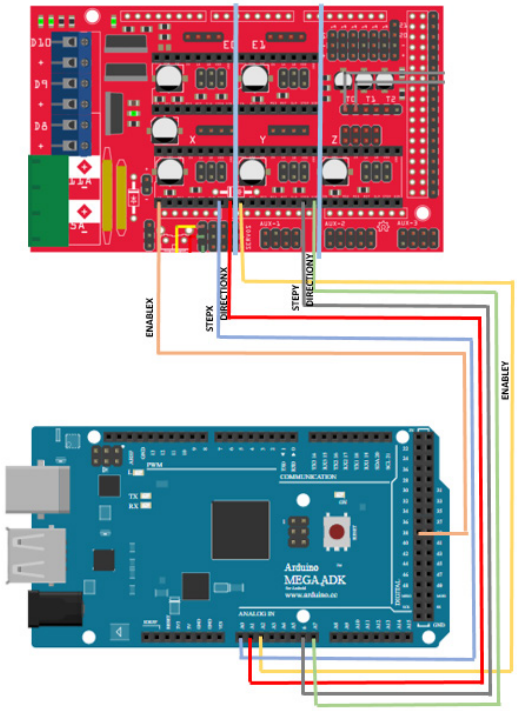


Figure 5. *Electrical connection and connections of the Arduino used by RAMPS 1.4*

4. PLATFORM PROGRAMMING

The next step in creating a platform is programming the platform itself. The goal was to connect the platform to a computer with the LabVIEW program (LV [5]) in order to give movement commands via the computer, from the LV program. Considering the advantages of the RAMPS 1.4 board, it was decided to control the operation of the motor using the Arduino program [6], which is written on the Arduino MEGA board, and to set only the desired dimensions and positions in movement that the platform should achieve from the LV program. The connection for sending data is realized by serial communication via the USB port, using the VISA driver for serial communication in LV. It is also necessary to manage the drivers at the lowest possible level of

programming, which enables further development of the platform.

The first step in programming is to assign digital and analog inputs and outputs, Figure 7.

```
const int ENABLEX=38;
const int ENABLEY= A2;
const int SENZORX=3;
const int SENZORY=2;
const int STX=A0;
const int DIRX=A1;
const int STY=A6;
const int DIRY=A7;
void setup() {
  Serial.begin(115200);

  pinMode(SENZORX,INPUT);
  pinMode(SENZORY,INPUT);
  pinMode(ENABLEX,OUTPUT);

}
```

Figure 6. *Assigning inputs and outputs to the microcontroller*

As can be seen in Figure 7, it is necessary to define in the program, before the void setup loop, all the names of the variables to which analog and digital inputs and outputs are assigned.

The first part of the machine's main program is the HOME function, Figure 8. Given that the stepper motors were used, which do not provide information about the current position of the motor (unlike servo motors), it was necessary to define their initial position. The HOME process itself is performed by starting the motors in the direction of the coordinate origin, where the two optical sensors are located. They will move independently of each other until their corresponding sensor is activated, the sensor is a condition for stopping the motor.

The second part of the code is related to the LV program, which was created for the needs of the platform. The Arduino program allows data to be sent and read on the computer via USB. During the development of the platform, it is planned to realize the movement of the sensor carrier from the initial position, through four arbitrary points, until it is placed back in the initial position. Assignment of points would be done from the LV program. In order to achieve this, it is necessary to load the coordinates of those points from the LV program. The easiest way to transfer information from LV is to send the information as a string, Figure 9.

The written function reads the incoming string, divides it into a certain number of parts and finally converts those smaller strings into Int data type (Int is the only data type that can be used to specify the number of steps the motors should take).

```
#include<string.h>
String ulazniniz="0";
char ulaz[50];   // initial string
const char del[]=";";
char *token;
int i=0;
char *niz[8]; //number of values to store
String prvi;
String drugi;
String treci;
String cetvrti;
String peti;
String sesti;
String sedmi;
String osmi;
int pozicijaX1=0;
int pozicijaX2=0;
int pozicijaX3=0;
int pozicijaX4=0;

int pozicijaY1=0;
int pozicijaY2=0;
int pozicijaY3=0;
int pozicijaY4=0;
```

Figure 7. *Calling and defining a string in a program*

```
// HOME process

if (ulazniniz.toInt()==1 && pom3==0){ //command from LV to return motors to HOME position
   analogWrite(ENABLEY,0); //setting enable signal to Y motor
   digitalWrite(ENABLEX,0);  // setting enable signal to X motor
   analogWrite(DIRY, 0);    // setting direction of Y motor
   analogWrite(DIRX, 1023);    // setting direction of X motor
   for(int x = 0; x < 3000, pom3==0 ; x++) {
       analogWrite(STY,1023);       // beginning of code for generating STEP signal
       analogWrite(STX,1023);
       delayMicroseconds(1000);
       analogWrite(STY,0);
       analogWrite(STX,0);
       delayMicroseconds(1000);      // end of code for generating STEP signal
        if (digitalRead(SENZORX)==HIGH){      // checking if the X-axis motor has reached HOME position
          digitalWrite(ENABLEX,1);      // if it has arrived, its driver is turned off
          pom1=1;
          }
        if (digitalRead(SENZORY)==HIGH) {
          analogWrite(ENABLEY,1023);
          pom2=1;
          }
        if (pom1==1 && pom2==1){
          pom3=1;
          }
       } // end of FOR loop
       //Serial.print('ZAVRSEN HOME');
  }
//Serial.print("ZAVRSEN HOME");
```

Figure 8. *Part of the program code for returning the platform to its initial position*

```
if (pom3==1 ){ // condition for the machine to be in HOME position is met

1)  delay(5000);
    int i=0;
    //there must be a delay sufficient for the user to change the command selection in the CASE structure
    ulazniniz=Serial.readString();     //when the user chooses to move by points, the string from LV is reloaded
    ulazniniz.toCharArray(ulaz,47);    //input data is of type STRING and must be converted to type CHAR
    token = strtok(ulaz,del);   //auxiliary string that divides the string "ulaz"
    // Serial.println(ulazniniz);

2)   while(token != NULL){
     niz[i++] = token;
     //Serial.println(token);
     token = strtok(NULL,del);
    //for(i=0;i<=7;i++)
     // Serial.println(niz[i]);
```

Figure 9. *Splitting an input string into multiple parts*

```
// First point
    if ( pom18==1 && pom6==0){      //it is checked whether a different command arrived than the previous one
      //Serial.print("AAA");
      digitalWrite(ENABLEX,0);
      analogWrite(ENABLEY,0);
      if (pozicijaX1>0 ){ // it is checked whether the position of the next point is greater than the previous one along the X-axis
        analogWrite(DIRX, 0);    //if it is greater, the direction is positive along the X-axis
        }
      if (pozicijaX1<0){
        analogWrite(DIRX, 1023); // if it is not greater, direction is negative along the X-
        }
      if (pozicijaY1>0 ){
        analogWrite(DIRY, 1023);
        }
      if (pozicijaY1<0){
        analogWrite(DIRY, 0);
      }
```

Figure 10. *Part of the function to move to the first point*

The variable String input string is the data that carries information about the coordinates of four points. Figure 10 shows the function that extracts data for each coordinate point. At the end of the function, the data related to the points is written into new variables that will later be used for movement.

The third part of the program is related to movement from point to point. Motion functions can start executing immediately after entering the coordinates. Figure 11 shows part of the code for moving to the first point. There are three main conditions that determine how many steps each motor should take, in which direction each of them can move, and that after reaching the first point, it can move to the second point in exactly the same way as for the first. The Arduino microcontroller executes this code cyclically. That is why certain variables are used to lock re-movement to the first point (or a subsequent one), if this has already been done previously.

5. LABVIEW PROGRAM

The LabVIEW Program was created that can receive and send data to the Arduino via the USB port. In order for communication to be possible, it is necessary to use VISA drivers. Figure 12 shows the front panel used to run the platform. In the LV program, the port used (number 1) and the communication speed must be set, which in the Arduino program must be the same as on the front panel (number 2). It is important that these two speeds are the same, otherwise communication will not be possible.

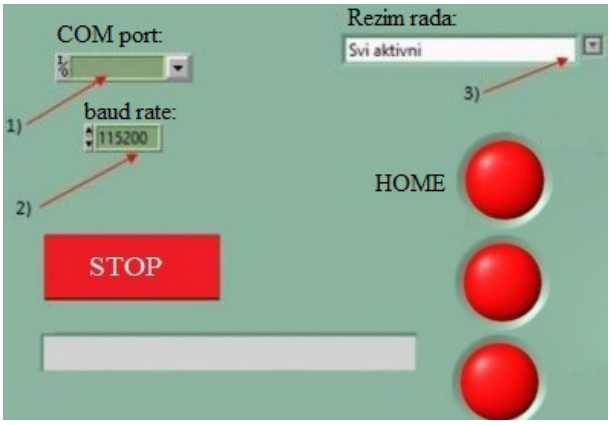


Figure 11. *LV display of front panel*

In the operating mode window (number 3), it is possible to choose several modes of movement on the machine. The first mode does not perform any movement, the second mode returns the machine to the starting position, and the third and fourth perform platform movement along four-point paths.

The block diagram in Figure 13 shows the use of the VISA driver. The Visa Write function (number 5) is used to send data via USB. This function sends data of type String. The field in which the String with point data (number 4) is entered is formatted as follows **X1**; **Y1**; **X2**; **Y2**; **X3**; **Y3**; **X4**; **Y4** with data for all 4 points in the Cartesian coordinate system.

The Visa Read function (number 6) reads the data sent from the Arduino, which is then displayed on the front panel of the LV program.

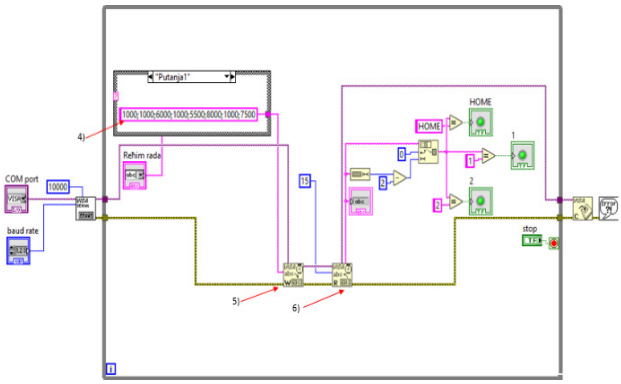


Figure 12. *Layout of the block diagram in the LV program*

6. FINAL APPEARANCE OF THE PLATFORM AND THE POSSIBILITY OF FURTHER IMPROVEMENT

Figure 13 shows the looks of the platform after construction.

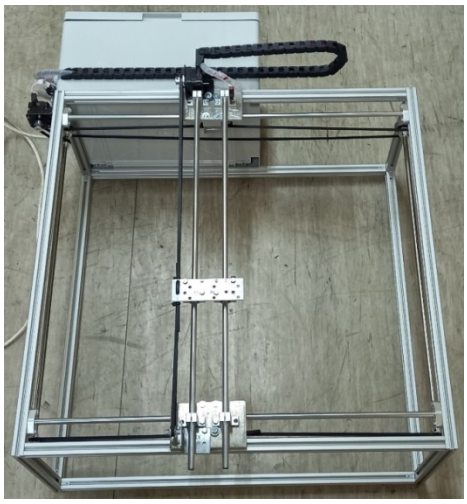


Figure 13. *The final looks of the platform*

The platform has been designed in such a way that numerous opportunities for improvement are left, and they are:

- placement of the sensor on the support and spatial recording on the given surface,
- mechanical finishing (if necessary),
- Improvement of the program for the Arduino board,
- simultaneous motor operation (currently, it is not possible to operate both motors at the same time in order to achieve movement along a given line, but first the operation of one motor to the given position along the corresponding axis is executed, and then the operation of the second motor along the other axis),
- improvement of the LV program so that the mapping of the given surface of an arbitrary shape is performed and the movement management and setting of the movement parameters (speed, resolution, etc.) is done from the LV program and
- speeding up of communication between the platform and the computer.

7. CONCLUSION

This paper shows the realization (construction and programming) of a platform for spatial imaging with sensors. The structural model of the platform implemented in the SolidWorks program is shown and the used mechanical and electrical parts are listed. The platform is made so that the sensor carrier moves in the horizontal plane (in two axes). The movement is performed using two stepper motors, and the Arduino MEGA board with the RAMPS 1.4 additional board and a personal computer, as well as the corresponding specially created Arduino and LabVIEW programs, were used to control the movement. During the testing of the platform, the movement of the carrier from the initial position, through four arbitrarily set points, to the return to the initial position was realized.

At the end text, the final looks of the platform is shown and possibilities for its improvement are listed. The next step in the development of the platform is to place the sensors on the support and test the operation of the entire system. This can be an assignment for students who will attend the VI and EMNEQ subjects in the master's studies.

ACKNOWLEDGMENT

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Getting Started with Wall Segmentation

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Abstract: *In recent years, convolutional neural networks have been widely used in the area of semantic segmentation. In this paper, semantic segmentation network for detecting walls of indoor scenes is presented. Given an image of an indoor scene, the network automatically locates the wall regions in the image. In other words, walls are distinguished from the furniture, windows, curtains, and other possible indoor elements. Encoder-decoder structure of the semantic segmentation module is used. Specifically, PSPNet is used, one of the most common semantic segmentation algorithms. Model is trained on a new indoor scene dataset made from the publicly available ADE20K dataset, consisting of only two semantic labels: wall and no wall.*

Keywords: *semantic segmentation; indoor scenes; encoder-decoder; ADE20K; PSPNet.*

1. INTRODUCTION

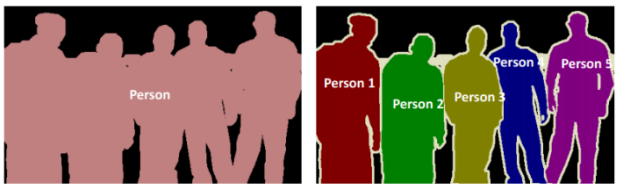
The rapid development of deep neural network architectures, availability of databases and increase of processing power have made it possible to solve more complex tasks in the field of computer vision. One such task is image segmentation [1]. Image segmentation is a process of classifying each pixel of an image to one of the predefined categories. Hence, image segmentation can be considered as a classification on pixel level. Contrary to classification, where the model identifies what is in an image, image segmentation model also performs localization. Image segmentation has two variants: semantic segmentation and instance segmentation [2].

Due to its capabilities, image segmentation can be used in different areas, such as autonomous driving [3], agriculture [4], robotic navigation [5], medical imaging [6], satellite imagery [7], scene understanding [8], etc. The main area of interest in this paper is indoor scene parsing.

Scene parsing is a process of segmenting and parsing an image into different image regions associated with semantic categories [9]. As it predicts class label, location, and shape of the object in an image, it provides complete understanding of a scene. Our goal is to develop a system for segmenting walls in images of indoor scenes. Indoor semantic segmentation is a challenging task due to the high variability of data. This variability is the result of indoor scenes often being cluttered, with a lot of illumination variation [10]. Also, there is often similarity between walls and other semantic parts, such as ceilings, that makes it more difficult to distinguish between these classes.

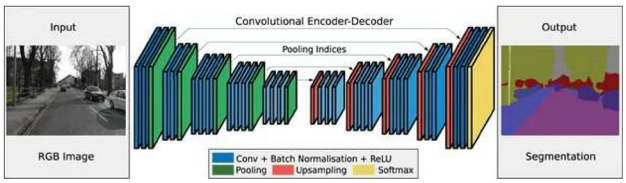
2. Semantic segmentation

Semantic segmentation is the process of assigning class label to every pixel in an image. It treats multiple objects of the same class as a single entity. Instance segmentation, the other type of image segmentation, treats multiple objects of the same class as distinct objects. In the Fig. 1 difference between semantic segmentation and instance segmentation is shown.



2.1 Architectures

The most commonly used architecture for semantic segmentation is symmetric. This architecture consists of an encoder and a decoder, followed by a pixel-wise classifier, as shown in the Fig. 2.



Typical semantic segmentation algorithms that use this structure are SegNet [12], U-Net [13], DeepLab [14], etc.

The encoder part of the architecture is typically a pre-trained classification network that is used for extracting complex semantic features. As preserving image dimensions throughout the entire network is computationally expensive, encoder performs downsampling of the input resolution. The output of the encoder structure is a low-resolution feature map that is learned to be efficient at discriminating between classes. Due to the downsampling of the input image, a lot of information is lost.
The decoder part of the architecture is a network whose main role is to recover details from the feature map. Input to the decoder is the output of the encoder. Decoder can also use additional feature maps from middle layers of the encoder using skip connections. This helps the decoder to prevent loss of information that is imposed by the encoder. The decoder upsamples encoded features to the resolution of the input image and outputs the segmentation mask.

2.2. Loss functions

The most widely used loss function for the classification task is a cross-entropy loss. Since semantic segmentation is pixel level classification, loss function that is often used, is pixel-wise cross-entropy loss [15]. This loss examines each pixel of an image individually, after which, an averaging over all pixels is done. This can be a problem if different classes are not equally represented in an image, because the most prevalent class will dominate during training. Hence, the cross-entropy loss is not a good choice in the case of imbalanced classes. One of the potential solutions is to use weighted cross-entropy loss, where each class is assigned with the appropriate weight. Larger weights are assigned to the less represented classes, which leads to the decrease in influence of the more represented classes.

Focal loss is an improved version of cross-entropy loss that makes the model focus on "difficult" examples by assigning them the larger weights. In the case of semantic segmentation, difficult examples are the pixels for which the model prediction (probability of belonging to the genuine class) is small, such as pixels of a background with noisy texture, pixels of partially cluttered objects, etc.

Another popular loss function, that successfully deals with the problem of imbalanced data in semantic segmentation, is dice loss. However, this loss only addresses the foreground-background imbalance, but ignores imbalance between "easy" and "difficult" examples. It is based on the dice coefficient that is a measure of overlap between two masks.

2.3. Metrics

The best-known metrics for evaluating semantic segmentation models are pixel accuracy (PA) and intersection over union (IoU).

Pixel accuracy is a ratio between the amount of correctly classified pixels and total number of pixels in the image. In the case of multiple classes, mean pixel accuracy (mPA), which represents the class average accuracy, is used. It is not recommended to use this metric in the case of imbalanced class datasets because only the correct classification of the dominant class will yield a high accuracy.

Intersection over union calculates the ratio between the overlap between the ground truth and the output segmentation mask, and their union. In the case of multiclass datasets, mean intersection over union (mIoU) is used. mIoU is calculated by averaging the IoU over all classes.

3. Wall segmentation

Wall segmentation is a special case of semantic segmentation. The task is to classify each pixel in one of two classes: wall and no wall. The goal is to distinguish walls from the rest of the room: ceilings, windows, paintings, doors, furniture, floors…

Wall segmentation is not an easy task. The wall edges are usually hard to detect due to the similarity with other semantic parts of the indoor scene. Also, often there are blurred parts of an image, representing items hanging on the wall that are difficult to localize, thus making it difficult to segment walls.

3.1. Dataset

In this paper, a modification of the ADE20K dataset is used [9]. The original ADE20K dataset consists of more than 20000 images of both indoor and outdoor scenes, annotated with 150 different categories. Each image has an associated segmentation mask. Most objects are also annotated with their parts. Examples of images from the ADE20K dataset with their associated segmentation masks are shown in the Fig. 3.

As the ADE20K dataset consists also of images that are not useful for the task of wall segmentation, it is modified so that it contains only images of interiors. Only a third of the original dataset are images of interest. Only three labels are kept: wall,

no-wall and not annotated pixels. Examples of images from the modified dataset are shown in the Fig. 4.

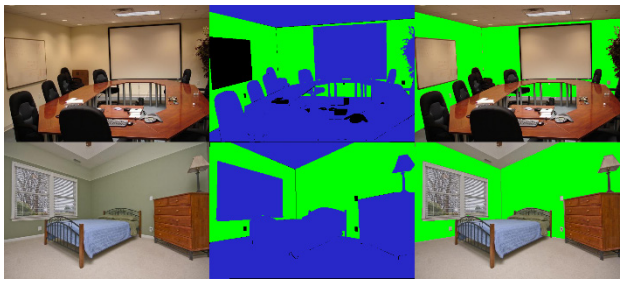


Figure 4. *Indoor images in the modified ADE20K dataset with associated segmentation masks (green - wall, blue - no wall, black - not annotated pixels)*

3.2. Model

In this paper an encoder-decoder semantic segmentation model based on PSPNet [16] is utilized. The encoder forms a feature map of low resolution from the given image, while the decoder upsamples the coarse feature map into a full-resolution map and produces the segmentation mask.

Encoder

Encoder is usually a modified convolutional neural network, typically used for classification tasks. In this paper ResNet-50 network is used. In [14], a variety of techniques for improving performance of the existing semantic segmentation architectures are proposed. These techniques reflect in obtaining finer results with less computational power. One of the improvements refers to the application of a dilated convolution, instead of a standard convolution within the encoder network.

Working with low-resolution feature maps leads to having less parameters of the model. Another advantage is having a large receptive field that enables extracting more context information. On the other hand, the main disadvantage of low-resolution feature map is the lack of spatial information that is very important for obtaining fine details for the task of semantic segmentation.

Dilated convolution enables having a large receptive field without increasing the number of parameters, while preserving spatial resolution. An example of the dilated convolution with a kernel size 3×3, with different dilation rates is given in Fig. 5.

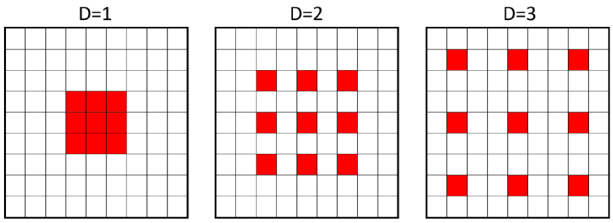


Figure 5. *Example of 3×3 dilated convolution with dilation rate D={1, 2, 3}*

In this paper, dilated ResNet-50 network is used. Following the work in [14], in the last two building blocks of the network, stride is reduced to 1 and all the following convolutions are replaced with dilated convolutions with a dilation rate D=2.

Decoder

The main part of the decoder is the pyramid pooling module (PPM) [16]. The entire structure of the used semantic segmentation model, with the PPM module, is shown in the Fig. 6.

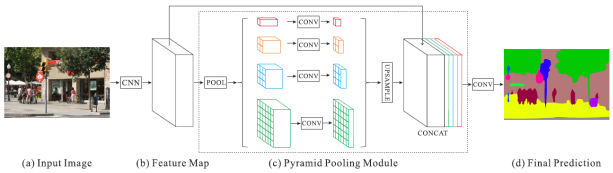


Figure 6. *Overview of the semantic segmentation model with PPM module [16]*

PPM gathers global context information by different region-based context aggregation. On top of the encoded feature map, adaptive pooling is applied, followed by 4-level pyramid pooling. Outputs of different levels of pyramid module are feature maps of different sizes. On top of each of these feature maps average pooling is used, followed by 1×1 convolution. The purpose of this convolution is to reduce the number of channels N times compared to the feature map produced by the encoder, where N is the number of pyramid levels. Obtained feature maps are upsampled to the size of the input feature map using bilinear interpolation. Finally, all four feature maps, along with the input feature map, are concatenated, thus obtaining a global feature map. It is followed by a convolutional layer in order to generate the final prediction map.

The number of pyramid levels, as well as the size of each level can be changed, according to the size of the feature map that is an input to the PPM. Using 4-level pyramid, the pooling filters cover the entire image, half of the image and the small regions of the image. This is a reason why information gathered by the PPM is more representative than information gathered by global average pooling. After the PPM module, the segmentation mask is upsampled to the resolution of the input image.

4. Experiments

The described semantic segmentation model was implemented in PyTorch [17].

The criterion function used for model training was sum of cross-entropy for each spatial position in the feature map. All pixels in an image, as well as the class labels (wall/no wall), have the same weight. Non-annotated pixels were ignored during training. Three different approaches to the model training were used.

4.1. Training

Optimization algorithm used for training is stochastic gradient descent (SGD). "Poly" learning rate strategy was used (1).

$$\alpha_{curr} = \alpha_{start} \cdot \left(1 - \frac{iter}{max\_iter}\right)^{0.9} \quad (1)$$

The starting learning rate was set to $\alpha_{start} = 0.02$, while the maximum number of iterations was set to $max\_iter = 100000$. Current iteration is given by $iter$. Number of epochs was 20 with 5000 iteration per epoch. The learning rate over iterations is shown in the Fig. 7.

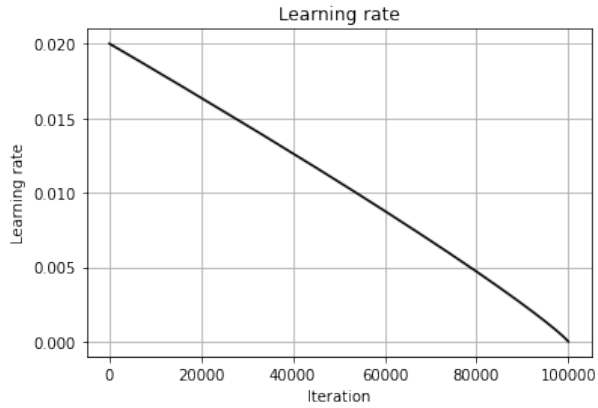


Figure 7. *Learning rate value during training*

For data augmentation, random mirror flip and random resize to the one of the pre-defined sizes were applied. As additional regularization, dropout with the parameter p=0.1 was performed before the last convolutional layer in the decoder part. Also, each batch consists of two images.

First approach to model training consists of two separate steps. Firstly, the model was trained on the entire ADE20K dataset (with all 150 classes), after which transfer learning, on the modified ADE20K dataset, was performed. In the first training, encoder was initialized with weights of the ResNet-50 model pre-trained on ImageNet, while the decoder was randomly initialized using Kaiming initialization. Transfer learning was performed by changing only the last output layer of the decoder (in order to enable classification into 2 classes, instead of 150), and training only this new layer, while freezing all previous. The model was trained for only one epoch after transferring the weights.

Second approach to model training, unlike the first approach, trained the entire decoder structure, not only the last layer, while the encoder weights were frozen. The changed model was trained for 5 epochs.

Third approach used the modified ADE20K dataset from the start. Unlike previous approaches, there was no transfer learning. After initializing the encoder with pre-trained ResNet-50 and random initialization, the model was trained end-to-end with two classes.

4.2. Results

Dataset used for model evaluations is a subset of the modified ADE20K validation dataset, consisting only of indoor images. Metrics used for model evaluation are pixel accuracy and intersection over union.

Evaluation results of models trained by the three different approaches are given in the Table 1.

Table 1. *Evaluation results on the validation set*

	First approach	**Second approach**	**Third approach**
PA [%]	84.82	86.24	90.75
IoU [%]	56.87	59.08	69.05

From the results given in Table 1, it can be seen that the best pixel accuracy and IoU are obtained by the third approach to model training, where model was specialized to classify only two classes from the start. It is important to note that high pixel accuracy doesn't always mean that the segmentation model performs good for each class, especially in the case of imbalanced class datasets. For that reason, IoU is the better metric.

Results of wall segmentation for all three approaches, with the corresponding pixel accuracy and IoU, for one image from the validation set are given below. In the Fig. 8 original image and ground truth are given, while in the Fig. 9 predicted segmentation masks are given.

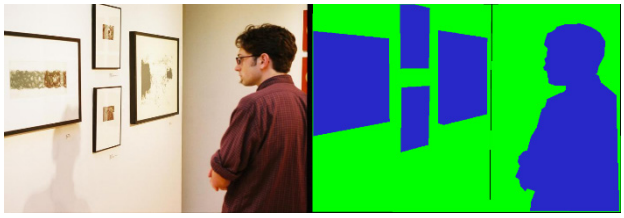
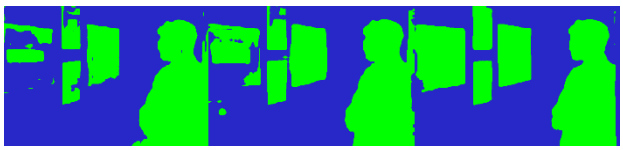


Figure 8. *Original image (left) and ground truth (right)*



a) b) c)

Figure 9. *Predicted segmentation masks: a) first approach, b) second approach, c) third approach*

Based on previous images, it can be seen that the first approach gives the worst results. A lot of pixels of paintings are classified as wall. There is an improvement using the second approach, but the third approach gives the best results.

In the Fig. 10, smoothed accuracy and smoothed loss of the best model on the train set during training, at each iteration, are shown.

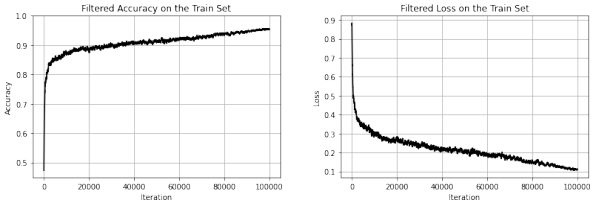


Figure 10. *Accuracy (left) and loss (right) of the best model on the train set during training*

In the Fig. 11, pixel accuracy and IoU on the validation set, for each epoch during training, are shown.

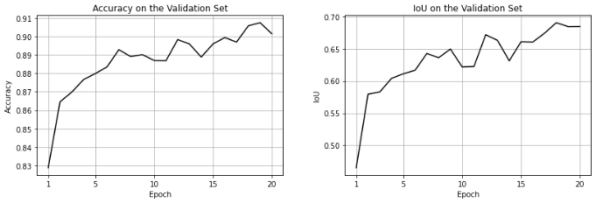


Figure 11. *Accuracy (left) and IoU (right) on the validation set during training*

5. Limits of the current approach

During model testing, it has been observed that there are different limitations imposed mostly by data quality. Some limitations are discussed in more detail below.

5.1. ADE20K scenes

All data in the ADE20K dataset is grouped into different scene categories, such as living room, bedroom, church, airport, etc. When creating a modified ADE20K dataset used for training, described in this paper, a subset of scene categories was selected. This selection was done under the assumption that images belonging to a certain category contain walls. There was no validation whether the selected images contain walls or not. As a result, there is a number of images in the final dataset that are not of interest for training the wall segmentation model. This may result in model performance degradation.

5.2. Annotation quality

During error analysis, it has been noticed that there are certain images with either wrongly annotated walls, or pixels of wall regions not annotated at all. Examples of these two cases are given in the Fig. 12.

Figure 12. *Examples of low-quality annotations*

5.3. Overcluttered images

Another dataset related problem that may affect model quality is when scene in the image is cluttered with various object, as shown in Fig. 13.

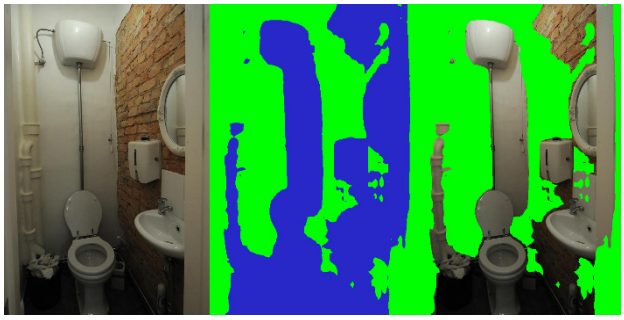


Figure 13. *Example of a cluttered scene and the model prediction*

5.4. Image resolution

The model is trained on the range of different resolutions and gives the best results for images of similar resolution. For images of substantially different resolution, the model does not behave as expected. When the input resolution is large, image should be downsampled to a lower resolution within the range the model was trained on. On the other hand, if the input resolution is too small, the model is not able to extract all the information, from the image, necessary for segmentation.

5.5. Difficult images

When it comes to semantic segmentation, human error performance is a good proxy for the bayes error [18]. So, if humans are not able to successfully distinguish between wall and no wall classes in an image, it cannot be expected from the model to perform well on this image. Example of such an image is given in the Fig. 14.

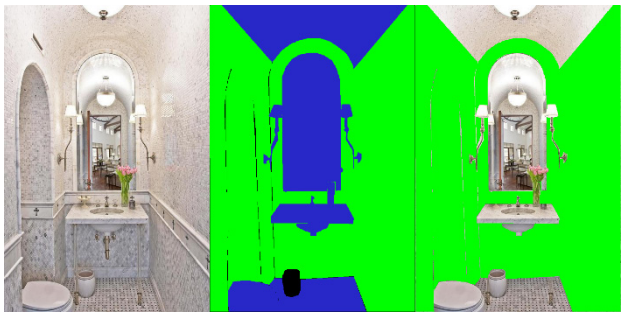


Figure 14. *Example of an ambiguity*

6. CONCLUSION

In this paper, a model structure for semantic segmentation of walls, was described. Encoder-decoder architecture was used. As the encoder, dilated ResNet-50 network was used. Building block of the decoder was pyramid pooling module in combination with bilinear interpolation. The model was trained on a modified ADE20K dataset, consisting only of interior scene images with two classes (wall and no wall). Three different approaches to model training were tested. The best

approach was directly training the model on the modified ADE20K dataset, without transfer learning. Implementation of all approaches is provided in [17].

Wall segmentation is a complex task, due to strong occlusions, similarity with other semantic parts of the interior scenes, as well as different objects that occlude the wall and are hard to localize. During model development, different problems with the current setup of the project, were observed. In the future work, most of these problems can be overcome. When it comes to the selected images, validation of each image, whether it is an image of interest and contains walls, should be performed. Also, all images with bad mask annotations should be discarded. Regarding images with any ambiguities, these images should be treated carefully. All ambiguous images reflect on the model performance and their influence cannot be predicted. Each image should be separately reviewed whether to discard or keep.

Except data cleaning, future work may also consist of experimenting with different model architectures in order to increase validation metrics. Also, lighter models can be implemented with the goal to speed up the entire wall segmentation system. In future work, practical application of such a system can also be explored.

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Implementation of embedded messages using steganography in the PHP software package

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Abstract: *The term steganography is usually associated with hiding and concealing information and messages. People, and even IT professionals, very rarely come into contact with steganography and steganalysis. Only messages are protected by cryptographic protection, while steganography can be said to protect both messages and parties participating in the communication. Steganography also means hiding messages inside computer files and data streams. This paper provides an overview of the implementation of embedded messages using steganography in the PHP software package. Emphasis is placed on hiding information, i.e. messages in JPEG images. As well as decoding or reading a hidden message. The field of steganography is naturally linked to the field of steganalysis, the primary goal of which is the detection of a hidden message, and then its extraction from the object of the message carrier. The most commonly used method for hiding messages is LSB, it is a method that changes the least significant bits to match the secret message. Then, by passing the steganographic key, the message is encrypted using the RC4 algorithm.*

Keywords: *Cryptography; Steganalysis; Steganography; JPEG; PHP*

1. INTRODUCTION

Information is one of the most important resources in this world, so it must be protected from third parties. The method of protecting information content is cryptography. We use cryptography to prevent the leakage of classified information to third parties [1].

The rapid development of technology has had a major impact on the exchange of information. In this modern era, maintaining security during the exchange of information is essential. Many algorithms have been used to ensure that the data exchanged is confidential [2]. One way to protect information is to keep it secret. The secrecy of information can be preserved by encrypting it.

By using mathematical tools, it is possible to achieve that only authorized persons have access to confidential data.

Encryption moves the original message so that it becomes incomprehensible, and obtaining original information from the encrypted message is achieved by decrypting using the appropriate key. This type of confidentiality encroaches on the field of steganography. The field of steganography is naturally associated with the field of steganalysis, whose primary goal is the detection of a hidden message, and then its separation from the object of the bearer of the message. Steganography is the practice of concealing information or a message in secret communication that involves hiding information in any multimedia variant such as text, image, or video [3].

The paper describes the procedures and techniques of steganography and steganalysis of digital images. Emphasis is placed on BMP and JPEG image formats.

2. STEGANOGRAPHY AND STEGANALYSIS

2.1. Steganography

Steganography is a technique of hiding secret messages in such a way that no one except the transmitting and receiving sides is aware of the existence of communication. Hiding messages is based on disguising the message within images, movies, and text. The main advantage of steganography over cryptography is the fact that messages do not attract attention. We can say that steganography can avoid an attack since the attacker is not aware of the existence of communication in a communication channel [4].

Steganography has an advantage in countries where cryptographic techniques for encrypting messages are prohibited. Cryptographic protection protects only messages, while steganography can be said to protect both messages and parties involved in communication. Steganography also involves hiding messages within computer files and data streams. In the case of digital steganography, the message may be within a document, image, or film [4].

Steganography is the science and writing skills of a message in such a way that no one, except the sender and recipient of the message, doubts its existence [5].

Steganography is used to hide secret messages in other messages so that only existing secrets are hidden. In recent times, people are hiding messages in pictures. Replace the least significant bit of each byte of the image with the message bits. The image will not change significantly - in most graphic formats, more colors are displayed than the human eye can recognize - so the message can be unpacked at the end of its journey [6].

Image steganography is the technique of changing image colors as a mechanism for hiding data in an image. This is usually done by changing the smallest significant part, to change the color of the pixels very slightly. A pixel in an image is stored as a 24-bit binary number consisting of red, green, and blue channels. By choosing the least important bit, the color remains almost unchanged [13].

To convert a string to its ASCII equivalent using PHP, we need to run each character through the ord() function which will give us the integer for that character that represents its ASCII code. To convert a decimal number to binary in PHP we use the decbin() function which will return a string representing the binary number. The problem with this function is that it will return the binary number to the most significant digit. In other words, the 8-bit number we need to represent 'a' will be converted into a 7-bit number since the leading 0 will be removed. Since the return of this function is a string, we pass it through the str_pad() function to force all 8-bit numbers to be present [13].

In the continuation of the work, the PHP codes are shown.

2.1.1. Steganographic system

How safe a steganographic system is depends on how well it resists passive, active, and malicious attacks.

The steganographic system is robust if the hidden information can be changed only by major changes to the stego object [10].

A secure steganographic system meets four conditions:

• The hiding algorithm is public, but a secret key is used.

• Only the person with the secret key can detect, remove and prove the permanence of the secret message. No one else can detect any statistical trace of the existence of a secret message.

• Even when an attacker knows the content of one transmitted message, he is unlikely to decipher the content of the remaining messages.

• Detection of a secret message by a computer is too demanding [10].

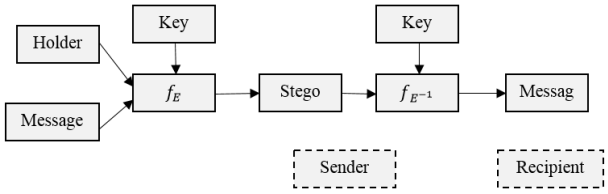

Figure 1. *Steganographic system*

Fig. 1, shows the way the steganographic system works, where:

- Holder - an image within which a secret message is hidden,
- Message - a secret message that needs to be hidden,
- Key - steganographic key, function parameter f E,
- f_E - steganographic function "embedding"
- Stego - steganographic file,
- f_(E^(-1)) - steganographic function "extraction"

2.2. Steganalysis and methods of detection

Steganalysis is a continuation of steganography. It is a science that deals with the detection of hidden messages. When a message is detected, the analysis determines the size of the hidden message and how to separate it from the existing object. With the development of technology and the Internet, cryptographic methods are being replaced by new digital methods, where there is less risk of revealing information during transmission. It is increasingly common to hide information in an image file, due to less suspicion and a large number of photos that are constantly transmitted.

Steganalysis techniques can be classified similarly to cryptanalysis techniques, depending on how much information we have:

• “Steganography-only” attack - when only steganographic media is available for analysis,

• “Known-holder” attack - when we have a carrier and medium for analysis,

• “Known-message” attack - when we know a hidden message,

• “Chosen-steganography” attack - when we know the medium and algorithm,

• "Chosen-message" attack - when we know the message and algorithm,

• “Known-steganography” attack - when we know the carrier, medium, and algorithm [11].

The process of discovering these contents is much more complicated and complex than in cryptanalysis because in cryptanalysis it is known that the subject file under investigation contains some data or information, while in steganalysis it is not known whether there is other content in the suspicious file. Such hidden content can be inserted anywhere (eg on the Internet on the web) in:

- Website text,
- Pictures on the web,
- Audio-video content on the website,
- Within any link (extended HTML).

2.3. LSB method

Most images on the Internet consist of a rectangular map of image pixels (represented as bits) where each pixel is located and it is color. These pixels are displayed horizontally row by row. The number of bits in a color scheme, called bit depth, refers to the number of bits used for each pixel. The minimum bit depth in current color schemes is 8, which means that 8 bits are used to describe the color of each pixel. Grayscale images use 8 bits for each pixel and can display 256 different colors or shades of gray. Digital color images are usually stored in 24-bit files and use the RGB color model. All color variations for the pixels of a 24-bit image are derived from three primary colors: red, green, and blue, and each primary color is represented by 8 bits. So in one given pixel, there can be 256 different amounts of red, green, and blue, which is more than 16 million combinations, resulting in more than 16 million colors.

The most commonly used steganographic technique is the use of LSB because it may contain hidden patterns. Statistical analysis of LSB data is a widespread method for detecting these samples. One of the most common patterns is the correlation between HOB (High Order Bits) and LSB, which is usually presented in hardware, such as a camera, which is used to generate original data. This type of attack is the most successful because most steganographic algorithms work under the assumption that LSB is random. Statistical analysis can detect changes made to the LSB [12].

The LSB method changes the least important bits to match the secret message. The following paper will explain how to hide a message in a 24-bit BMP image using the LSB method.

The pseudocode of the simple LSB method of hiding the implemented image within the work is given in Fig. 2. If a steganographic key is passed to the algorithm, then the key initializes PRNG, but also encrypts the message using the RC4 algorithm. If no key is specified, the message is hidden without encryption. The algorithm first hides the size of the message and then the message itself.

To understand the steganography algorithms that can be used when embedding data in the transform domain, one must first explain the type of file format connected with this domain. The JPEG file format is the most popular image file format on the Internet, because of the small size of the images. To compress an image into JPEG format, the RGB color representation is first converted to a YUV representation. In this representation, the Y component corresponds to the luminance (or brightness) and the U and V components stand for chrominance (or color) [6].

```
LSB_hide(picture, message, key = -1)
{
        If (key == -1) positions = Sequentially ();
        else
        {
                positions = PRNG (key);
                message = RC4 (message, key);
        }
        bit_info = bits (message);
        size_message = bits (length (bit_inf));
        stego = picture;
        works while (i = 0; i < 32; i++)
        {
        LSB (stego(positions[i])) = size_message[i];
        }
        works while (i = 0; i < lenght (bit_info); i++)
        {
        LSB (stego(positions[i+32])) = bit_info[i];
        }
        return stego;
}
```

Figure 2. *Pseudocode hiding of the message by the LSB method*

3. RC4 CRYPTOGRAPHIC ALGORITHM

RC4 is the most commonly used cryptographic data flow algorithm. The paper uses the RC4 algorithm, which, in addition to encryption, can also serve as a generator of pseudo-random numbers.

The algorithm works in OFB mode, the key sequence does not depend on the plaintext. It has an 8 * 8 S-box: S0, S1, ..., S255. The elements of the box are the permutation of numbers from 0 to 255, and the permutation is a function of the key of variable length. The algorithm has two counters, i and j, which are initialized with zero. To generate a random byte, do the following:

$$i = (i + 1) \bmod 256$$

$$j = (j + Si) \bmod 256$$

replace Si and Sj

$$t = (Si + Sj) \bmod 256$$

$$K = St$$

The open-source XOR operation is applied to byte K to obtain a code or with a code to obtain plaintext. Shifting is fast, about 10 times faster than when DES is used [6].

3.1. Encryption and decryption of RC4 algorithms

Encryption and decryption by the RC4 algorithm are identical. A pseudo-random number generator is used. An 8-bit pseudo-random number is generated for the 8-bit input, and then the XOR operation of those numbers is performed. The pseudocode of encryption and decryption is shown in Fig. 3.

```
S = RC4_initialize (key);
i = 0; j = 0;
While there is data in the input stream
{
        i = (i + 1) % 256;
        j = (j + S[i]) % 256;
        replace (&S[i], &S[j]);
        k = (S[i] + S[j]) % 256;
        exit = entrance XOR S[k];
}
```

Figure 3. *Pseudocode of encryption and decryption by RC4 algorithm [7]*

4. APPLICATION

4.1. Xampp

XAMPP is a completely free open source server package for easy installation of Apache servers on computers running Windows, Linux, or OSX. Xampp is intended for use in the local network not as a web server and is primarily used by developers to create a server to test their scripts. Xampp belongs to the family of WAMP software packages, where WAMP is an abbreviation of Windows, Apache, MySQL, and P can refer to PHP, Python, or Perl [8].

4.2. PHP programming language features

PHP is an open-source server-side programming language for dynamically generating HTML code. In other words, PHP is a programming language that can be used to create an HTML page on a server before it is sent to a client filled with dynamic content. In this way of generating the content, the client cannot see the code (script) that generated the content he is watching but has access to pure HTML code, Fig. 4.

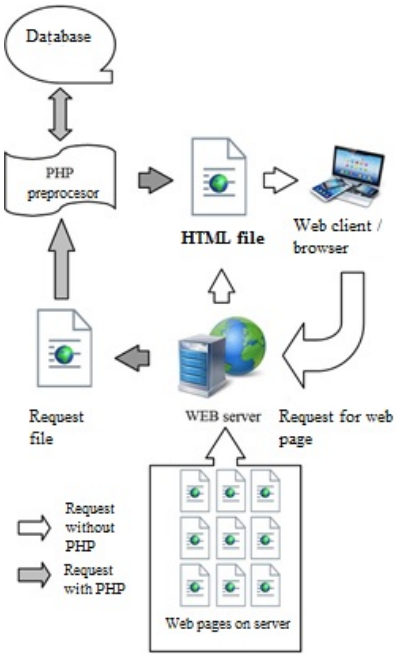

Figure 4. *Execution of dynamic HTML script by PHP program*

PHP is a server-side programming language and a very powerful tool for creating dynamic and interactive Web pages. PHP program code is executed on the server and the result of the execution is an HTML file that is sent to a Web browser. PHP files have a .php extension.

After receiving the request with the PHP document, the server executes the PHP code and based on it generates HTML code and sends it to the client. This means that the page displayed in the client's browser does not exist in that form anywhere on the server from where the client received it. This can create difficulties in positioning - ranking the created pages. In other words, PHP is a scripting language used to create an HTML page on a server before it, filled with dynamic the content, is sent to the client. In this way of generating content, the client cannot see the code (script) that generated the content he is watching but has access to pure HTML code [9].

4.3. Display results and code

After starting Xampp and within it the Apache web server, localhost is entered in the web browser, to access the local server and select the project. The application is launched by entering the following address in a web browser:

http://localhost:1234/steganografija/index.php

In addition to the main program: index.php, and Php-1, three more subroutines have been created, which are called from the main program.

These subroutines are:

- functions.php (Php-2),
- encrypt.php (Php-3) and
- descrypt.php (Php-4).

Fig. 5 shows the layout of the form, which was created in the Php-1 program code. By clicking on Choose File, the image in which the hidden message will be embedded is selected, while the desired hidden message is entered in the label and by clicking on the ENCRYPT button the message is placed inside the imported image, as shown in Fig. 6.

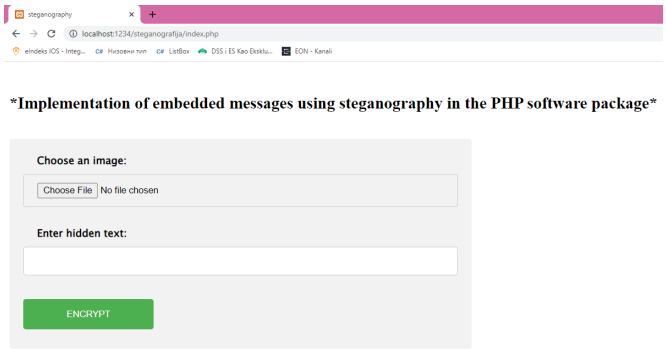

Figure 5*. The appearance of the initial form*

Php-1.

```
<!DOCTYPE html>
<html>
<title> steganography </title>
<body>
<h2 align="left">*Implementation of embedded messages using steganography in the PHP software pack
<link rel="stylesheet" type="text/css" href="style.css" >
<div>
<form action="upload.php" method="post" enctype="multipart/form-data" >
<label class="label" for="fname">Choose an image:</label>
<input type="file" name="fileToUpload" id="fileToUpload"><br><br>
<label class="label" for="fname"> Enter hidden text:</label>
<input type="text" name = "tekst" id = "tekst">
<br><br>
<input type="submit" value="ENCRYPT" name="submit">
</form>
</div>
</body>
</html>
```

***Figure 6**. Select an image and enter the desired message*

The ENCRYPT button uses the Php-3 code (encrypt.php), which includes the Php-2 program code (function.php) and thus opens the PHP image page that contains the hidden message.

Php-3.

```
<link rel="stylesheet" type="text/css" href="style.css">
<?php
include('functions.php');
$msg = 'Test KRIPTOGRAFIJA.';
$src = 'DSC_0075.jpg';
$msg .='|';
$msgBin = toBin($msg);
$msglenght = strlen($msgBin);
$img = imagecreatefromjpeg($src);
list($width, $height, $type, $attr) = getimagesize($src);
if($msgLength>($width*$height)){
  echo('Message too long. This is not supported as of now.');
  die();
}
$pixelX=0;
$pixelY=0;
for($x=0;$x<$msgLength;$x++){
  if($pixelX === $width+1){
    $pixelY++;
    $pixelX=0;
  }
if($pixelY===$height && $pixelX===$width){
    echo('Max Reached');
    die();
  }
$rgb = imagecolorat($img,$pixelX,$pixelY);
  $r = ($rgb >>16) & 0xFF;
  $g = ($rgb >>8) & 0xFF;
  $b = $rgb & 0xFF;
$newR = $r;
  $newG = $g;
  $newB = toBin($b);
  $newB[strlen($newB)-1] = $msgBin[$x];
  $newB = toString($newB);
 $new_color = imagecolorallocate($img,$newR,$newG,$newB);
  imagesetpixel($img,$pixelX,$pixelY,$new_color);
  $pixelX++;
}
$randomDigit = rand(1,9999);
imagepng($img,'result' . $randomDigit . '.png');
echo('done: ' . 'result' . $randomDigit . '.png');
imagedestroy($img);
?>
```

Php-2.

```
<?php
function toBin($str)
{
$str = (string)$str;
    $l = strlen($str);
    $result = '';
    while($l--)
{
$result = str_pad(decbin(ord($str[$l])),8,"0",STR_PAD_LEFT).$result;
}
return $result;
}
function toString($str)
{
   $text_array = explode("\r\n", chunk_split($str, 8));
   $newstring = '';
for ($n = 0; $n < count($text_array) - 1; $n++)
{
      $newstring .= chr(base_convert($text_array[$n], 2, 10));
 }
   return $newstring;
}
```

After selecting an image, called slika.jpg, a PHP page opens with an image that implements hidden text that is not visible to the human eye, Fig. 7. An RGB color system is used in which each of these colors (red, blue, and green) has an 8-bit channel. The LSB method changes the least significant bits for each channel, which means that it is possible to hide 3 bits per image element. For each bit of the message, it is determined in which image element it will be inserted.

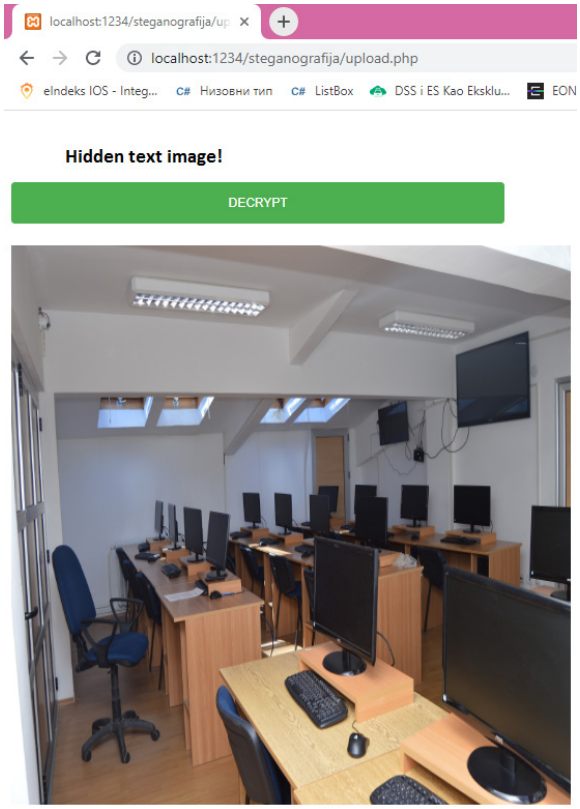

***Figure 7**. Showing an image with a hidden message*

The Php-4 code (decrypt.php) and the Php-2 code (function.php) allow you to click the DECRYPT button to display the decrypted message on the new PHP page, as well as the original image, shown in Fig. 8.

Php-4.

```
1   <link rel="stylesheet" type="text/css" href="style.css">
2   <?php
3   include('functions.php');
4   $src = $_POST["hidden_image"];
5   $img = imagecreatefrompng($src);
6   $real_message = '';
7   $count = 0;
8   $pixelX = 0;
9   $pixelY = 0;
10  list($width, $height, $type, $attr) = getimagesize($src);
11  for ($x = 0; $x < ($width * $height); $x++) {
12    if($pixelX === $width+1){
13      $pixelY++;
14      $pixelX=0;
15    }
16  if($pixelY===$height && $pixelX===$width){
17      echo('Max Reached');
18      die();
19    }
20  $rgb = imagecolorat($img,$pixelX,$pixelY);
21    $r = ($rgb >>16) & 0xFF;
22    $g = ($rgb >>8) & 0xFF;
23    $b = $rgb & 0xFF;
24  $blue = toBin($b);
25  $real_message .= $blue[strlen($blue) - 1];
26  $count++;
27  if ($count == 8) {
28  if (toString(substr($real_message, -8)) === '|') {
29  $real_message = toString(substr($real_message,0,-8));
30          echo('<label class="label"> hidden text:</label> ');
31          echo ('<label class="label2">' . $real_message .'</label> ');
32  echo "<br>";echo "<br>";
33          echo('<label class="label"> Orginal image!</label> ');
34          echo "<br>";echo "<br>";
35         echo "<img src = ./" . $_POST["orginal_image"] . " width=\"600\" height=\
36          die;
37       }
38       $count = 0;
39  }
40  $pixelX++;
41  }
42  ?>
```

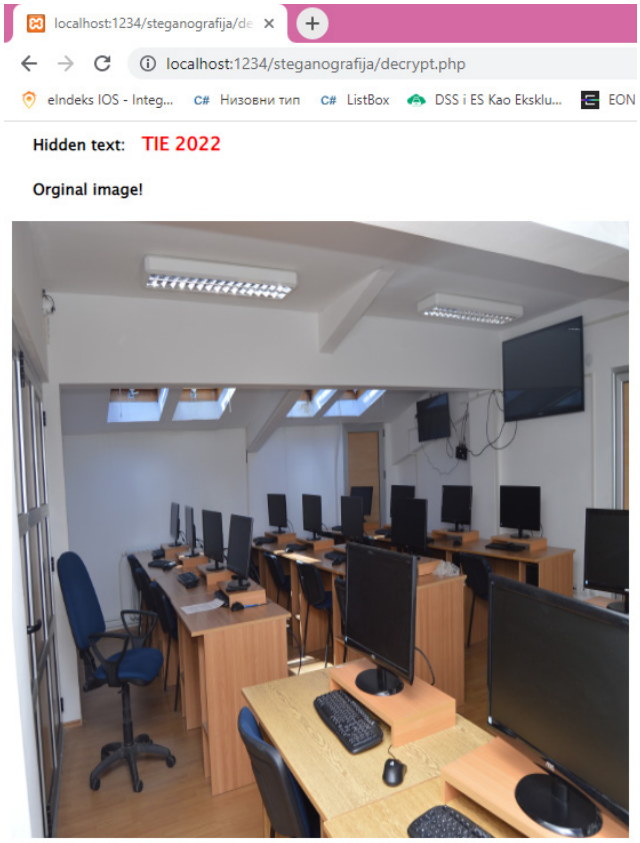

***Figure 8**. Display of the original image and hidden text*

5. CONCLUSION

In the last few years, steganography has been the main topic of many discussions related to its abuse. For this reason, many legal bodies have raised concerns about the use of steganography to exchange illegal material through digital multimedia content on websites.

Particularly interesting are steganographic systems that use encrypted messages, which further improves the security of the system, even if the message is separated, it is still encrypted and incomprehensible to the attacker.

In this paper, the existing steganographic systems that use JPEG images as stego media and transmit encrypted, secret messages through them are analyzed.

Also, the paper presents codes for the appearance of the website, as well as codes for hiding and showing a secret message, which is not visible to the human eye.

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Determining source code repetitiveness on various types of programming assignments

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Abstract: Software projects code duplication and plagiarism are very important in various test cases. The purpose of the work presented in this paper is to observe how various software architectures, project structures, and coding approaches generate different views on code changes. In this paper, code plagiarism - code comparing, in different types of projects has been analyzed through two different approaches. Python script based on the sequence matcher function and the GitLab compare tool are analyzed and compared. Results are presented and discussed in the paper.

Keywords: code repetitiveness, duplicate code detection, python, GitLab compare, web application

1. INTRODUCTION

It is widely believed that software projects have certain similarities to each other. Similarities in programming imply similarities in their solutions.

According to that, it is quite obvious that copying code from someone else happens very often [1]. After copying solution-specific code, it has to be adjusted in order to be reused in some other project. This could be done in potentially similar proposed features but usually with different project design concepts and architecture. In some broader sense, this means that new software products are based on older code [2], [3]. In some corner cases even on reverse-engineered code. It has been noticed that for some high confidentiality source code, methods such as code obfuscation can protect the final product from reverse engineering.

Besides its vast importance in the software development industry, code plagiarism detection plays a significant role in machine learning and deep learning research efforts as identifying repetitive pieces of code can lead to making any future progress in code writing automation.

Also, it is worth mentioning that code plagiarism detection methods are necessary for cheat-proofing programming assignments in engineering universities and schools throughout the world [4], [5], [6].

There are several code plagiarism tools used for this purpose nowadays, such as Codeleaks, Codequiry, Codegrade, Moss, and Unicheck. Almost all of those tools use the benefits of AI pattern recognizing capabilities and as such require quite a lot of computing power. On the other hand, these tools are not free of charge and as such are not fitting into the philosophy of this work which aims to analyze as simple as possible ways of detecting code plagiarism. The authors in this paper attempt to test new tools and functions by avoiding standard, commercial solutions.

Besides these, there are some free tools in the form of desktop apps and web online solutions like WinMerge, CodeCompare, and Diffchecker. Even if they could do the purpose, the focus was to use tools that are learned during studies in faculty and try to extend their usage to some new purposes.

In this paper, Python script and GitLab compare functionality are analyzed for the aim of laying the foundations for the development of a new system that would be used for these purposes.

The paper is structured as follows: at first, the used methods are explained. After that, three different test cases of code samples and project structures are presented. The paper finishes with results, conclusions, and ideas for future work.

2. USED METHODS

In all three cases, analysis has been done using two methods: the modified integrated GitLab compare tool and the Python script provided in Fig. 1.

The first method is based on the integrated Gitlab compare tool. In order to use the GitLab compare tool properly, source code files whose differences we seek to find should be put into different commits on different branches. After that integrated comparator can be used to compare code files line by line, thus producing differences between two files which is suitable for version control systems and software project progress tracking needs.

The second method is based on the Python script which uses *difflib* [7] library and a *SequenceMatcher* [8] function. Difflib library

contains classes and functions for comparing sequences. It can be used for example, for comparing files, and can produce information about file differences in various formats ranging from text matching (which is our case) up to image comparison [9]. SequenceMatcher is part of the difflib library which covers the task of finding code similarities on the character level. SequenceMatcher leverages Ratcliff/Obershelp pattern recognition (also known as Gestalt pattern matching) [10] and code comparison using such method produces detailed and qualitatively stable comparison and as such is very suitable for the required purpose.

```
from difflib import SequenceMatcher
text1 = open("db1.txt","r",encoding='utf-8',errors='ignore').read()
text2 = open("db2.txt","r",encoding='utf-8',errors='ignore').read()
m = SequenceMatcher(None, text1, text2)
print(m.ratio()*100)
```

Figure 1. *Python script used for comparing code files*

In contrast to GitLab compare results, the output of Python script is the percentage of similarities/duplication of two code files determined by *SequenceMatcher* imported from *difflib* library.

3. TEST CASES

In this paper, the repetitiveness of programming code has been analyzed in three test cases which are very different. Different programming languages, code, and project structures between test cases are used. Three specific cases have been covered.

3.1. First Test Case - Change Of A Single Line Of Code In A Boilerplate (Prepared For Reusability) Code

Observed code is a connection file that connects a database with an application. Code is written in the PHP programming language and is used as boilerplate code. It defines parameters for PDO (PHP Data Objects) like hostname, port, username, and password for MySQL server connection. It is expected to be involved in all projects that use PDO connections to MySQL databases. Before and after modification code contains 29 lines of code. The expected output of the comparator function should be very high.

3.2. Second Test Case - Solution Of The Same Task In The C Programming Language, With And Without Using Functions.

In both cases, the code solves the basic programming assignment of entering and printing out array elements. If solved without functions, source code is 33 lines long as opposed to 48 lines of code for a solution with functions. In this case, code matching in some percent should be detected even if there was no plagiarism between authors since the two approaches are applied to solving the same problem. Solutions are very different in structure, but still similar in a textual manner.

3.3. Third Test Case - Four Different Implementations of a Large-Scale Web Project

Projects are created as practical work within the "Internet programming" course exam at the Faculty of technical sciences Cacak. The course is scheduled in the VIII semester (IV year) as one of the final courses before graduation. It relies on the acquired knowledge from several other courses so a large variety of techniques, platforms, and software architecture patterns could be used. The subject of the practical work was to develop a dynamic Web site for *recreational tennis* using PHP and JS programming languages with a responsive front user interface design. It consists of 19 functional tasks (presented in Table 1) which could be developed in any desired way so that the functional requirements are met. Four separate teams were created and they had daily and weekly scrum meetings (what is done and what should be done in the project for every individual team member) within the team. In this case, not all four project implementations have covered all 19 feature requirements. Details of covered features per team are provided in Table 1. Since all implementations have only 7 out of 19 features in common (about 37% of all features) and taking into consideration that all implementations have completely different approaches, a high percentage of code matching was not expected since it would lead to code plagiarism between teams. It is unnecessary to emphasize that the total program lines of code for these projects are quite large: team 1 has a total of 11462 lines of code, team 2 has 4171, team 3 sums up to 9009 lines of code while team 4 has a total of 7905 program code lines.

Table 1. *Large scale web application project features*

N	FEATURE	T1	T2	T3	T4
1	Log of played matches between recreational players and record of results are to be taken care of by application	+	+	+	+
2	Players and clubs can register and edit their profiles	+	+	+	+
3	Clubs can register and edit their court profiles.	+			+
4	Players and clubs can login with valid credentials (email, password)	+	+	+	+
5	Matches can be filtered (filter example: list all yesterday/today/tomorrow matches)	+		+	+
6	Players and clubs can reserve matches and keep match log	+	+	+	+
7	Player/Club can perform court availability check	+			+
8	Auto-fill of required fills while creating a new match based on who is logged in	+	+		+
9	Admin (insert score, ban player, delete match, ban club…)	+	+	+	+
10	Photos upload	+	+	+	+
11	Support for doubles matches	+			
12	Player ranking based on Wins/Losses ratio	+	+		+
13	User profile edit	+	+	+	+
14	Player ranking with filtering(filter examples: current week, last week, this month, this year)		+		+
15	Create a new tournament (name, description, place)				
16	Scheduling matches				
17	Activity information (example: scheduled match confirmation sent by email)		+	+	
18	Favorite clubs, adding club to list of favorites	+			
19	Favorite players, add a player to list of favorites	+			+

4. RESULTS

In this section results obtained by GitLab compare and Python script in all three test cases will be presented.

4.1. First Test Case Results

GitLab compare tool. The code differs in only one line of code, and it is shown in Fig. 2.

Figure 2. *Diff image of database connection file provided from compare function in Gitlab*

Python script. Thus, the two codes are quite similar which is algorithmically confirmed by getting a 98.84% matching percentage.

4.2. Second Test Case Results

GitLab compare tool. As mentioned above, solutions with and without functions will differ greatly in structure, so diff images generated from GitLab will show that the two source codes are quite different. For practical reasons, only part of the diff image is provided in Fig. 3.

Figure 3. *Diff image of C programming assignment provided from compare function in Gitlab*

Python script. On the other hand, the matching percentage determined by the Python script is 37% which proves that the two codes, although structurally different, indeed have a shared code base.

4.3. First Test Case Results

GitLab compare tool. In this case, since files contain thousands of lines of code, diff image would be too impractical to be provided here. As an effective alternative GitLab compare Addition/Deletion output (numerical indicator on how many lines of code are Added/Deleted) will be provided. In the same table, a number of mutual lines of code and

percent values of duplication/plagiarism will be provided as well.

Table 2. *GitLab compare statistics for Test case 3*

GitLab Compare Addition/ Deletion	Team 1	Team 2	Team 3	Team 4
Team 1	11462	**505** 4.4% 12.2%	**880** 7.7% 9.8%	**1232** 10.7% 15.6%
Team 2	3666/ 10957	4171	**678** 16.2% 7.5%	**657** 15.7% 8.3%
Team 3	8129/ 10582	8331/ 3493	9009	**1015** 11.3% 12.8%
Team 4	6673/ 10230	7248/ 3514	6890/ 7994	7905

Data in Table 2 are organized as follows. The main diagonal contains the code line number per team. In the lower triangle of the above-mentioned table, the number of Added/Deleted code lines is provided.

In the upper triangle, are the main results of the comparison and it consists of 3 values.

- The upper value is the number of mutual lines of code detected. A number of mutual lines of code are calculated either by subtracting the number of added lines of code from the target code lines number or by subtracting the number of deleted lines of code from the source number of code lines.
- The middle value is the percentage value of detected code in the first-column team code
- The bottom value is the percentage value of detected code in the first-row team code

For example, Team 1 vs Team 2 comparison detected **505** duplicate lines of code which are **4.4%** of Team 1 code, and **12.2%** of Team 2 code.

Presented results vary from the lowest 4.4% to the highest 16.2% of code duplication between teams. Since the Web application project is analyzed, which contains some boilerplate code that has to be the same in all teams, the presented results show that there was no plagiarism between teams.

Python script. Since there are four independent source codes, their matching to each other is provided in the table.

Table 3. *Percentage of code match between four projects*

Matching of Code (%)	Team 1	Team 2	Team 3	Team 4
Team 1		1.08	0.64	0.76
Team 2	1.08		2.28	3.11
Team 3	0.64	2.28		1.95
Team 4	0.76	3.11	1.95	

As expected, since projects have been implemented in quite different ways, the matching percentage is low.

Calculated results by both methods are confirmed at the project presentation where all four teams presented completely different solutions both visually and functionally.

5. CONCLUSION

From previous results, the conclusion regarding the usability of various methods of comparison to different sizes of source code files. Shortcode files can be easily compared by either the *SequenceMatcher* function or the *GitLab* compare tool. On the other hand, big source code files are very difficult to compare using the diff Gitlab function, so rough code difference estimation should be done using analytical methods. It is worth mentioning here that big source codes can be compared using diff in the Gitlab method as well, but navigating through code and its differences gets very difficult. Using diff Gitlab creates the great benefit of exactly knowing what code changes have been applied, and as such is a valuable tool for the Version Control System.

For future work, frontend and backend files in large-scale web applications would be analyzed separately. Different user interface designs could be based on the same backend code, as well as one user interface design could be used for different backend logic implementations. Also, different functions and tools would be tested for these purposes.

For automation of plagiarism detection, maximum acceptable values should be determined according to project type and assignments.

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Estimation of CPU Scheduling Algorithms Efficiency Using Object Oriented Programming

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Abstract: *Modern operating systems require sophisticated strategies for computer resources management that allows efficient allocation of Computer Processing Unit (CPU) within minimal response time for active users. CPU allocation shemas use different scheduling algorithms, such as First Come First Served (FCFS), Shortest Job First (SJF), Shortest Remaining Time (SRTF), and Round Robin (RR). These algorithms will be presented and evaluated in the terms of scheduling parameters, such as average waiting time (AWT), average turnaround time (ATT), average reponse time (ART), CPU utilization and throughput. Scheduling criteria metrics is done over two sets of input data, within 20 cases, with five processes in each case. Cases in which processes have the same arrival times (ATs) and cases when processes arrive in different times are considered. Randomly generated ATs and burst times (BTs) are used as input data in executable files, obtained from C++ source codes. Files are running by clicking on proper button from Graphical User Interface (GUI), developed in Python programming language. The results for obtained values of AWT, ATT, ART, CPU utilization and throughput for all cases and for FCFS, SJF, SRTF, and RR algorithms are analyzed and compared with the aim to estimate the efficiency of proposed algorithms.*

Keywords: *CPU scheduler; FCFS; SJF; SRTF; RR*

1. INTRODUCTION

Computer resources sharing is one of the basic tasks of a modern multitasking and multiprogramming operating system (OS). Managing and allocation of Central Processing Unit (CPU) between programs in executions, known as processes, is done by the part of OS called CPU scheduler. Whenever the CPU becomes idle, CPU scheduler makes a decision about which process should run at a certain point in time by selecting one of them for execution from the ready queue [1]. Three types of schedulers perform mediation in access to CPU: long-term scheduler, medium-term scheduler and short-term scheduler [2,3,4,5]. Long-term scheduler or admission scheduler decides which processes are to be accepted to the ready queue. Medium-term or mid-term scheduler temporarily removes processes from primary memory to secondary memory or vice-versa. Short-time scheduler, also known as dispatcher or CPU scheduler, decides which of the processes from the ready queue are to be allocated to CPU [2,3,4].

There are two main policies for switching CPU between multi processes, classified into preemptive and non-preemptive scheduling [1,4,6]. In preemptive scheduling, the process may be interrupted on force for some time, and the CPU will be allocated to another process, due to certain critical command [2,5,7]. The interrupted process will be resumed when the process of higher priority finishes its' execution [6,7]. On the contrary, there is no interruption of running process until it terminates in the case of non-preemptive scheduler [2,5,6,7]. This scheduler is also known as "voluntary" or "co-operative" [2,3].

Making decision about assigning a CPU core to a specific process from the ready queue is based on several algorithms: First Come First Serve (FCFS), Shortest Job First (SJF), Shortest Remaining Time First (SRTF), Priority Scheduling (PS), Round Robin (RR), Multilevel Queue Scheduling (MQS), Multilevel Feedback Queue (MFQ), and Completely Fair Scheduler (CFS) [1,2,4,5,8,9]. Some algorithms as the opposite of SJF and SRTF are proposed, such as the Longest job first scheduling non-preemptive and the Longest remaining time first scheduling [4]. MQS proposed dividing ready queues into several separate queues, while MFQ or "front-ground/back-ground multilevel" allows the process to move between queues [5]. In the Highest Response Ratio Next scheduling algorithm the priority of the process was assigned to the process based on the response ratio which depends on process' waiting time (WT) and service time. Different approaches were used for calculating the process priority in varying response ratio priority scheduling technique [10]. CFS, as the default Linux scheduling algorithm from release 2.6.23 of

the kernel, is based on scheduling classes, with each runnable task placed in a red-black tree [1].

Scheduling algorithms comparison is based on multiple criteria, such as CPU utilization, throughput, WT, turnaround time (TT), response time (RT), and fairness [1,2,3,4,6,9,10,11]. Some authors suggest additional criteria, such as context switch [6,9,10]. CPU utilization determines the percentage of time the processor is busy [1,2,6]. The number of processes that are fully executed for unit of time represents throughput [1,6,9,10,11]. The total time that the process spends waiting in the ready queue is WT [1,2,6,9,10], while TT represents the difference between time of completion and time of process submission [2,3,6,9,10]. The period from process submission to first reaction production is RT [1,2,3,4,6,10,11]. Given the equal opportunity to all processes to execute and prevent starvation is fairness [2]. Every time when a process in execution is interrupted before it is finished, with the aim to allocate CPU to another process, a context switch occurs [6,9,10].

For the purpose of this study, two sets of 10 cases with five processes in each case are determined. In order to evaluate FCFS, SJF, SRTF and RR scheduling algorithms, the executable files, converted from source codes in C++ programming language, are used. These executable files are running from proper GUI that was developed for this purpose in Python programming language. The results in the form of values for scheduling parameters are analyzed and estimation the efficiency for chosen algorithms is conducted.

2. SCHEDULING ALGORITHMS

In the simple FCFS algorithm, based on the process's arrival to the queue, the process which enters to the ready queue first is executed first [1,2,5,8,9]. The implementation is managed with FIFO queue [1,4]. When the CPU is assigned to the process, there is no interruption until it is terminated, which classifies FCFS into the class of non-preemptive schedulers [2,5,9]. The average waiting time (AWT) and average turnaround time (ATT) for high priority processes are often quite long, which are the main disadvantages of FCFS [1,9]. The order of processes' execution is according to their CPU BT in SJF algorithm, which means that the process with the least CPU BT will be executed first [5,8,9]. In the case when two process have the same BTs, FCFS algorithm is used for CPU allocation [1]. SJF algorithm can be implemented as non-preemptive (described above) and preemptive, known as SRTF [1,2,4,9]. The process that is currently executed will be preempted when newly arrived process has less CPU BT in SRTF implementation [1]. Both SJF algorithms have better performances than FCFS algorithm, considering AWTs and ATTs [4]. In PS priority is associated with each process and the processes which have the higher priority are executed first [1,2,8]. If two processes have the same priority, FCFS scheduling is implemented for CPU allocation [1]. Some issues, like indefinite blocking (starvation) of the processes with less priority, may arise in PS implementation [5,9]. Another type of preemptive scheduling that is widely used is RR scheduling, designed for time-sharing systems [4,8,9]. It is similar to FCFS scheduling, but added preemption enables switching between processes from circular ready queue [1]. Execution of every process is done within particular time quantum or time slice, usually from 10 to 100 milliseconds [1,5,9]. After that, CPU is allocated to a new process, while the old process is returned to the ready queue, waiting for its' turn again [4,8]. RR algorithm provides an average share of time for every process, but the performances mostly depend on the size of time quantum [1,4].

The AWT, the ATT, and the number of context switches for five processes with different arrival times were calculated and compared for FCFS, SJF, SRTF, PS, and RR scheduling techniques [9]. Five different cases for four processes P_1, P_2, P_3 and P_4 with different BTs and priorities were scheduled using FCFS, SJF, RR and PS algorithms. The values of AWTs and ATTs were calculated with the aim to compare all algorithms. The results of the study indicated that for every case the SJF algorithm was the most efficient, taking into account AWT and ATT, due to its' lowest values [8]. FCFS, SJF, RR and PS scheduling were compared in accordance to calculated values for TT and WT for each of the processes, as well as to ATT and AWT for every scheduling algorithm. These led to conclusion that FCFS and SJF are suitable for batch OS, while RR and PS are the most suitable for time-sharing systems [3]. Modeling of FCFS, Last-Come First-Served and SJF scheduling policies was done with neural networks [6].

Some variants of RR algorithms like shortest job RR, enhanced RR and adaptive RR were introduced with the aim to improve WT, AWT, TT, and ATT for RR scheduling [12]. RR scheduling with time quantum equal to the shortest BT of all processes solved the problem of starvation and enhanced performances which are expressed through reduction of ATT and AWT [11]. Modified RR with Dynamic Time Quantum used time quantum that was equivalent to average value of BT of the remaining processes in ready queue, rounded to the nearest integer value. Time quantum was updated after each cycle. This modified RR algorithm reduced the AWT, ATT, and number of context switches, comparing with traditional RR [13].

The processes were classified in two separate queues, one for processes with higher priority, and

the other for processes with lower priorities. The processes were alternatively chosen, starting from the process from queue with higher priority. This method reduced by half the AWT for high priority processes [7].

Maximizing throughput and CPU utilization, minimizing TT, RT, and WT, as well as the minimum overhead of context switches are the basic goals of every scheduling algorithm [4,5,6,9,10]. Choosing the proper scheduling algorithm relies on basic criteria metrics.

3. RESEARCH METHODOLOGY

The first step in this study was obtaining two input data sets. The first one consists of 10 cases with all processes which arrive at the same time, and the second, in which the processes in every case have different arrival times. All cases have five processes, namely P_1, P_2, P_3, P_4, and P_5. The values for BTs for every case and every process in the first set are generated using random.sample() method, for the range of 1-20, from random module. The values for ATs and BTs for each process from the second set are generated using random.randint() method, for the range of 0-20, from numpy module in Python programming language. The sets of input data are presented in Tables 1 and 2.

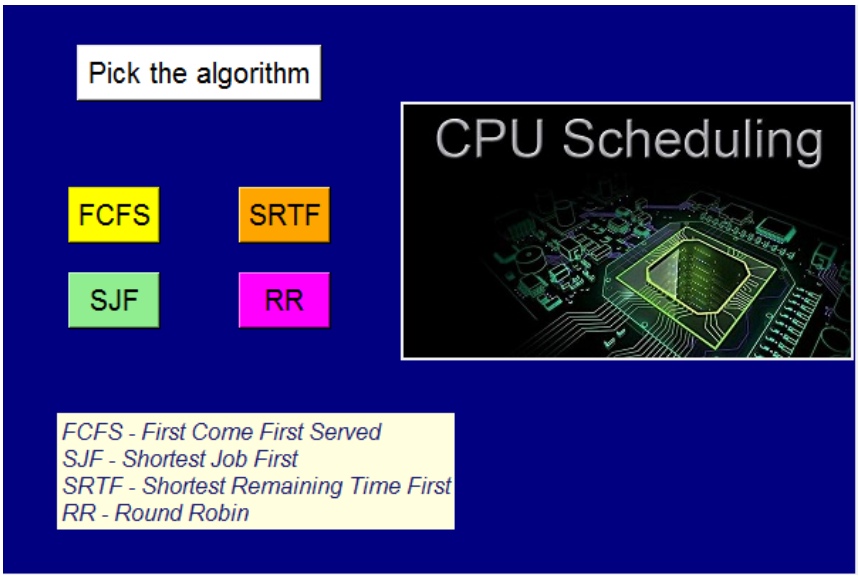
Source codes written in C++ programming language for FCFS, SJF, SRTF, and RR scheduling algorithms [14], are adapted and converted to executable files. GUI with labels in Python programming language is designed (Fig. 1) with the aid of tkinter module and its' methods.

Table 1. *Processes' burst times for the first set*

Process	Burst times (ms)				
	P_1	P_2	P_3	P_4	P_5
Case 1	1	6	8	3	16
Case 2	3	4	16	8	5
Case 3	18	14	13	15	7
Case 4	9	16	18	12	1
Case 5	12	15	17	4	16
Case 6	7	10	1	18	15
Case 7	13	12	2	10	8
Case 8	8	1	12	17	2
Case 9	15	1	9	11	16
Case 10	10	8	6	16	12

Table 2. *Process' arrival times and burst times for the second set*

Process	Arrival times and Burst times (ms)									
	P_1		P_2		P_3		P_4		P_5	
	AT	BT	AT	BT	AT	BT	AT	BT	AT	BT
Case 1	7	9	8	15	6	14	13	18	3	4
Case 2	6	10	1	15	0	2	7	17	1	1
Case 3	3	18	5	9	13	16	4	16	13	18
Case 4	3	10	2	18	8	9	2	10	6	7
Case 5	10	15	0	9	2	3	3	15	5	6
Case 6	0	9	3	10	10	16	8	10	6	10
Case 7	7	12	1	7	11	16	15	16	8	16
Case 8	5	18	6	13	2	17	8	14	2	7
Case 9	6	17	0	17	14	19	6	17	14	17
Case 10	1	10	1	17	17	18	14	15	10	16



Simple click on the button named as appropriate algorithm (see Fig. 1) allows for input data entry, AT, BT, and Time quantum for RR algorithm. The values such as Start time of the process (ST), Completion time of the process (CT), TT, WT, and RT, are obtained. TT, WT and RT are calculated using the equations (1) - (3).

$$TT = CT - AT \quad (1)$$

$$WT = TT - BT \quad (2)$$

$$RT = ST - AT \quad (3)$$

The time quantum for RR is set to 2 ms. Cases are tested on Windows 11 with Intel i5 12600k and 16 GB of RAM. The results of execution for FCFS algorithm are presented in Fig.2, as an example.

```
P No.   AT      BT      ST      CT      TT      WT      RT
1       0       1       0       1       1       0       0
2       0       6       1       7       7       1       1
3       0       8       7       15      15      7       7
4       0       3       15      18      18      15      15
5       0       16      18      34      34      18      18

Average Turnaround Time = 15.00
Average Waiting Time = 8.20
Average Response Time = 8.20
CPU Utilization = 100.00%
Throughput = 0.15 process/unit time
Press any key to continue . . .
```

Figure 2. *Results of the execution in the case of FCFS algorithm*

4. RESULTS AND DISCUSSION

The values for ART are excluded due the fact that these values are equal to AWT in all cases for FCFS, SJF and SRTF algorithms. There are differences for RR algorithm, where ART is less than AWT.

Table 3. *AWT and ATT for the first set*

	FCFS		SJF		SRTF		RR	
	AWT	ATT	AWT	ATT	AWT	ATT	AWT	ATT
Case 1	8.2	15.0	6.6	13.4	6.60	13.4	11.4	18.2
Case 2	12.8	20.0	8.40	15.6	8.40	15.6	15.2	22.4
Case 3	31.0	44.4	31.0	44.4	22.0	35.4	44.6	58.0
Case 4	26.4	37.6	14.2	25.4	14.2	25.4	28.2	39.4
Case 5	26.2	39.0	11.0	20.8	19.6	32.4	37.2	50.0
Case 6	15.6	25.0	12.0	22.2	12.0	22.2	22.8	33.0
Case 7	20.4	29.4	12.8	21.8	12.8	21.8	24.8	33.8
Case 8	15.2	23.2	7.60	15.6	11.6	19.6	13.6	21.0
Case 9	18.4	28.8	13.6	24.0	13.6	24.0	26.4	36.8
Case 10	18.4	28.8	16.0	26.4	16.0	26.4	29.6	40.0

With the aim to compare and conduct evaluation of presented algorithms, the results of the study for the first set are shown in Figures 3 and 4, in the form of graphics for AWT and ATT, respectively. ART is not presented due the fact that the values are equal to AWT in all cases for FCFS, SJF and SRTF algorithm.

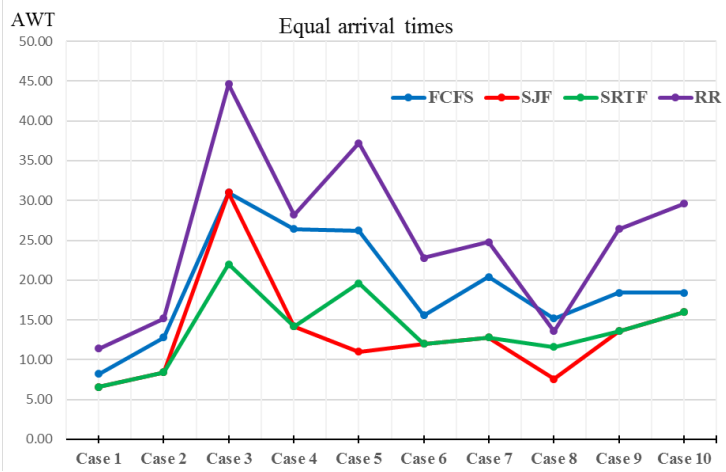


Figure 3. *The values of AWT for FCFS, SJF, SRTF and RR algorithms for the first set*

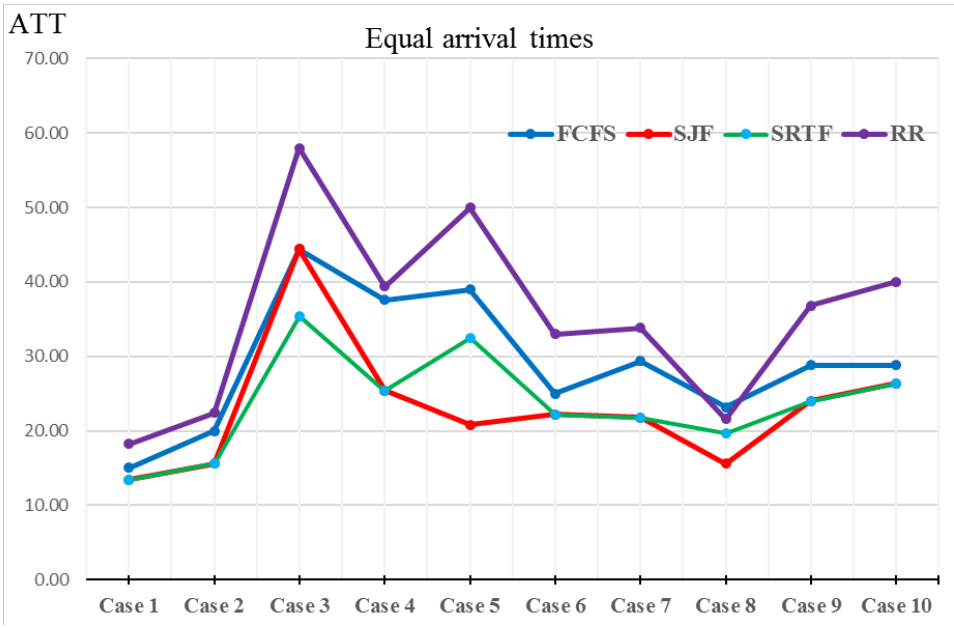


Figure 4. *The values of ATT for FCFS, SJF, SRTF and RR algorithms for the first set*

In general, SRTF and SJF algorithm gives the best performances according to AWT and ATT for all cases from the sets, compared to the other observed algorithms. This is especially the case when burst times are longer (Cases 3, 5, and 10). RR algorithm shows the worst performance, while SJF algorithm proved to be the best solution for CPU allocation according to the criteria of minimizing AWT and ATT, in the cases when all processes arrive at the same time.

Calculated values for the cases from the second set, for AWT and ATT are presented in Table 4, when all processes have different arrival times. The values for ART are excluded due to the fact that these values are equal to AWT in all cases for FCFS, SJF and SRTF algorithms. There are differences for RR algorithm, where ART is less than AWT.

Table 4. *AWT and ATT for the second set*

	FCFS		SJF		SRTF		RR	
	AWT	ATT	AWT	ATT	AWT	ATT	AWT	ATT
Case 1	13.8	28.8	12.8	24.8	12.8	24.8	23.6	35.6
Case 2	10.0	19.0	7.2	16.2	6.8	15.8	14.2	23.2
Case 3	26.2	41.6	24.8	40.2	23.0	38.4	44.2	59.6
Case 4	23.6	34.4	15.6	26.4	15.6	26.4	29.6	40.4
Case 5	12.2	21.8	10.4	20.0	9.40	19.0	21.4	31.0
Case 6	13.8	24.8	13.8	24.8	13.80	24.8	26.6	37.6
Case 7	15.0	28.4	15.0	28.4	15.0	28.4	27.8	41.2
Case 8	25.0	38.8	19.8	33.6	19.8	33.6	41.2	55.0
Case 9	26.4	43.8	26.0	43.4	26.0	43.4	53.2	70.6
Case 10	20.0	35.2	19.4	34.6	19.4	34.6	38.6	53.8

The results for the second set are shown in Figures 5 and 6, in the form of graphics for AWT and ATT, respectively. ART is not presented due to the fact that the values are equal to AWT in all cases for FCFS, SJF and SRTF algorithm.

SRTF algorithm gives the best performances according to the criteria of minimal AWT and ATT for all cases in which the processes have different arrival times. SJF is only slightly less effective then SRTF (just in two cases), while RR algorithm shows the worst performances. This is especially the case when BTs are longer than BTs from the other cases, as it is in Cases 3, and 9.

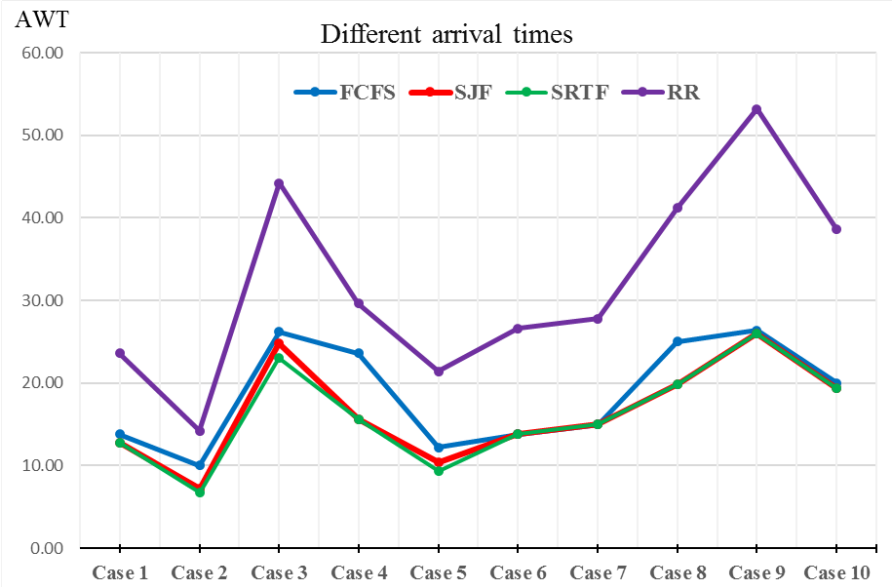


Figure 5. *The values of AWT for FCFS, SJF, SRTF and RR algorithms for the second set*

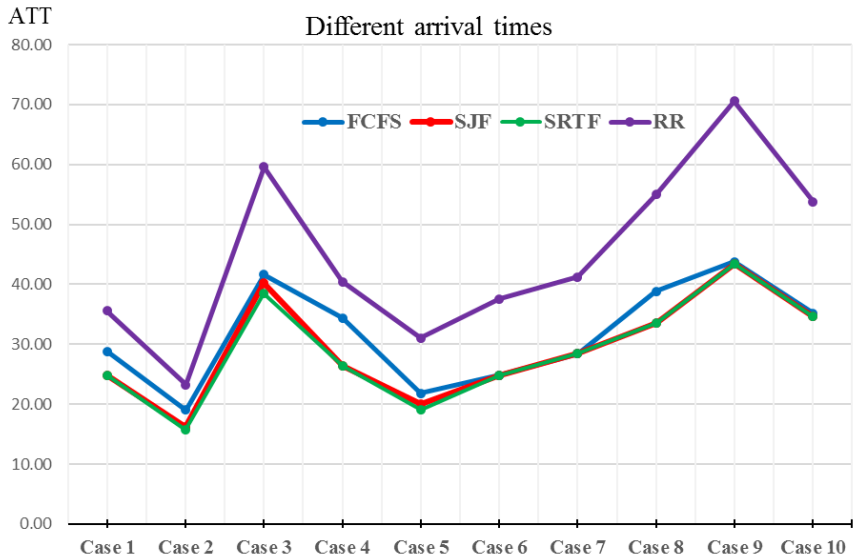


Figure 6. *The values of ATT for FCFS, SJF, SRTF and RR algorithms for the second set*

The values for CPU utilization is 100% in all cases from the first set for all algorithms. In 50% of the presented cases from the first set, the values for throughput are the same for all algorithms (Case 1 - 0.15, Case 5 - 0.08, Cases 6, 9 and 10 - 0.10). In the Cases 2, 3, 4, 7, and 8 these values are the same for FCFS, SJF and SRTF algorithms, respectively 0.14, 0.07, 0.09, 0.11 and 0.12. In these Cases the values for throughput are greater for RR algorithm (0.21, 0.13, 0.56, 0.15 and 0.56). In the second set the values for CPU utilization slightly deviates under 100% (see Table 5). In Cases 3, 9, and 10 there is no difference between the values for CPU utilization and throughput for all observed algorithms. In cases 1, 2, 4 - 8 the values of throughput for RR are slightly higher than values for FCFS, SJF and SRTF algorithms.

Table 5. *CPU Utilization (CPU u) and Throughput (Thr) for the second set*

	FCFS, SJF, SRTF		RR	
	CPU u	Thr	CPU u	Thr
Case 1	95.24	0.08	100	0.19
Case 2	100	0.11	100	0.38
Case 3	96.25	0.06	96.25	0.06
Case 4	96.43	0.09	100	0.12
Case 5	100	0.10	100	0.15
Case 6	100	0.09	100	0.10
Case 7	98.53	0.07	100	0.08
Case 8	97.18	0.07	100	0.12
Case 9	100	0.06	100	0.06
Case 10	98.70	0.07	98.70	0.07

5. CONCLUSION

Efficient CPU management is a very important issue, especially in modern multitasking and multiprogramming operating systems, where CPU is constantly being allocated and deallocated many times to different processes during programs' execution. Another additional issue is increasing scheduling performances, through minimizing TT, WT and RT, with maximizing throughput and CPU utilization.

In this study, different issues of FCFS, SJF, SRTF, and RR algorithms, as examples of preemptive and non-preemptive scheduling are compared and evaluated in terms of AWT, ATT, ART, CPU utilization and throughput. The results show that the SRTF algorithm, followed by SJF algorithm, provides the best performances in the sense of AWT and ATT, while the worst is, according to these two criteria, RR algorithm. On the other side, RR algorithm proved to be the best according to the ART. CPU utilization is almost equal for all presented cases, while the value of throughput is is slightly better for RR algorithm in regard to other proposed algorithms.

The implementation of proposed methodology for scheduling algorithms' application is easy, due to a simple GUI. Further analysis can include some improvements in the future, in the sense of increasing the number of cases in both sets, and expanding the list of algorithms with priority scheduling algorithm. There is also a need to analyze the RR algorithm with different quantum values, with the aim to find the best solution in terms of AWT and ATT.

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Kinematic analysis of door closer mechanism using software package SAM 8.1

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Abstract: *The topic of this paper is to study and describe kinematic analysis of a door closer. By performing kinematic analysis, the velocity, acceleration and point position values are obtained. These data are important for the optimal sizing of the mechanism and supporting elements. We compare the analysis made by the graphical method with the analysis obtained with computer programs designed for kinematic analysis (SAM 8.1).*

Keywords: *kinematic analysis; SAM 8.1; door closer*

1. INTRODUCTION

The door closing mechanism (Fig 1) is a mechanical apparatus which absorbs the energy of opening a door (usually by human hand), using it to close the door without excessive force. This yields a practical solution for closing the door completely, without unnecessary physical damage to the door frame.

Figure 1. *Door closer mechanism*

One of the first references to a device used for closing doors can be found in the "Hero of Alexandria" scriptures, where automata used for closing temple doors were described. It is supposed that the door closing apparatus was working using weights and levers. A smaller version of the device, used for smaller doors (found on houses, stores, and such), used a rope with a loop, connected to the door frame.

Nowadays, door stopping mechanisms (door stoppers in later text) are commonplace. Modern door stoppers can be adjusted meticulously. They can be set for the door to stay open, the door could be closed at a certain speed, and the pressure to the frame can be defined. The velocity regulation option is important for those doors which are used by a lot of people throughout the day. A smaller closing velocity allows a small group of people to pass quickly. By increasing the door closing velocity, the movement of a group of people is made more convenient, and the thermal losses and gains are reduced, therefore increasing the energy efficiency of a building.

Door stoppers are also tightly connected with fire safety regulations of an object, especially in those objects where the possibility of a fire hazard is high. By putting a door stopper on a fire door, which needs to be fully closed in the case of fire accident, the spreading of smoke and fire is mitigated. The door stoppers can also be used for security purposes. The electronic locks, for instance, are not completely safe without a stopper. When a person enters the room, the door is closed automatically. There is a possibility that the person who just entered the room does not close the door, leaving it unlocked. In order to prevent this case, a door stopper is installed in order to completely close the door at all times, thereby locking it as well. Door stoppers play an important roll in keeping the air conditions in a room constant. As an example, let us assume the case of a mechanical engineering company with fine-grain processing. In the laboratory which contains measuring apparatuses, the exact temperature and air humidity must meet the prescribed values, yet the conditions found in the plant are different. Therefore, it is important to keep all doors open for as minimum as possible, in order to prevent air flow between these rooms. Door stoppers are often used for privacy purposes in bathrooms and changing rooms. Door stoppers are also used in cases where the velocity of opening

a door must be kept constant, in order to mitigate the air flow conditions (e.g., draft, wind).

2. SAM 8.1

SAM (Synthesis and Analysis of Mechanisms) is an interactive PC-software package for the design, analysis (motion and force) and optimization of arbitrary planar mechanisms. Mechanisms can either be generated via the design wizards or they can be assembled from basic components, such as: beams, sliders, gears, belts, springs, dampers and friction elements. SAM integrates pre-processing, numerical analysis and post processing, such as animation and xy-plots, in an easy to-use environment offering pull-down menus, mouse support and help facilities.

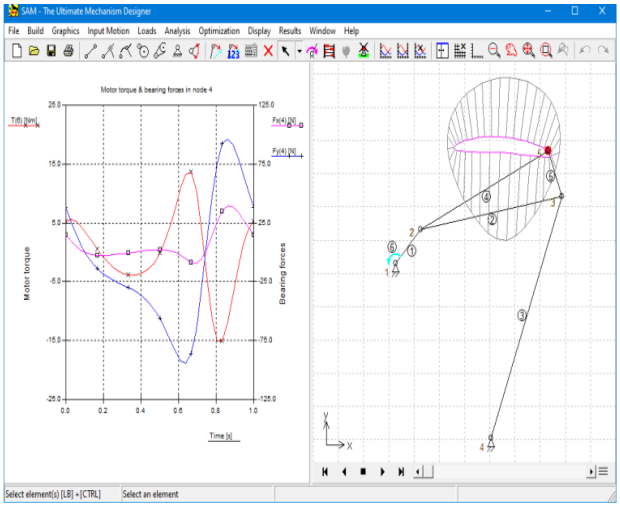

Figure 2. *Typical screenshot of SAM 8.1*

The mathematical foundation of the analysis kernel, which is inspired by the well-known finite element approach, offers a large number of features and overcomes many of the problems of traditional mechanism programs. Open loop, closed loop, multiple loops and even complex planetary mechanisms can equally well be analyzed due to the finite element formulation. Even the most complex mechanisms, including planetary gear trains, can be modeled within minutes.

The analysis results can be displayed either in tabular or graphical form. The tabular listing can be viewed on the screen, send to a printer or stored in a readable formatted list file. The x/y plot option allows to plot any variable against time or any other variable. An unlimited number of functions can be combined into one x/y plot with optionally two different scalings to allow proper multiple display of variables with different amplitude ranges. It is possible to output selected data to an external file (ASCII format) for customized post-processing.

SAM can also animate the mechanism motion. As a further aid for the designer the path and velocity hodograph of any number of moving points can be plotted. Also, a complete project documentation (ASCII-format) can be automatically generated.

Once the mechanism has been constructed and the inputs have been defined any of the following kinematic quantities can be calculated (all relative or absolute):

- nodal position, displacement, velocity, acceleration
- angles, angular velocity and acceleration

Furthermore, SAM can perform force-analysis, thus enabling the calculation of:

- driving torque (force)
- reaction forces in bearings
- internal forces in elements
- required or transmitted power

External forces, such as process forces, can be applied as function of time or as function of any motion result, that is calculated by SAM. The same holds for external torques. The user can define a force (value & direction) as function of time.

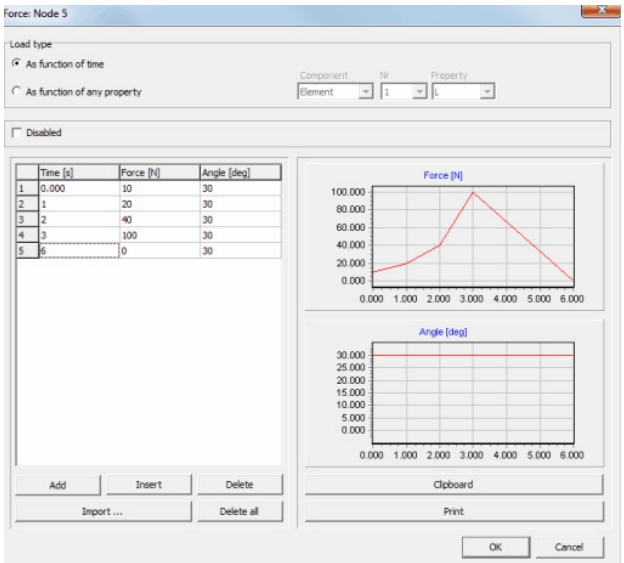

Figure 3. *Force profile as function of time*

SAM can also optimize the parameters of a mechanism such that a desired trajectory is followed as good as possible. The first screenshot below shows the result of a manual attempt to find a 4-bar mechanism with a coupler point motion that mimics the Bezier curve through 8 specified points. This mechanism is used as a starting point for an optimization in which the RMS-value of the deviation of the actual trajectory from the target curve is chosen as optimization objective function and the positions of the nodes of the mechanism are the design parameters. All moving nodes can be chosen arbitrarily, whereas the support points are limited in their range, as indicated. As can be seen, the mechanism that resulted from the optimization process shows significantly better correspondence with the requested target path.

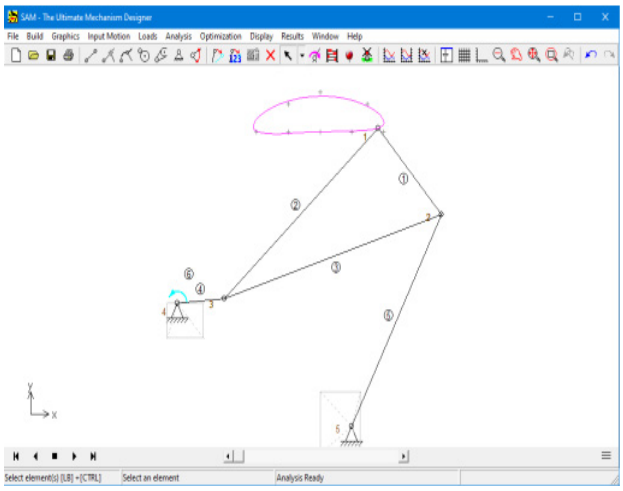

Figure 4. *Optimized 4-bar mechanism*

3. KINEMATIC ANALYSIS USING SAM 8.1

The kinematic analysis will be performed using SAM 8.1 software tool. The first thing that needs to be done is draw a schematic of the door stopper when the door is fully open.

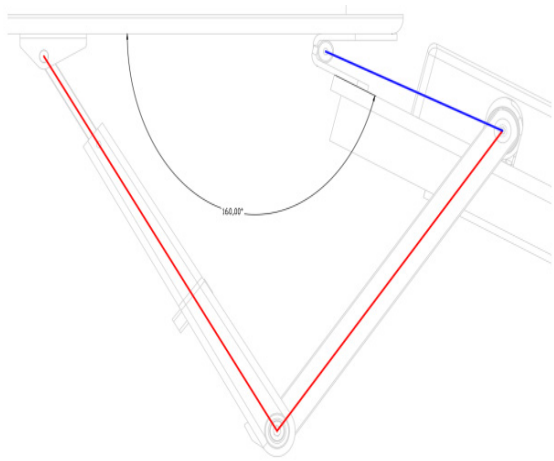

Figure 5. *Polygon position in AutoCad*

First, draw a beam using SAM. The fixed support is positioned on one end of the beam, where the origin of the coordinate system is to be placed. After that, the coordinates of each point is read from AutoCad (Fig 6).

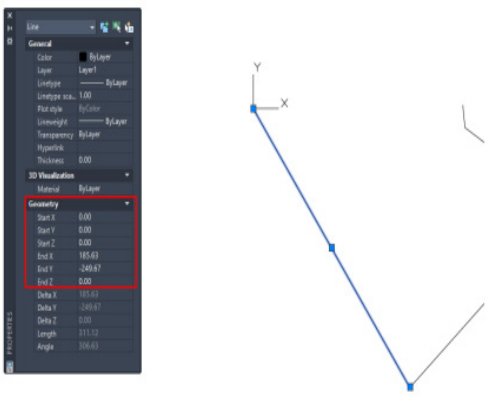

Figure 6. *Coordinate display in AutoCad*

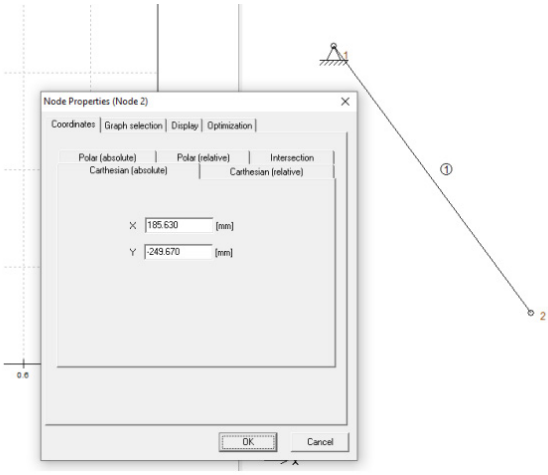

Figure 7. *Node properties dialog box*

After the coordinates for all the points are noted, the kinematic schematic of the mechanism is obtained.

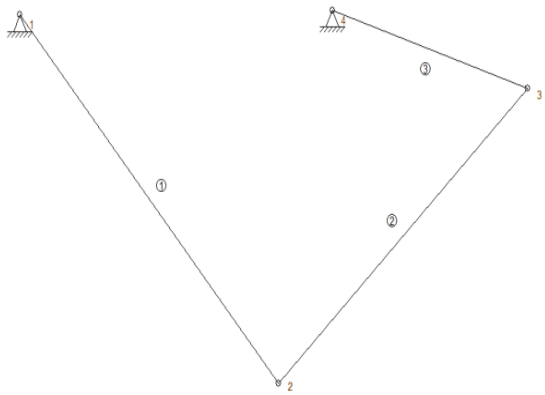

Figure 8. Kinematic scheme of mechanism

For the kinematic analysis, the most important point for velocity and acceleration calculation are points 2 and 3.

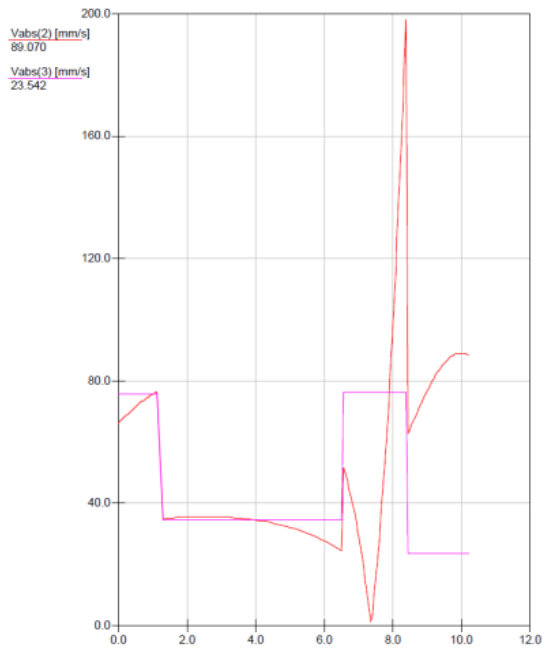

Figure 9. *Velocity diagram of point 2 and 3*

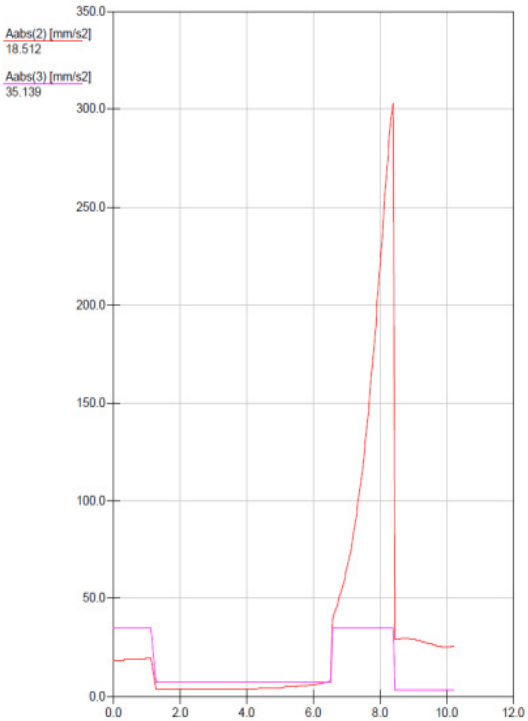

Figure 10. *Acceleration diagram of point 2 and 3*

Also, the angular velocity of point 3 can be of interest. The angular velocity of point B is interesting because the mechanism (located in point B) and the door is considered a single body.

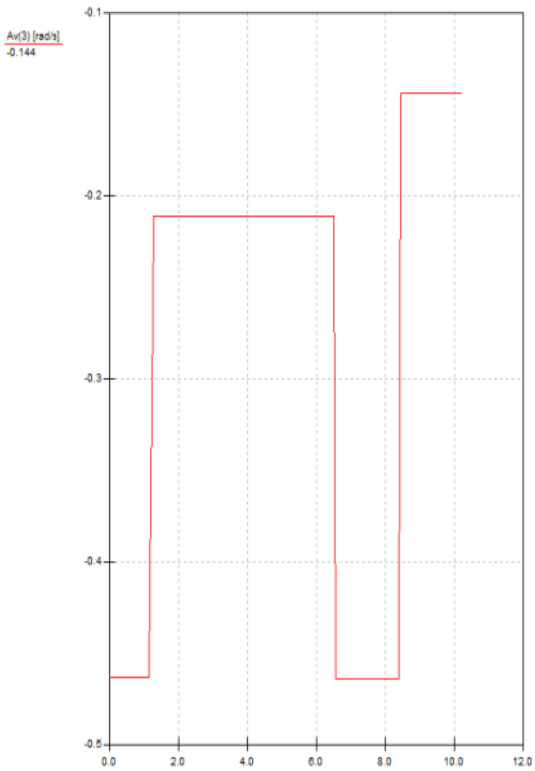

Figure 11. *Angular velocity of point B*

Another interesting fact for SAM is that this software plots the graphs for the location of points.

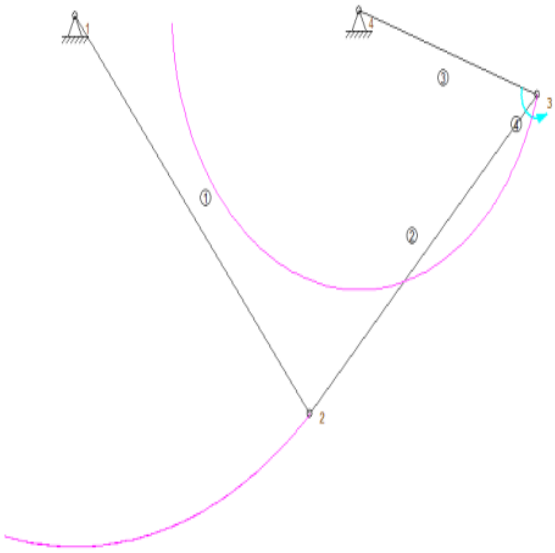

Figure 12. *Path of point 2 and 3*

Results can also be displayed in tabular form.

Table 1. Comparison of velocity results

Point	Velocity (m/s) AutoCad	Velocity (m/s) SAM
A-2	0,071	0,07061
B-3	0,076	0,07583

Table 2. Comparison of acceleration results

Point	Acceleration (m/s^2) AutoCad	Acceleration (m/s^2) SAM
A-2	0,019	0,01897
B-3	0,035	0,03514

Table 3. Results of relative error

Point	Velocity	Acceleration
A-2	0,00039	0,00003
B-3	0,00017	0,00014

The relative errors between the results are insignificant. Therefore, the results of solving this problem graphically are same as solving it by using simulation.

4. CONCLUSION

The door stopper is a very useful apparatus, which has extensive uses, such as in security, social and ecological. For security purposes, it is used mostly for fire doors in order to keep them tightly closed, as well as for automatically closing and locking a door. The goal is to optimize closing time in order to meet social and energetic requirements. The less the door is opened, the less the thermal losses,

thus saving the energy, positively affecting the environment and reducing the financial costs.

The kinematic analysis yields the velocity and acceleration values for all characteristic points of the mechanism. Also, the position values for each point are important in designing the mechanism, in order to avoid collisions with other parts of the mechanism or other bodies. The analysis was conducted in a graphical manner using the CAD software suite, but in a way that can also be performed by hand. Also, a modern way of kinematic analysis, where the calculation of velocity and acceleration for each position was performed by using the given parameters.

By knowing all velocity and acceleration values, a kinematic diagram is generated. The maximum values can easily be read from the diagram. With the help of these diagrams, tension and force inside the beams should be calculated as a next step, in order to optimally determine the dimensions of the mechanism. The flaw of this kind of analysis is the precision of time and angular velocity measurement. For a more precise analysis, the measurements should be made using modern equipment, such as sensors.

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Two-axis Pneumatic Manipulator as a Test Bed for Teaching Energy Efficiency of Compressed Air Systems

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Abstract: *The two-axis pneumatic manipulator has a wide range of possible applications in terms of experimental tests. In this paper, the pneumatic manipulator was used as a test bed on which students tested two different control methods in terms of the energy efficiency of the compressed air systems. Traditional proportional control and stand-alone performance using fast switching directional control valves for Pulse Width Modulation (PWM) control were considered. The circular movement of the pneumatic manipulator carrying the tool and processing by planing lighter material such as plastic was chosen. The results showed that lower consumption is achieved with PWM control.*

Keywords: *teaching; energy efficiency; compressed air; programmable pneumatic manipulator; PWM control; proportional control*

1. INTRODUCTION

The shortage of energy sources means that more attention must be paid to their rational consumption. When describing the quality of energy consumption, terms "combined into one" are used - Energy efficiency [1-4]. The performance of the observed system should not be impaired by the application of energy efficiency. In addition to rational consumption, the motive for applying energy-efficient systems is reduced energy consumption which implies money saving, since unnecessary consumption is eliminated. Therefore, energy efficiency should not be seen as forced savings or reduced energy consumption, but a thoughtful approach to rationed energy consumption that maintains the functionality of the system to which it is applied. Reducing energy consumption has, apart to financial, other non-energy benefits, such as environmental implications.

Compressed air is often used as a drive energy in industry. But compressed air represents a relatively expensive source of energy, and it is justified and desirable to introduce energy efficiency concepts into compressed air systems [5], [6].

Teachers and researchers around the world have begun to involve energy efficiency concepts in teaching [7-9]. Namely, in order for energy efficiency to be taken seriously, it should be presented to young people so that they use energy rationally. There are researches conducted to determine the degree of presence of energy efficiency in teaching as well as methods for better mastery of these principles by students [7], [9]. The advantages of spreading relevant information and participating in energy education projects, using the example of students and parents who have improved their behavior to be more energy efficient are highlighted in [8].

The importance of applying energy efficiency, especially in the field of compressed air system, is also recognized at the Faculty of Technical Sciences in Novi Sad. Courses on Master's and Doctoral studies dedicated to the possibilities of practical application of energy efficiency have been introduced. Subjects in which the theoretical concepts of energy efficiency are practically applied are Energy efficiency of compressed air systems within the Master's studies [10], [11] and Selected chapters of the energy efficiency of automated systems within the Doctoral studies [12], [13], both in study programmes of Industrial Engineering and Mechatronics.

As the part of the above, several research papers have already been done on the mentioned topic [14-18].

The main goal of this paper is to present a way for testing energy efficiency of compressed air systems during practical classes using the two-axis pneumatic manipulator [19]. In this way, it is possible to clarify theoretical knowledge as well as the various possibilities of practical application of energy efficiency for future engineers, who will apply it in their later works depending on how specific tasks allow them to do that.

2. EXPERIMENTAL STATION FOR EDUCATIONAL PUROPSE

In order to test different types of pneumatic control systems in contact tasks, a two-axis manipulator was developed [19]. At the same time, this device enables the monitoring and analysis of energy efficiency, as well as the realization of the desired processing process.

2.1. Acquaintance of students with assigned tasks

With the help of two-axes manipulator, excess material can be removed from the workpieces. Therefore, with this practical example, the characteristics of the software and hardware can be analyzed for two control methods on the experimental station.

With the developed two-axis pneumatic manipulator, a wide range of tests is open to students. The following possibilities can be realized:

1. Modularity:
   - change of actuators,
   - change of measuring pistons (position sensors),
   - implementation of three or more axes;
2. Testing:
   - force sensor,
   - remote sensors,
   - different types of processing,
   - different types of materials,
   - energy efficiency,
   - etc.;
3. Systematization of remote control in accordance with the I4.0 concept.

2.2. Two-axis pneumatic manipulator

As the first step, a 3D model of two-axis pneumatic manipulator (Fig. 1) was created [19]. The numbered components are given in Table 1.

Fig. 2 shows the practical realization of two-axis pneumatic manipulator. It represents a mechatronic system and consists of mechanical, pneumatic and electronic components, with appropriate control components. This mechatronics system is also used for the preparation of graduation, master's theses, professional practices of students, as well as research works of young associates.

For the purposes of this paper, one cycle of the tool movement of the programmable two-axis pneumatic manipulator in the planing process is used and it is shown in Fig. 3. Respectively, numbers from one to four represent the movement

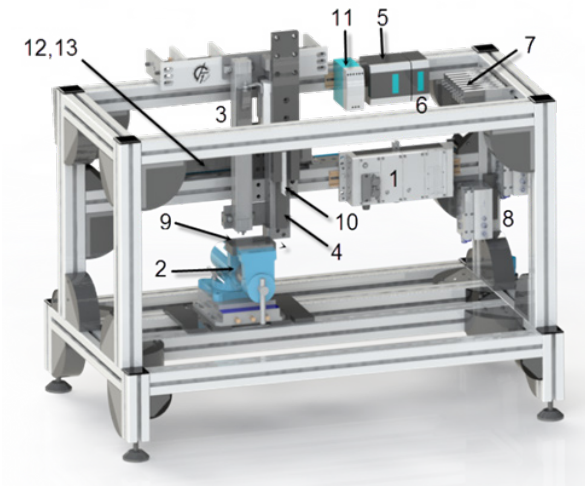

Figure 1. *3D model of the developed station*

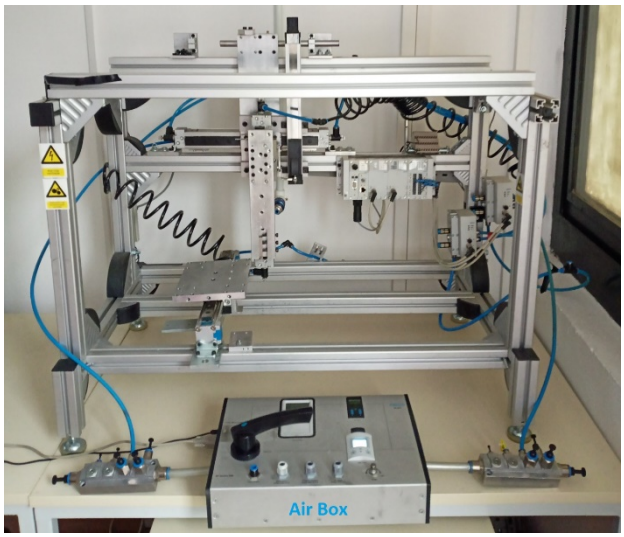

Figure 2. *Two-axis pneumatic manipulator*

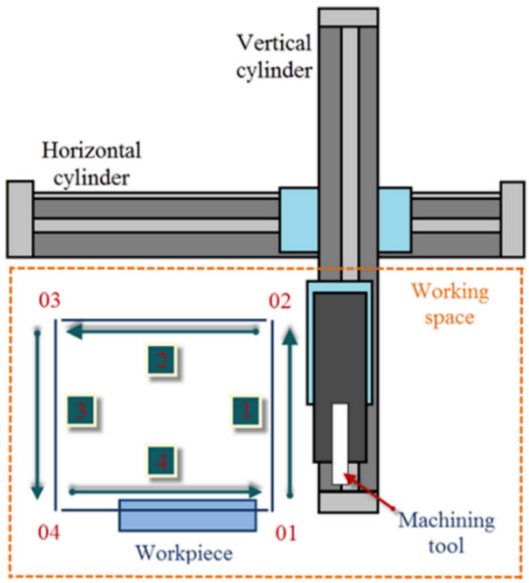

Figure 3. *Material processing by planing*

This research (paper) has been supported by the Ministry of Education, Science and Technological Development through project no. 451-03-68/2022-14/200156 "Innovative scientific and artistic research from the FTS (activity) domain".

Table 1. *Specification of components*

Name	Type	Description/Purpose
PLC	Festo - 50E-T06GCQST21T21YJ-Z	For proportional control (CPX); Fig. 1, position 1
Clamp	-	For workpiece clamping; Fig. 1, position 2
Linear encoder	MLO-POT-225-TLF	Analogue displacement encoders, stroke 200 mm, resolution 0.01 mm; Fig. 1, positions 3,13
Vertical and horizontal cylinder	DGPL-25-200-PPV-A-B-KF-KU-D2	The rodless cylinders, with stroke 200 mm; Fig. 1, positions 4-12
PLC	Fatek – FBs – 24MAT2 – D24	For PWM contro; Fig. 1, positions 5
Data Acquisition System (DAQ) module	Fatek - FBs – 4A2D	For PWM control; Fig. 1, position 6
Solenoid valves	MHE3-MS1H-3/2G-1/8	Fast switching 3/2-way directional control valves, normally closed, monostable, nominal flow rate 200 L/min, for PWM control; Fig. 1, position 7
Proportional valve	Festo - VPWP-6-L-5-Q8-10-E-G	5/3-way proportional control valves, nominal flow rate 700 L/min; Fig. 1, position 8
Workpiece	Polyethilen (PE)	Fig. 1, position 9
Machining tool	High Speed Steel	Fig. 1, position 10
Power supply	Festo 220 to 24VDC	Fig. 1, position 11
Air Box	FESTO GHDA-FQ-M-FDMJ-A	Measurement of compressed air consumption; Fig. 2 marked as Air Box

path of the manipulator axis. The planing machining process (work stroke), which removes shavings from the workpiece, is performed by moving a machining tool along a horizontal path from position four to position one (left to right).

Before performing the exercises, students are reminded of the basics of machining and the used procedure - planing. Planing implies the removal of material from the workpiece by linear movement of the planing knife. Using a pneumatic manipulator, the planing of flat surfaces by removing material takes place using a programmable device.

Fig. 4 shows some of the possible material profiles obtained by planing, i.e. realized grooves with different shapes. In this paper, it is obtained a shape which is shown in Fig. 4a.

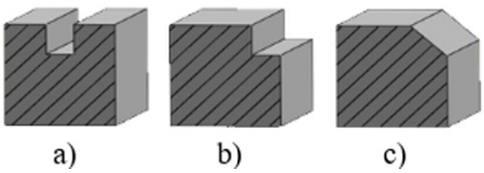

Figure 4. *Material profiles obtained by cutting*

2.3. Measuring the compressed air consumption

For the purposes of this research from the aspect of energy efficiency, the laboratory device Air Box type GHDA-FQ-M-FDMJ-A [20], manufactured by Festo, was used. The flow meter enables the monitoring and measurement of compressed air consumption on individual components or in the entire system, as well as leakages in the system. In the specific task, the emphasis is on measuring compressed air consumption.

The Air Box was placed immediately after the compressed air service unit. In this way, it is possible to measure the consumption of the entire system. The maximum pressure at the input port of the AirBox is 10 bar, with a deviation of less than 100 mbar. Air Box is shown on Fig. 2 and is marked as Air Box.

Total consumption for one cycle was calculated as the area under the graph of the consumption function:

$$Q = \frac{1}{2}\sum_{1=1}^{n}(t_i - t_{i-1})\,(q_i - q_{i-1}) \qquad (1)$$

where:

Q is compressed air consumption in *Nl*,

t_i is measurement time in *s*,

t_{i-1} previous measurement time in *s*,

q_i is compressed air flow in t_i in *Nl/min* and

q_{i-1} is compressed air flow in t_{i-1} in *Nl/min*.

2.4. PWM and proportional control

After familiarizing with the hardware structure of the experimental station, students are able to produce the appropriate control actions. It is important to compare the behavior of the system from the aspect of energy efficiency in the next step.

As part of the teaching, two control methods are considered - proportional and PWM.

In order to compare two different ways of control, the execution of an identical cycle for both control methods will be observed.

For PWM control system, control valves must have a very short state change time, otherwise PWM control will not be able to be realized. Namely, if the duration of the PWM pulse is less than the opening/closing time of the directional control valve, the valve will not react. Otherwise, if the duration of the high level of the PWM signal is longer than the difference between duration of the PWM pulse and the sum of the time required for opening and closing, the valve will not close. The compressed air flow to the cylinder will remain open until the next cycle. These switching valves do not have the possibility of changing their flow due to the construction of the valve. With proportional valves, the flow of fluid through it can be changed and it is proportional to the current (or voltage) flowing through the armature windings of the valve. That means that they are more expensive than standard control direction valves.

For realization of PWM control, P regulator has been used and that way of control is discussed in [21]. Also, it were used 3/2-way fast switching monostable directional control valves, with one port blocked (function as 2/2-way valve) and the main control unit with build-in HSPWM (High Speed Pulse Width Modulation) outputs.

The pneumatic scheme of PWM control is shown in Fig. 5. Valves Y7 and Y0 are responsible for moving cylinder A in one direction, (Y2 and Y1 for cylinder B), and for moving in the opposite direction valves Y4 and Y5 (Y2 and Y1 for cylinder B).

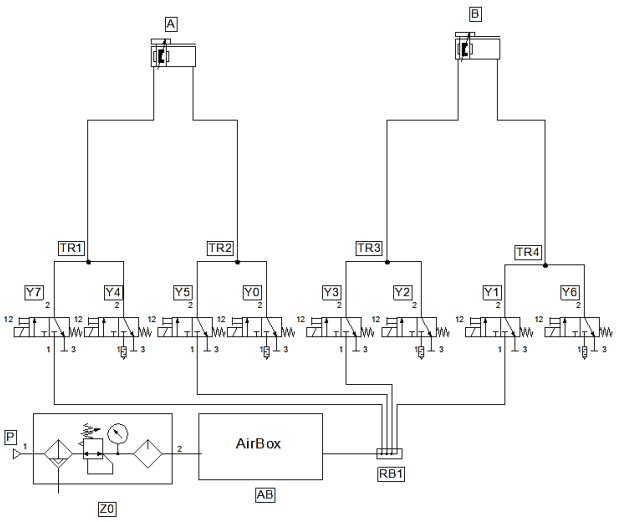

Figure 5. *Pneumatic control scheme for PWM control*

Output frequency for the HSPWM can be calculated by using equation (2):

$$f_{pwm} = \frac{18432}{P_n+1} \quad (2)$$

where P_n is the value of the output frequency in the range from 0 to 255.

For the experimental verification of the PWM control, the initial value of the register was set to be optimal for horizontal (210) and vertical (213) cylinders. It follows that the time period for the horizontal cylinder is 11.45 ms, and for the vertical 11.61 ms.

The architecture of the system in the case of proportional control includes a controller CPX-CEC with separate modules for controlling pneumatic axes marked as CPX-CMAX-C1-1 and 5/3-way proportional pneumatic valve, marked as VPVP-6, by Festo manufacturer. Fig. 6 shows the corresponding pneumatic scheme for appropriate system.

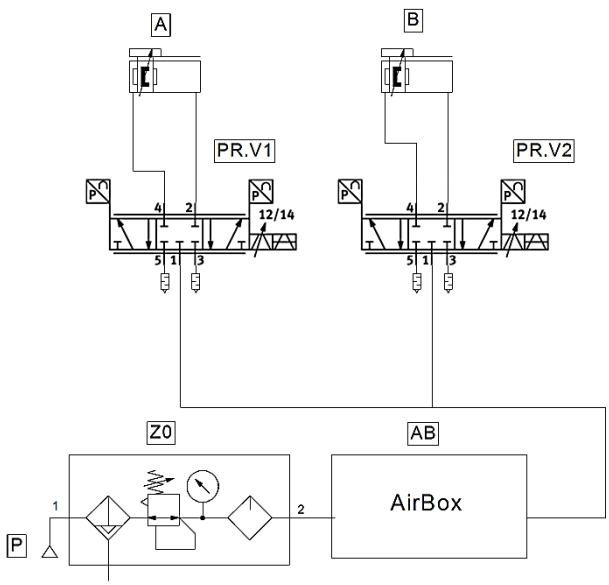

Figure 6. *Pneumatic control scheme for proportional control*

3. RESSULTS AND DISCUSSION

Since the two control models used were compared in terms of energy efficiency, it is necessary to compare their compressed air consumption.

An identical knife with a width of 3 mm was used for both control models. Measurements were made on three different materials: Polyethylene (PE), Polypropylene (PP), Polyamide (PA). Compressed air consumption was measured for one identical grooving cycle on each of the three materials, for the cutting profile shown on Fig. 4a.

In Fig. 7 is presented a comparison of compressed air consumption of the entire system during one cycle with proportional and PWM control when machining three different materials (PE, PP, PA).

For easier understanding, in Fig. 8 and Fig. 9 are shown two examples of compressed air consumption when PWM and proportional control were applied in case of processing PE workpieces, respectively.

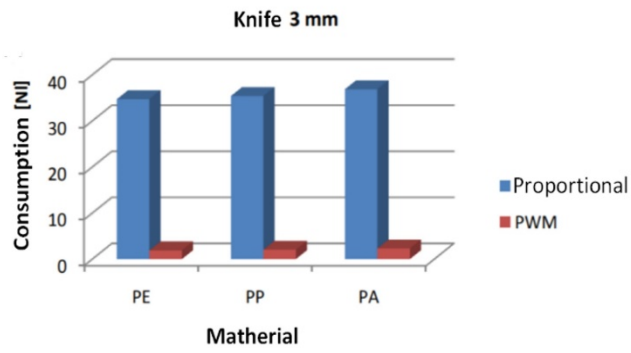

Figure 7. *Compressed air consumption of the entire system per cycle during the machining of three different materials*

With proportional control, compressed air consumption ranges from 34.69 *Nl* to 36.84 *Nl* per cycle, while with PWM control, compressed air consumption is from 1.88 *Nl* to 2.3 *Nl* also per cycle. Namely, PWM and proportional control methods are characterized by two different ways of maintaining the achieved position. With proportional control, for the purpose of maintaining the position, compressed air is constantly consumed. With PWM control, both chambers of the rodless cylinder are filled and the supply of compressed air is blocked with the fast switching direction control valves.

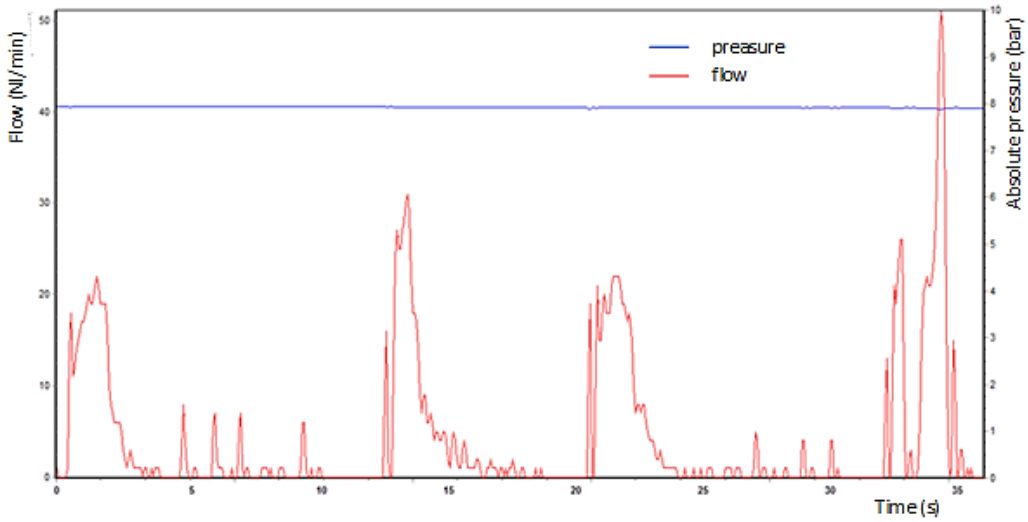

Figure 8. *Compressed air consumption for PWM control and PE workpiece*

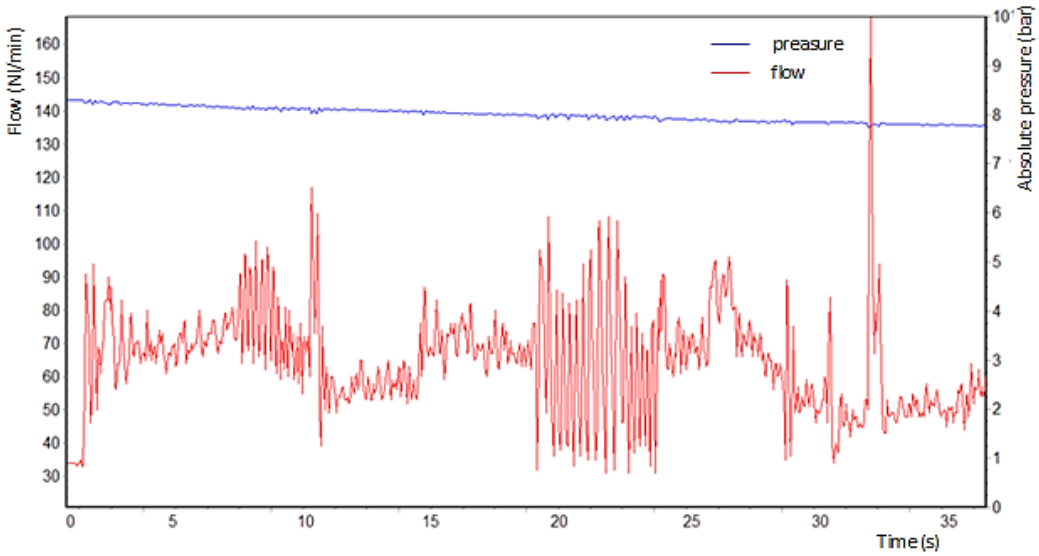

Figure 9. *Compressed air consumption for proportional control and PE workpiece*

4. CONCLUSION

In order to enable students to become practically acquainted with the energy efficiency of compressed air systems, a two-axis manipulator with pneumatic drives was used. A realistic planing machining operation task adapted for performing laboratory exercises was chosen.

After carrying out practical exercises on the testing of energy efficiency of the compressed air system, students will be able to:

- Build and connect the system;
- Collect and process data;
- Calculate compressed air consumption;
- Analyze the obtained results;
- Draw appropriate conclusions.

Students were given the opportunity to apply a traditionally known proportional control system, which is inherently expensive and has a high compressed air consumption, but is effective in performing accurate and fast positioning tasks. After that, by considering a different type of control system - PWM, the goal was to achieve successful performance of the same task. Functionality was maintained (performance may be slightly impaired up to the permitted limit), but consumption was reduced (the system becomes more energy efficient) and more profitable.

Based on the measurement results, it can be concluded that the compressed air consumption with proportional control is 15÷20 times higher compared to PWM control.

By forming their own control circuit and analyzing the obtained results, students get the conclusion that the same functionality can be achieved by using standard and cheaper components comparing to the ready-made solution that is available. The advantage of such an approach is seen through the achievement of a more economical and energy efficient device for use in contact tasks.

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Application of Robotic Vision and PSO algorithm for determining the optimal path of movement of the robotic system

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Abstract: *The application of robotic vision and biologically inspired algorithms improves the process of programming the movement of a robotic system. In the work, the optimal path of movement of the robotic system during the welding process was determined. The shape of the path to be taken was recorded using a 2D camera, i.e. robotic vision, and the optimal path of movement determined by the PSO (Particle swarm optimization) algorithm.*

Keywords: *robotic vision; PSO algorithm; optimal path.*

1. INTRODUCTION

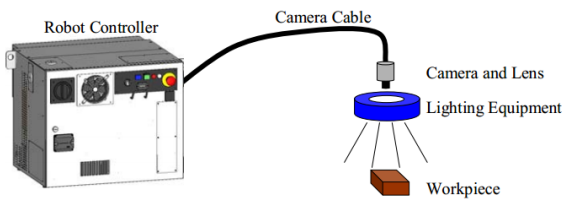
In order to achieve accuracy in the movement of the robot system, reduce the time of completing tasks and maintain quality, it is necessary to apply Industry 4.0 concepts. The Fanuc company has developed the iRVision program, which is used for cooperation between the robot and the camera in order to better perform the task assigned to the robot. With this approach, so that the robotic system can communicate with the camera and coordinate its work, opportunities are created for solving tasks in assembly, welding, control, etc. In the production of boilers for steam heating, there is a need for welding parts. The seams are mostly straight, but they are in space along different axes and at different heights. In the work, first the position of the seams through which the robotic system should pass was recorded with a 2D camera, and then the optimal path along which the robotic system should move was determined by the PSO algorithm in order to minimize the time required to perform the task.

2. *i*RVision FANUC VISION SYSTEM

The camera and lens of 3D Laser Vision Sensor are sane as the two-dimensional camera, so the 3D Laser Vision Sensor can also be used for the two-dimensional applications.

*i*RVision consists of the following components:

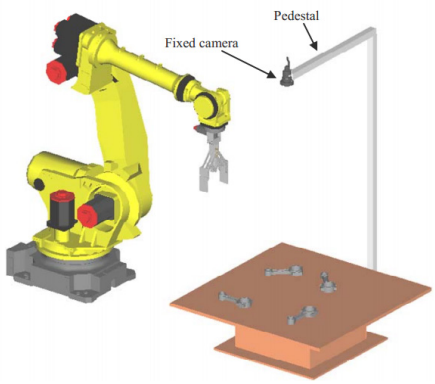
- Camera and lens,
- Camera cable,
- Lighting Equipment,
- Camera multiplexer (used if needed)



2.1. Fixed camera and robot-mounted camera

Fixed camera

- Detect workpieces using the camera installed on the stand,
- A fixed camera will always snap the same place from the same distance,
- While the robot transfers the workpieces, *i*RVision can detect the other workpieces, so the cycle time can be shortened,
- Use a sufficient strength camera stand so that the camera doesn't vibrate.



Robot-mounted camera

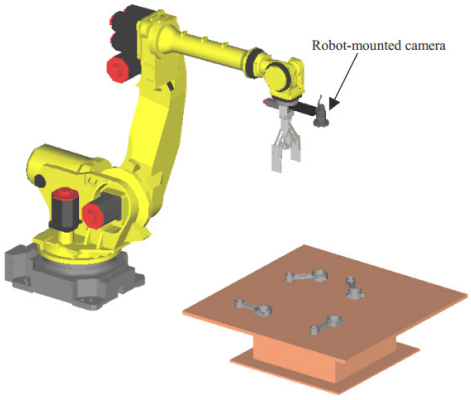
• The robot-mounted camera is mounted on the wrist unit of the robot,

• By moving the robot, you can measure different places with a robot-mounted camera,

• When a robot-mounted camera is used, *i*RVision calculates the position of the workpiece based on the movement of the robot,

• The camera must be mounted on the final axis of the robot. For example, when a six axis robot is used, the camera must be mounted on the sixth axis of the robot.

• The camera cable moves according to the robot movement, so be careful so that the cables doesn't tangle.



Depending on the size and location of the workpiece, determine the size of the field of view of the camera. The size of the field of view of the camera is determined by three factors: The size of the image sensor, the focal distance of the lens, and the distance from the camera to the workpiece. The size of the image sensor (Lc) is calculated by the following formula:

$$Lc = \text{Cell size} \times \text{Image size (pixels)} \quad (1)$$

The rough value of the field of view of the camera (L) is calculated by the following formula.

$$L = (D - f) \div f \times Lc \quad (2)$$

When the distance D from a camera to a workpiece is 700mm and the monochrome camera (SC130EF2) is used, the view size is shown below table.

Table 1. *Table captions should be placed above the table*

Distanc	Area
8 mm	587 mm x 469 mm
12 mm	389 mm x 311 mm
16 mm	290 mm x 232 mm
25 mm	183 mm x 147 mm

The calculation result is an approximate value. Some difference may occur between the calculated value and the actual measurement value. When an accurate value is required, please confirm by the actual measurement.

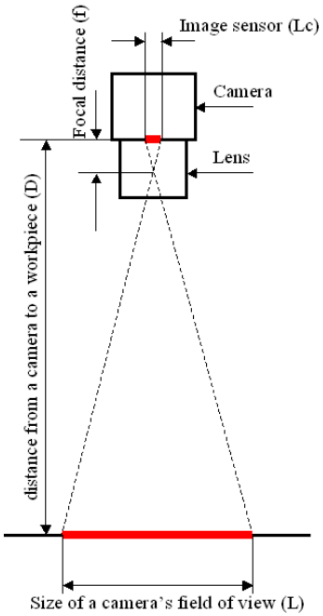


Figure 4. Size of field of view of a camera [1]

2.2. Fixed camera and robot-mounted camera

The fixed frame offset and the tool offset can be used to offset the robot positions. *i*RVision supports both kinds of robot position offsets. Fixed frame offset detect the workpiece on the table, and offset the robot positions so that the robot works (for example, the robot picks up the workpiece.) in correct.

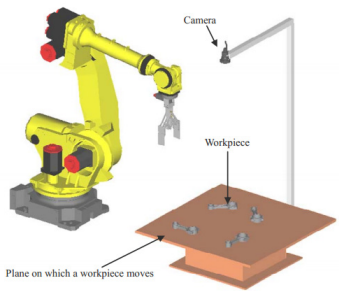


Figure 5. Fixed frame offset [1]

Tool offset detect the workpiece which gripped by the robot, and offset the robot positions so that the robot works (for example, the robot places up the workpiece.) in correct.

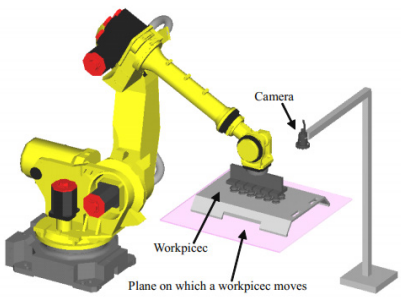


Figure 6. Tool offset [1]

2.3. Calculation of the offset data

The offset data is calculated from the position of the workpiece of when teaching the robot program and the position of the current workpiece. The position of the workpiece of when the robot program was taught is called as the reference position, and the current position of workpiece is called the actual position. *i*RVision measures the reference position when the robot program is taught, and stores it internally. The operation of teaching the reference position to *i*RVision is called reference position setting.

In the case of the following figure, the position of "+" mark is a found position of a workpiece. If a robot approaches only to the position of "+" mark, the offset data can be calculated by subtracting the value of the actual position and the reference position. When the calculation of the offset data is subtraction, it is easy to understand, however there are also limitations.

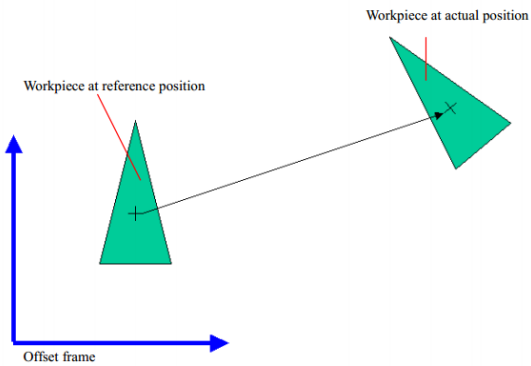


Figure 7. Tool offset calculation by subtraction[1]

In the following figure, the position M is the reference position and the position m is the actual position. A workpiece is placed on the reference position and the robot traces from the position A to the position B and C. When the workpiece is placed at the actual position, to trace the -- a, b and c --, each positions information are required. However, the movement of (a – A), (b – B) and (c – C) differ from the movement of the found position (m – M). So, it is necessary to calculate the offset data of a, b and c individually.

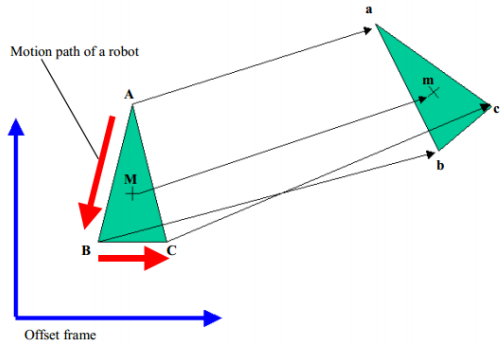
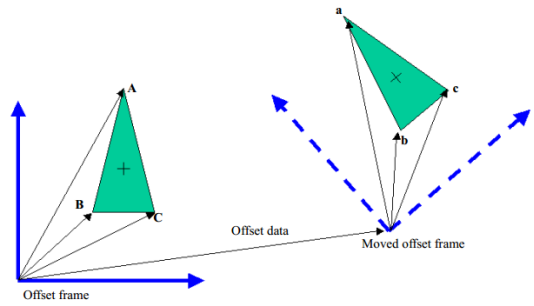


Figure 8. Position information and movement amount [1]

*i*RVision uses an offset frame, it is unnecessary to calculate each position individually. In the following figure, *i*RVision moves the offset frame to a new position. The position of the workpiece relative to the offset frame is the same as the position of the workpiece at the reference position by moving the offset frame, it becomes unnecessary to calculate the offset data for each point individually, and teaching becomes easy. *i*RVision outputs the movement of offset frame as the offset data. Since the offset data is the movement of the user frame, it is not the physically movement of the workpiece. Moreover, the offset data does not become an intuitive value in many cases. Normally, when the amount of rotation of the workpiece is the larger or the distance from the origin of the user frame to the workpiece is the further, the value of the offset data differs from the physically movement of the workpiece.



3. ALGORITHM PSO

Particle swarm optimization PSO (Figure 10) represents metaheuristic method of optimization based on agents (particles) population, which was accidentally discovered by James Kennedy and Russell Eberhart in 1995, while studying the simulation of social behaviour of bird flocking [2]. Just as it is the case with all algorithms based on population, initial particle population is generated first. Position of the particle represents vector of parameters which are optimized:

$$x = (x_1, x_2, \ldots, x_n) \tag{3}$$

or potential solution. Random position in space which is explored, as well as inital velocities, is given to each particle. After that, the value of goal function of each particle is determined, and that value is added to it as the best value for the particle in question, and the initial position becomes the best position of the particle $\mathbf{p}_{\mathbf{best}}$. When all the best values of particles are determined, the particle with the minimum value is searched, and its position becomes the best position for the entire swarm $\mathbf{p}_{\mathbf{gbest}}$. Afterwards, it needs to be checked whether the criteria of optimization are satisfied, and if they are, the obtained results are shown. If the criteria are not satisfied, new velocities and positions need to be calculated.

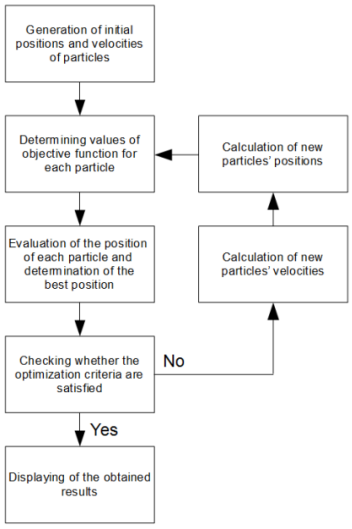


Figure 10. *Algorithm of the method of particle swarm optimization.*

Figure 11 graphically shows how to determine new velocities and positions in two-dimensional space of search.

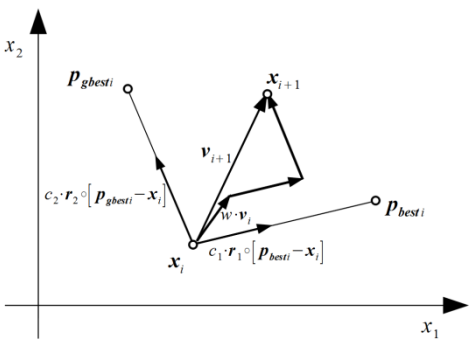


Figure 11. *Updating of velocity and position of the i particle.*

New velocity of each particle consists of three components:

1. the component which depends on instantaneous particle velocity,
2. the component which is proportional to the distance of instantaneous position of the particle and its best value,
3. the component which is proportional to the distance of instantaneous position of the particle and its best position for the entire swarm.

$$\mathbf{v}_{i+1} = w \cdot \mathbf{v}_i + c_1 \cdot \mathbf{r}_1 \circ \left(\mathbf{p}_{\mathbf{best}i} - \mathbf{x}_i\right) + c_2 \cdot \mathbf{r}_2 \circ \left(\mathbf{p}_{\mathbf{gbest}i} - \mathbf{x}_i\right) \quad (4)$$

where w represents inertia weight, c_1, c_2 are acceleration coefficients or correction factors, $\mathbf{r}_1, \mathbf{r}_2$ represent two random vectors of the length *n* within the limits [0,1]. The symbol $\circ$ represents Hadamard product [4]:

$$\left(A \circ B\right)_{i,j} = \left(A\right)_{i,j} \cdot \left(B\right)_{i,j} \quad (5)$$

Inertia weight w impacts the first component, and for the values in the range of 0,9 – 1,2 [3] it gives the best results, that is, the algorithm has greater chances of finding the global minimum for a reasonable number of iterations. For coefficient values which are smaller than 0,8, if algorithm finds global minimum it will find it fast. Particles in this case move quickly and it can happen that they "fly over" some area, so it can happen that they do not find global minimum. On the other side, if inertia weight has bigger value, then particles search the solution space more thoroughly and the chances of finding global minimum are greater.

Acceleration coefficients c_1 and c_2, when multiplied by random vectors $\mathbf{r}_1$ and $\mathbf{r}_2$, stochaistically manage the impact of the two other velocity components. Usually, their assumed value is approximately 2, in order for the middle value of the product of acceleration coefficient and random vector to be approximately 1. New position of the particle is determined by simple adding of the current position $\mathbf{x}_i$ and new particle velocity $\mathbf{v}_{i+1}$.

$$\mathbf{x}_{i+1} = \mathbf{x}_i + \mathbf{v}_{i+1} \quad (6)$$

This is the simplest version of the algorithm of particle swarm optimization. Other versions do not have constant values for the parameters *w*, c_1 and c_2, but they alter by specific rules during the implementation of the algorithm. In addition, other

PSO algorithms also include different swarm topologies, that is, the way in which particles in the swarm communicate.

4. ANALYSIS OF THE WELDING TASK THAT THE ROBOT SYSTEM SHOULD PERFORM

Welded joints are often used in the production of heating boilers. In places where it is necessary that there is no permeability of smoke and fire, a welded joint is the ideal solution. In order to solve this task, robots with six degrees of freedom of movement are applied: PUMA type industrial robot as shown in the picture.

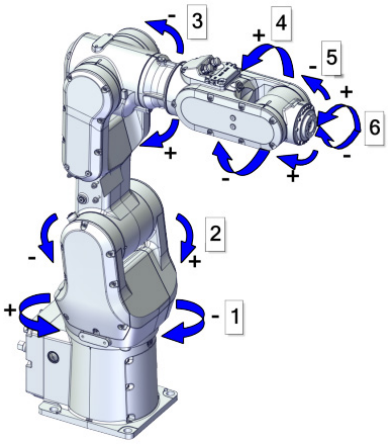


Figure 12. ABB industrial robot IRB1100[4]

Table 2. *The axis of robot system*

Pos	Description	Pos	Description
1	Axis 1	2	Axis 2
3	Axis 3	4	Axis 4
5	Axis 5	6	Axis 6

Picture 13 shows a boiler that needs to be welded together.

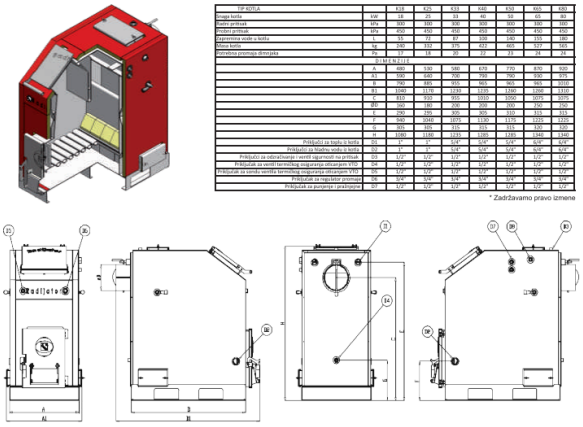


Figure 13. Technical characteristics of the boiler to be welded

5. APPLICATION OF *i*RVision FANUC VISION SYSTEM-A FOR DEFINING THE PICTURE OF THE TASK THAT THE ROBOT SYSTEM SHOULD PERFORM

To program the robot movement using the iRVision FANUC VISION SYSTEM, a 3D model of the products to be welded is first required.

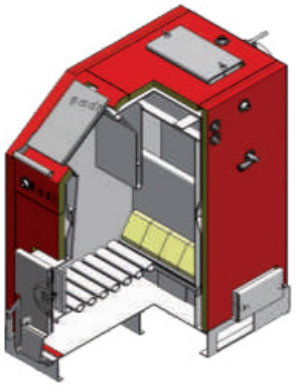
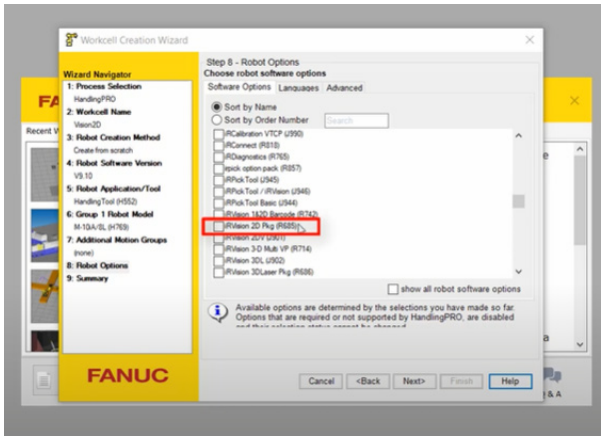


Figure 14. 3D model of the product to be welded

By starting the program, we select a 2D robot vision based on which we can create an image of the path that the robot system should describe.



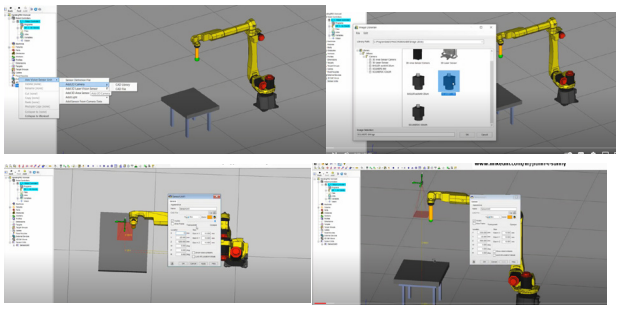


Figure 16. Necessary steps to set up the camera and workspace where the robot should perform its task

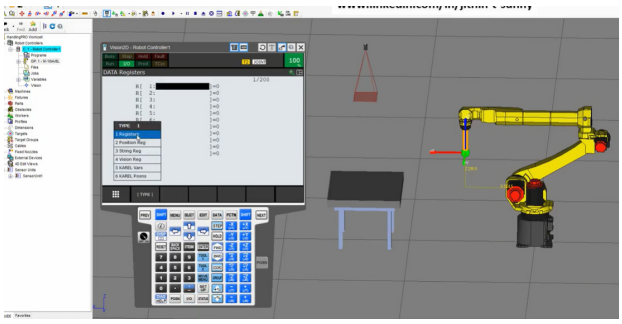


Figure 17. Adjusting the position of the 2D camera

Based on the application of robotic vision, the paths of movement of the robot 1,2,3,4,5 were derived, but the movement of the robot system from point P1 to path 5 was not. The optimal path (shortest) from point P1 to circle 5 can be found using the PSO optimization algorithm. First of all, the objective function and constraints on the basis of which the algorithm can find the optimal movement path should be defined.

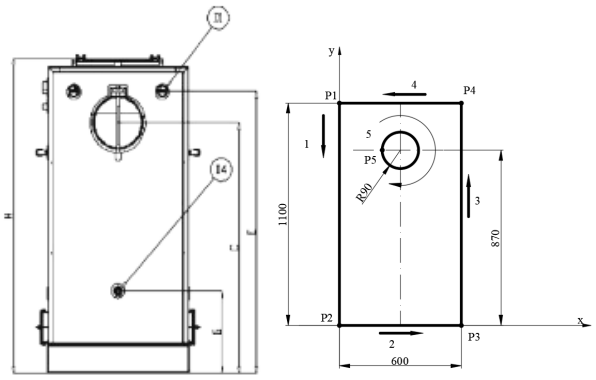


Figure 18. Task analysis in iRVision program of FANUC VISION SYSTEM

6. APPLICATION OF THE PSO ALGORITHM FOR FINDING THE OPTIMAL ROBOT SYSTEM MOVEMENT PATH

Based on the analysis of the geometry and position of the points and the circle, it can be concluded that the objective function must be the minimum path of the robot from point P1 to the circle and it can be written in mathematical form [5]:

$$F(x)=\sqrt{(x_B-x_A)^2-(y_B-y_A)^2} \tag{7}$$

Point A is point P1 in the picture and point B is the other end of the shortest distance from point P1 to the circle.

There are limitations:

$$x \in (210, 390) \tag{8}$$

$$y \in (780, 960) \tag{9}$$

The condition that should be satisfied by x and y is that the equation holds:

$$(x-300)^2+(y-870)^2=90^2 \tag{10}$$

```
% Memory and screen cleaning
clear;clc;

iterations = 200;
inertia = 1.0;
correction_factor = 2.0;
swarm_size = 3;
nd = 3;
lower_bound = [ 0, 0, 0];
upper_bound = [ 1, 1, 1];
velocity_max = 0.2.*(upper_bound -
lower_bound);

% Memory reallocation
swarm(swarm_size) = particle();

% Initial position of the swarm
for i = 1 : swarm_size
  swarm(i).position = lower_bound + rand(1,
nd).*(upper_bound - lower_bound);
  swarm(i).velocity = rand(1, nd) .*
velocity_max;
  swarm(i).best_position = swarm(i).position;
  swarm(i).best_value =
funkcija_cilja(swarm(i).position);
end

gbest = 1;
number_of_iteration = 1;
while number_of_iteration < iterations
   % Ocenjivanje pozicije
   for i = 1 : swarm_size
      % Azuriranje pozicije
      swarm(i).position = swarm(i).position +
swarm(i).velocity;
      % Ogranicavanje pozicije
      for j = 1 : nd
        if swarm(i).position(j) > upper_bound(j)
           swarm(i).position(j) = upper_bound(j);
        end
        if swarm(i).position(j) < lower_bound(j)
           swarm(i).position(j) = lower_bound(j);
        end
      end

      value = funkcija_cilja(swarm(i).position);
      % Ocenjivanje trenutne pozicije
      if value < swarm(i).best_value
        swarm(i).best_position =
swarm(i).position;
        swarm(i).best_value = value;
      end
```

```
    end
    % Searching for the best position right now
    for i = 1 : swarm_size
      if swarm(i).best_value <
swarm(gbest).best_value
        gbest = i;
      end
    end
    % Azuriranje brzine
    for i = 1 : swarm_size
      swarm(i).velocity = inertia * rand(1, nd) .*
swarm(i).velocity + ...
        correction_factor * rand(1, nd) .*
(swarm(i).best_position - ...
        swarm(i).position) + correction_factor *
rand(1, nd) .* ...
        (swarm(gbest).best_position -
swarm(i).position);
      % Ogranicavane brzine
      for j = 1 : nd
        if abs(swarm(i).velocity(j)) >
velocity_max(j)
            swarm(i).velocity(j) =
sign(swarm(i).velocity(j))* velocity_max(j);
        end
      end
    end
    number_of_iteration = number_of_iteration +
1;
end

swarm(gbest).position
funkcija_cilja(swarm(gbest).position)
```

After running the PSO algorithm, a solution in the form is obtained:

$$(228{,}6-300)^2+(924{,}8-870)^2=90^2$$

$$x_B=228{,}6\,\text{mm}$$

$$y_B=924{,}78\,\text{mm}$$

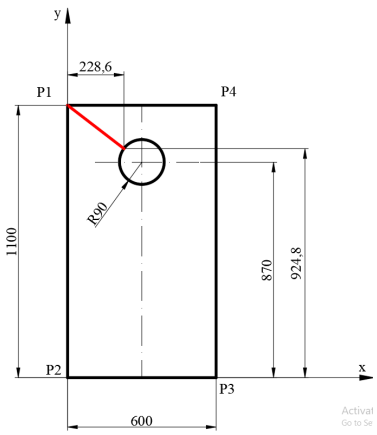


Figure 19. Defining the optimal movement path using the PSO algorithm

7. CONCLUSION

The application of software for programming the movement of robots when performing technological tasks increases the degree of usefulness of the robotic system. iRVision Fanuk's robot system is adapted to work with industrial robots and communicates with all 3D programs. This enables the simulation of the operation of the robot system in real time and the analysis of possible errors in the operation.

For movement that is not defined by the iRVision software, we must determine the direction of movement and the path ourselves. That is why it is best to analyze paths that are not defined by the program with the PSO algorithm in order to obtain optimal paths of movement of the robotic system.

In the work, based on the PSO algorithm, the coordinate of the point on the circle where the robot system should reach when it completes path 4 is obtained. In this way, the shortest path moved by the robot system and the shortest time for completing the task are obtained.

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Flank wear as a function of cutting time

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Abstract: *The paper describes one teaching unit - tool wear, which is studied at laboratory classes in the Metal cutting technology course. Through laboratory classes, students gain practical knowledge. The main goal of this teaching unit is to help students to understand the wear process and to define the parameters that describe the wear process. The most important wear parameter is the width of the flank wear of the tool. By monitoring the changes in the values of this parameter, students can see how the wear process is progressing over time. An end mill was taken as an example. The width of the flank wear was measured at intervals of 5 minutes, at distances of 0.1 mm. Based on the measured values, a diagram of tool flank wear was created. Also, the change in the width of the flank wear depending on the cutting time is shown.*

Keywords: *flank wear; end mill; cutting time*

1. INTRODUCTION

During cutting, the tool wears out and loses its cutting capabilities, so wear is one of the most negative phenomena in machining processes. Tool wear is a normal phenomenon in the machining process, but is a detrimental factor that affects the quality and tolerance of machined parts [1]. Relatively high pressures and high temperatures on the surfaces of coupled pairs (tools, chips, cutting surfaces), as well as high relative speeds of coupled pairs represent the basic conditions for the occurrence and intensive development of the tool wear process. The consequence of the development of the wear process is the deformation of the cutting elements of the tool, which makes it harder for the cutting wedge to penetrate the material. The wear generally occurs over time and is a gradual failure in a cumulative process that affects tool life. Tool wear will also vary depending on tool geometry, depth of cut, cutting fluid and cutting speed [2].

1.1. Tool wear and the wear curve

The departure of the particles of the tool material with the chip, the machined surface and the cooling and lubricating agent leads to a change in the shape of the cutting wedge of the tool. This change is manifested through the appearance of: a crater on the rake face and a flank wear on the flank surface of the cutting wedge of the tool.

The three basic forms of wear of cutting tools are:

- wear exclusively on the rake surface of the cutting wedge of the tool in the form of a crater. It is characteristic for machining with high-speed steel tools without the use of cooling and lubricating agents,
- wear exclusively on the flank surface of the cutting wedge of the tool in the form of a flank wear of appropriate width. It is characteristic for the final machining and
- general form of wear (Fig. 1) (wear both on the flank and on the rake surface of the cutting wedge of the tool). It is characteristic for machining brittle materials, steel prone to deposits, machining with greater cutting depths and when applying cooling and lubricating agents, etc.

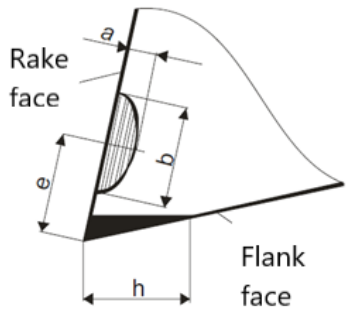


Figure 1. *General form of wear [3]*

A crater of certain depth ***a*** and length ***b*** appears on the rake surface, Fig. 1. The center of the crater is away from the cutting edge by a distance ***e***. Wear on the flank surface appears in the form of a wear zone - flank wear of a certain width ***h***. During cutting, there is a change in the size of the width of the wear zone, as well as a change in the position and depth of the crater. This means that in order to define and determine wear size, it is necessary to know these basic parameters (***a***, ***b***, ***e*** and ***h***).
The width of the flank wear ***h*** is the most important parameter for evaluating the wear of the tool. It is directly measured on the flank face of the cutting wedge of the tool. Based on this parameter, a wear

curves are created and the durability of the tool is defined.

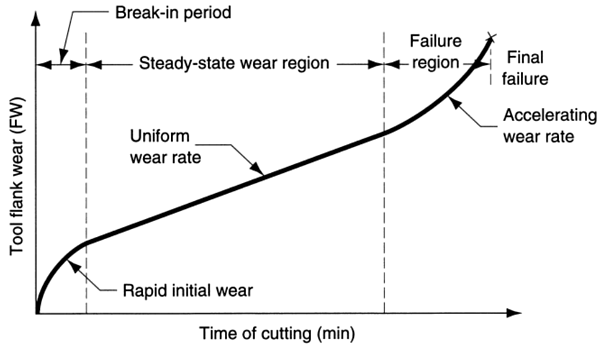


Figure 2. Tool wear as a function of cutting time [2].

Flank wear of a cutting tool is known to have detrimental effects on part surface integrity including surface finish, residual stress, microstructure alternations, etc. Flank wear is commonly thought to result from abrasive wear of the cutting edge against the machined surface and has been used to specify the tool life [4].

1.2. End mill wear

In order to determine the wear of the tool during the cutting time, the wear of the tool was monitored on the flank face, because in the case of end mill, pronounced wear occurs on the flank face. With these end mill tools, the chip thickness is relatively small, so the friction on the rake face of the cutting wedge is less pronounced. Hence, the formation of craters on the chest surface of the cutting wedge is insignificant [5]. Fig. 3 shows the wear of the flank face of the end mill.

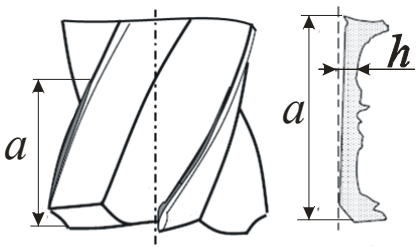


Figure 3. *End mill wear [5]*

2. EXPERIMENTAL INVESTIGATIONS

30CrNiMo8 steel (Č 5432, AISI-u 4340), with dimensions 50x30x7 mm, was used as the workpiece material.

During the investigations, high speed steel end mill, DIN 844-A10-K-N prečnikadiameter Ø10 mm (Fig. 4) was used. Characteristics of this end mill are:

- number of teeth z = 4,
- cutting angle χ = 30°,
- flank angle α = 6°,
- rake angle γ = 12°,
- twist angle ω = 30°,
- material: high-speed steel (HSS).

Figure 4. *End mill DIN 844-A10-K-N*

The investigations were performed on a vertical milling machine "Maho 600C" (Fig. 5), manufactured by the German manufacturer Maho, with the following characteristics:

- -electric motor power for main movement 5.5 kW,
- electric motor power for auxiliary movement 2 kW,
- number of revolutions of the main spindle 10 ☐ 3150 rpm with 4 gears,
- speed of auxiliary movement 0 ☐ 3000 rpm with 4 gears,
- maximum table load 1000 kg,
- the largest movement of the table in the direction:
- x-axis 600 mm,
- y-axis 500 mm,
- z-axis 450 mm,
- the possibility of turning the spindle axis up to 90°.

Figure 5. *Vertical milling machine Maho 600C*

Machining was performed with the following regimes: cutting speed v = 17.28 m/min, i.e.

number of revolutions n = 550 rpm, feed per tooth SZ = 0.045 mm/z and cutting depth a = 1 mm. No cooling or lubricating agent was used during machining. In order to measure tool wear, the cutting process was interrupted every 5 minutes of machining. The total time for which tool wear was measured was 25 minutes.

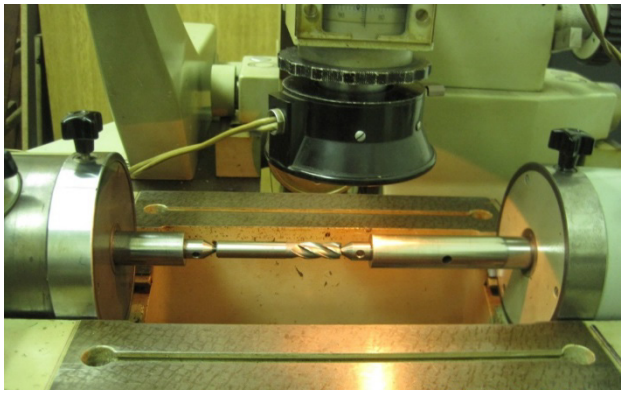


Figure 6. *Postavljanje alata na mikroskopu*

Tool wear was measured on a universal electronic microscope of the brand CARL ZEISS JENA, Fig. 6. On this microscope, rotating samples can be measured by placing them between auxiliary spikes whose range is up to 700 mm. The measurement range is from 0-200 mm and the reading accuracy is 0.001 mm. The mean value of the width of the flank wear was monitored on the flank face of the ehd mill tool.

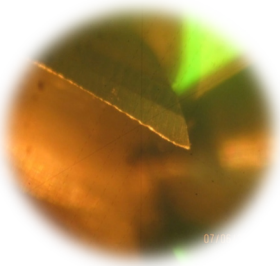
3. THE RESULTS OF THE EXPERIMENTAL INVESTIGATIONS

The width of the flank wear was measured on the flank face of the end mill tool at time intervals of 5 minutes during machining. Measurements were made at distances of 0.1 mm. The width of the flank wear was measured on the flank face of the ehd mill tool at time intervals of 5 minutes during machining. Measurements were made at distances of 0.1 mm, in the direction of the cutting depth, starting from the tip of the tool. The results obtained in this way are given in Table 1. The last measurement was made after the end mill had been cutting for 25 minutes.

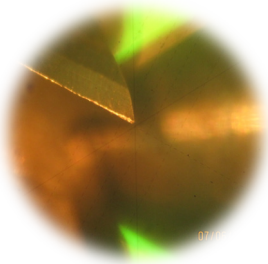
Table 1. *Flank wear – measured values*

x [mm]	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
5 min	0.166	0.102	0.096	0.073	0.05	0.076	0.069	0.065	0.066	0.101	0.052
10 min	0.172	0.112	0.105	0.078	0.064	0.08	0.071	0.069	0.074	0.105	0.064
15 min	0.175	0.122	0.108	0.083	0.074	0.083	0.08	0.077	0.08	0.109	0.072
20 min	0.184	0.136	0.11	0.086	0.097	0.086	0.09	0.099	0.085	0.111	0.081
25 min	0.188	0.139	0.114	0.09	0.103	0.105	0.098	0.099	0.115	0.116	0.091

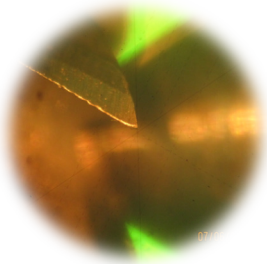
After every 5 minutes of machining, photos of the flank face of the end mill cutter were taken. Appearance of a worn milling cutter in time intervals is shown in Fig. 7.



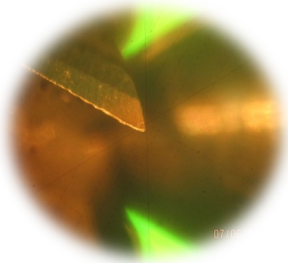
1) The appearance of a worn end mill cutter after 5 minutes of machining



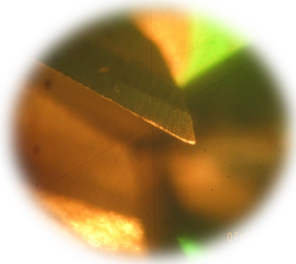
2) The appearance of a worn end mill cutter after 10 minutes of machining



3) The appearance of a worn end mill cutter after 15 minutes of machining



4) The appearance of a worn end mill cutter after 20 minutes of machining



5) The appearance of a worn end mill cutter after 25 minutes of machining

Figure 7. *Worn end mill*

Based on the measurement results given in Table 1, a diagram of the change in the width of the flank wear is given in Fig. 8.

The width of the flank wear was measured every 0.1 mm in direction of the cutting depth (*a*=1 mm), x-axis.

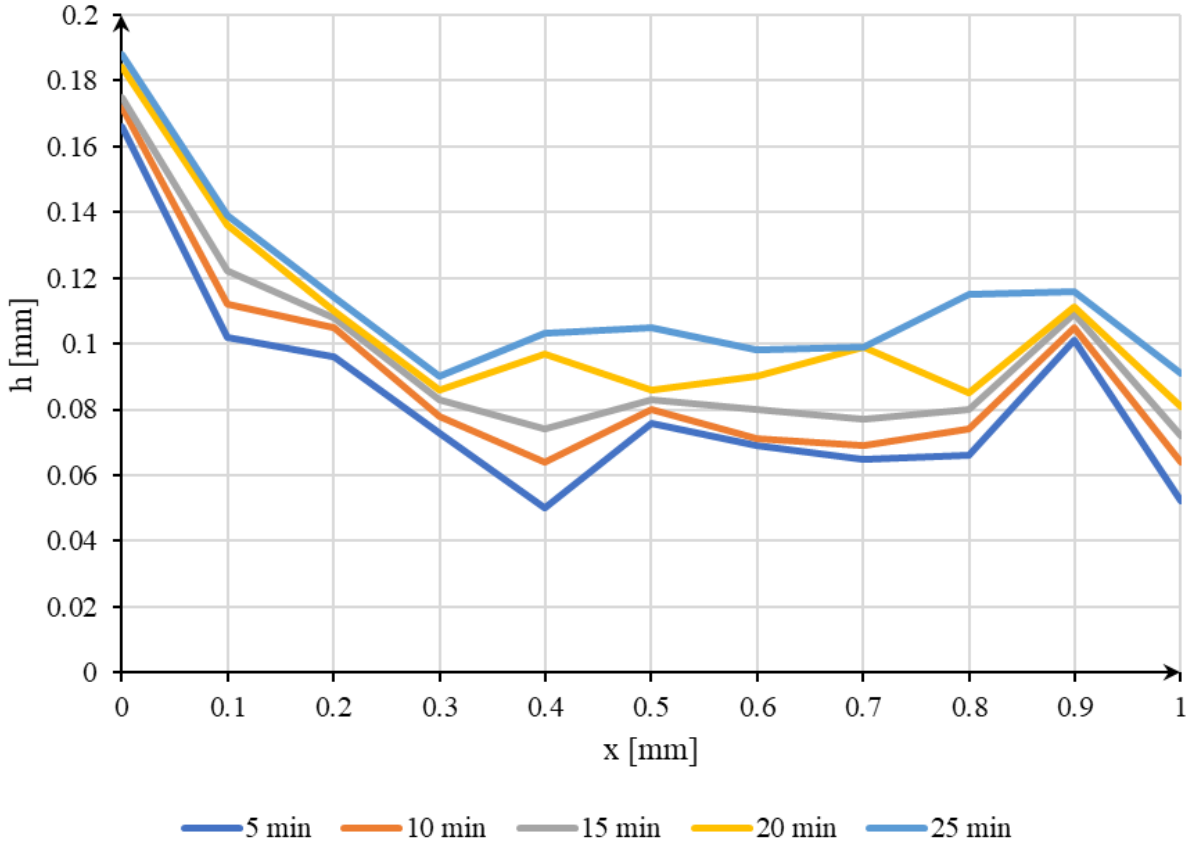


Figure *8.* Flank wear width as a function of position of measurement and time

For each time interval, the mean value of the flank wear width was calculated. These results are given in Table 2.

Table 2. Mean flank wear width

t [min]	0	5	10	15	20	25
h [mm]	0	0.085	0.09	0.094	0.106	0.114

Fig. 9 shows the appearance of the flank wear curve of a end mill cutter.

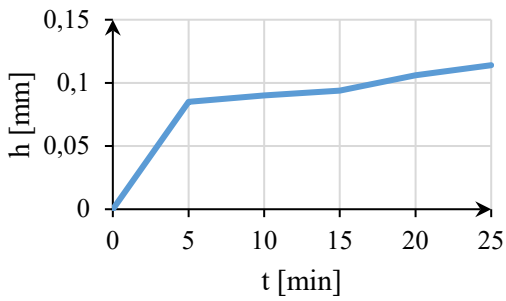


Figure *9*. *End mill flank wear curve*

4. CONCLUSION

By analyzing the obtained results, it is observed that the greatest width of the flank wear is at the tip of the end mill cutter, and then it decreases by about 50% of the value. The width of the flank wear width is almost unchanged right up to a distance from the tip of the tool equal to the depth of cut, when a slight increase in the width of the flank wear width, notch wear, appears. At a distance from the tip of the tool greater than 1 mm, no tool wear was observed. Also, it is observed that with the increase in cutting time, the width of the flank wear increases. By analyzing the diagram of the flank wear curve, it can be concluded that in the first interval of 5 minutes the intensity of flank wear is the highest. This period can be interpreted as a period of rapid initial wear. In this interval, the mass of the cutting tool, that is in contact with the workpiece, is relatively small, so intensive wear occurs. After this period, the flank wear curve has a slower growth and it is the period of uniform wear.

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Improvement of study programs for bachelor's and master's studies in Mechatronics in response to the requirements of Industry 4.0

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Abstract: *Development in information technology has resulted in revolutionizing all aspects of life and this revolution has been realized as Industry 4.0. A main approach that universities' educational systems may take towards Industry 4.0 is educating students who have the right skill set for reacting to the changes in their working environment, adapting their performance, and learning to cope with technological development. This paper presents the results of the project "Improvement of study programs for bachelor's and master's studies in Mechatronics in response to the requirements of Industry 4.0", which was funded by the Ministry of Education, Science and Technological Development of the Republic of Serbia as a part of program activity "Development of higher education" and performed in the 2020/21 academic year.*

Keywords: *curriculum redesign; university education; improving the student's skills; Mechatronics; Industry 4.0*

1. INTRODUCTION

The Mechatronics study program was founded at the Faculty of Technical Sciences in Čačak, as one of the first ones in Serbia, back in 1990. It has a tradition of 30 years, with permanent monitoring of modern trends in the industry, under which the study program was continuously innovated.

The purpose of such bachelor's and master's academic studies is the education of engineers who possess multidisciplinary knowledge in the field of mechanical, electrical and computer engineering, which are necessary for the successful implementation of academic and professional work in the field of mechatronic engineering and technologies, in accordance with trends and requirements imposed by modern industry 4.0 [1].

In consideration of the fact that the increase in interest in mechatronics engineers is conditioned by the accelerated technical and technological development and the increasing demand for that profession, the bachelor's and master's degree programmes in Mechatronics are aimed at the education of engineers for the design, development, reengineering and maintenance of mechatronic systems, in a way that they ensure the acquisition of competencies that are socially justifiable and useful [2].

These experts are necessary to work in the industry that will be applicable in the future period for many years and will maintain engineering knowledge in accordance with the needs of modern society.

By completing these study programs, students are qualified to be mechatronics engineers which are competent in both European and global frameworks [3].

The strategy and policy of industrial development of the Republic of Serbia envisage strengthening the educational capacities of technical faculties, with a focus on developing practical skills, creativity and leadership in all areas of engineering, in response to the requirements of modern Industry 4.0. According to this, the Faculty of Technical Sciences in Čačak developed a project "Improving the study programs of bachelor and master studies in Mechatronics", which is supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia through the fund for the support of projects for higher education development.

2. REDESIGNIG OF CURRICULUMS

The improvement of the students' skills was carried out due to the innovation of the educational content of courses in bachelor's and master's academic degree programmes in Mechatronics at the Faculty of Technical Sciences in Čačak. Improvements enable students to more easily integrate into the digital world of Industry 4.0 as future bachelor and master multidisciplinary engineers. The curriculum innovations in the selected courses enable future mechatronics engineers to understand modern trends in the field of information technologies and develop their awareness of the essential requirement for constant education and continuous upgrading of obtained theoretical knowledge [4].

The improvements include four courses in the bachelor's and master's degree programme in Mechatronics:

A. Bachelor degree courses

1. Hydraulics and thermotechnics, mandatory course, 4th semester
2. Process automation, obligatory course, 8th semester

B. Master degree courses

3. Robotics, the only mandatory course in 4th semester
4. Modeling and simulation of mechanical processes, obligatory course in 1st semester

2.1. Specific goals of improvement

Specific goals of curriculums improvement were:

1. Acquisition of new software tools (*MATLAB* with specialized follow-up modules: *Simulink*, *Robotics System Toolbox*, *Fuzzy logic toolbox*, *Deep Learning Toolbox*, *Simscape*, *Simscape Fluids toolbox)* which will provide students with quality professional education in the domain of application of information technologies essential for their training for the Industry 4.0 concept [5];
2. Purchase of equipment for creating new and improving existing laboratory exercises in laboratories for mechatronics, process engineering and mechanical testing;
3. Introduction of remote experiments in courses for access from distance locations;
4. Developing of four educational electronic publications to support the implementation of the courses;
5. Integrating the mentioned teaching elements into the distance learning system *Moodle*;
6. Building Faculty of Technical Sciences in Čačak - to - Industry partherships by signing agreements of cooperation, with a plan of activities that would be implemented at the Faculty and through professional visits to companies [6].
7. Establishing Faculty-to-Industry partnerships by establishing cooperation agreements, creating a schedule of activities to be carried out at the Faculty, and conducting professional visits to companies;
8. A special focus was aimed at the realization of a workshop on programming industrial robots in cooperation with the Science and Technology Park in Čačak, as support for improving the entrepreneurial skills among students.

2.2. Developing digital competences

One of the important goals of the project was the development of advanced and highly specialized competencies of students, i.e.:

1. Information literacy and understanding of data

The use of several types of specialized software for work simulation, design and programming of mechatronic systems are provided in classes. Innovating the content of the courses in bachelor's degree programme is the introduction of *MATLAB/Simscape*, *Simscape Fluids* software for simulating the operation of hydro-pneumatic components (course 1) and *MATLAB* software with following modules (*Fuzzy logic toolbox*, *Deep Learning Toolbox*) for the control and regulation of mechatronic systems (course 2).

Innovating the content of the courses in bachelor's degree programme is the introduction of *MATLAB/Robotics System Toolbox* software (course 3) and modern equipment and *ABB RobotStudio*'s software tools for robot programming (course 4) through which students will have the opportunity to be able to use the highly sophisticated equipment found in Industry 4.0 [7].

With the help of the above-mentioned software, students can realize simulation, management, control, measurement, and processing of the obtained results.

2. Communication and collaboration

The existing *Moodle* courses were improved for courses 1, 2, and 3, and a new one was developed for course 4. The course materials are published on the Faculty's e-learning system, which contains the content needed for teaching (presentations, animations, applets), as well as material for exam preparation (scripts, questions, solved examples). Students can use these materials on any available electronic device that has an internet connection (computer, tablet, or mobile phone).

The student acquires competences for communication and collaboration by selecting suitable digital services for communication.

3. Creation of digital content

By applying modern software tools *MATLAB* and *ABB RobotStudio* students can independently create, edit, and save digital materials within the laboratory exercises, based on the provided criteria. The software enables students to use ready-made elements of mechatronic systems and, based on the given criteria, realize their own system. Also, they can demonstrate competence in creating digital content through independent practical use of software tools for systems presented during lectures.

4. Safety

During the realization of laboratory exercises, students use components of mechatronic systems, a real industrial robot *ABB IRB* 120 as well as the most advanced collaborative industrial robot YuMi, they learn about the safe way of using the robots, and the proper connection and configuration of the system. During the implementation of exercises using software tools, students learn about the options of protecting digital content, in order to ensure the safe operation of industrial systems in real conditions.

5. Problem solving

The improved courses are designed so that students can independently solve specific real problems in exercises (calculation and laboratory). The practical functionality of the laboratory exercises that are realized using the software, students can also test in a laboratory environment. As part of the collaboration with the companies, students get to know how to solve problems that occur in real practice. Competence for solving problems is demonstrated through critical analysis and the selection of adequate software solutions for presentation, simulation, and management of mechatronic systems.

2.3. Development of entrepreneurial competences

The curriculums developed are primarily intended for students who plan their future professional engagement in the field of engineering. A wide range of knowledge and skills in the use of information technologies also enables them to work professionally (independently or collaboratively) in Industry 4.0 [8]. As part of the project, the following entrepreneurial competencies are developed among students:

1. Ideas and opportunities

Creativity - Advanced level: Students are able to transform ideas into solutions that create value for others. Through the lectures, the basic principles are explained to students, and they are introduced to a specific problem. Within a defined times frame during the semester, they have the task of realizing their ideas through a specific functional program. In order to realize the task, they combine theoretically acquired knowledge, IT and technical resources to achieve the best possible results.

Evaluation of ideas - Intermediate level: Students understand that ideas can have different values, which can be used in many ways. The concept of updated courses is that students can solve a specific practical problem independently or in teams. When programming, they independently design the algorithm and do the programming. Students present their projects in class and can compare solutions to problems, notice differences, advantages, and disadvantages, and improve their work if necessary.

2. Resources

Motivation and perseverance - Intermediate level: Students are ready to invest effort and resources to create value for others. By mastering the content of innovative courses, students increase their motivation and self-confidence to solve problems they may meet in the real industry environment. They develop competence for handling resources by using available technologies, equipment and software to solve given problems, thereby strengthening other competences needed for the idea realization.

3. Taking action

Taking initiative - Intermediate level: Students know how to initiate value creation activities. They are encouraged to independently recognize a relevant problem, define their project task, create an activity plan, face challenges and realize it by achieving the set goals.

Working with others - Basic level: Students know how to work in a team. Certain activities are realized as a team, where the final value relies on the successful performance of each individual. Most project assignments in updated subjects contain all or some of the following activities: understanding the problem, setting up the apparatus, setting the parameters, writing the program, testing the program, starting the application, checking for errors, recording the measurement results, writing the report, and presenting the work.

Learning through experience - Advanced level: Students can improve their ability to create value by learning from others, building on previous experiences, and interacting with others. By solving simplified programming tasks by applying the same learned programming principles, students can create new, significantly more complex programs based on the acquired experience (positive and negative). They are more willing to take on new challenges and gain confidence and readiness to solve more demanding tasks.

2.4. Human and technical capacities

Two accredited study programs relevant to the field of this project are realized at the Faculty of Technical Sciences in Čačak (Electrical and computer engineering and Mechatronics) at all levels of study, i.e., bachelor's, master and PhD. The Faculty is well equipped for the realization of these courses of these study programs and has appropriate IT resources.

For many years now, the Faculty has achieved intensive cooperation with companies with which it has signed contracts on business and technical collaboration, through the implementation of mutual projects, various types of training and research for the economy. Within this cooperation, the Faculty received modern industrial equipment, which is utilised through courses in the Mechatronics study program, where students can apply their theoretical knowledge to concrete applications found in the industry. The software was also acquired through the project which contributes to the innovation of the courses, together with the help of donated equipment, as well as equipment purchased from the Faculty's income. The faculty has a numerous number of signed agreements on the realization of students' professional practice with companies, mainly from western Serbia.

3. RESULTS OF IMPROVEMENTS

Through the realization of the project, all the planned goals were fully achieved, which are reflected in the following:

Course 1: ROBOTICS

Within the Science and Technology Park in Čačak, thanks to the funds provided by the Ministry of Education, Science and Technological Development of the Republic of Serbia, a new research laboratory in the field of robotics was created. Under the cooperation with the Science and Technology Park, the Faculty of Technical Sciences in Čačak was allowed to use a laboratory equipped with modern industrial robots for conducting practical laboratory exercises in the field of robotics.

Acquisition of new laboratory equipment and software tools: The course was innovated by expanding its content through the development of new laboratory exercises. In these exercises programming of industrial robots is studied using the *ABB RobotStudio* program, which represents software support for offline programming of *ABB* robots. For this purpose, the following parts were made: a gripper for the robot, aluminium supports and optical sensors with which a safety curtain was made between the two robots.

Preparation and implementation of new laboratory exercises: The innovative teaching content for cousre is very important for the future work of mechatronics engineers in the field of robot control and programming. As a part of the pre-examination activities, each student completed a project task using the ABB RobotStudio software. They modelled the robot system and the operating parameters of the system, such as: creating the robot's working environment, adding the necessary robot components, the workbench, the tool, and the object of processing. Then the characteristic points and paths of the robot's motion are defined. Path validation is performed by simulation, after which the code is transferred to the robot's physical controller. Once the code is loaded into the controller, the robot is fine-tuned and put into operation on a real robot system in the laboratory. In this way, students are fully familiarized with robotic systems, from theory to practice. This type of education allows students to develop an engineering way of thinking, connect theory and practice knowledge, and prepare them for work in the industry.

Faculty is increasingly emphasising and utilising close ties with industry and industry professionals to keep up with the changing role of Faculty in society, from centres of learning to centres training graduates to be job-ready. As a part of the course, an expert in this field Mr B. Mrgud from ABB Belgrade, gave the presentation "Management and programming of a collaborative industrial robot". (Fig. 1).

Figure 1. *Industry expert presentation for the students at the Science and Technology Park*

A robotics workshop was also held as part of activities outside of classes. (Fig. 2).

Figure 2. *Realization of a robotics workshop*

As a support for the implementation of laboratory exercises, a practicum in the form of electronic publication was issued: *OFF-LINE* programming of industrial robots - *ABB RobotStudio*, which is available to students on distance learning system *Moodle.*

Course 2: MODELING AND SIMULATION OF MECHANICAL PROCESSES

Acquisition of new laboratory equipment and software tools: Innovation through this course was carried out by expanding the content of the course through the introduction of new laboratory exercises based on the application of software tools for solving the mechanics of complex technical systems with multiple degrees of freedom. For this purpose, the *MATLAB* software package and its additional modules were acquired (*Simulink* and *Robotics System Toolbox*), as well as the corresponding literature, necessary for the proposed improvements.

Preparation and implementation of new laboratory exercises: New laboratory exercises have been introduced, with the implementation of computers in mechanical calculations. Each student completed a project using *MATLAB* software and its *Robotics toolbox* module as part of the pre-exam activities. He had the task of solving kinematics and dynamics, as well as simulating the movement of a complex mechanical system with multiple degrees of freedom, such as industrial robots. By modelling robotic systems using acquired software, the necessary parameters for sizing and selecting a robot for a specific application can be calculated. By simulating the operation of such systems, the possibilities of using robots for various purposes can be verified. In this way, students are introduced to the great importance of modelling and simulation of mechanical processes, from the standpoint of the fact that all mechanical systems can be modelled and tested in different conditions before final production, which can significantly reduce production costs.

As a support of the teaching classes (lectures and exercises), an electronic publication entitled: *Modeling and simulation of mechanical processes* was published and is available to students on the Moodle learning platform.

Remote access for performing laboratory exercises is provided for both courses of the master's degree programme (Robotics and *Modeling and simulation of mechanical processes*). Remote access is provided through a computer located in the Laboratory of Robotics at the Science and Technology Park in Čačak via the free application *AnyDesk* (with prior appointment via the *Microsoft Teams* platform).

Course 3: PROCESS AUTOMATION

Acquisition of new laboratory equipment and software tools: The proposed modifications and improvements of this subject, through project activities, are related to the introduction of new teaching content and introducing students to artificial intelligence techniques (neural networks, genetic algorithms, swarm intelligence, fuzzy logic, neuro-fuzzy systems) and their applications. For this purpose, the *MATLAB* software package and its additional modules (*Simulink*, *Deep Learning Toolbox*, *Fuzzy Logic Toolbox*) necessary for the proposed improvements of the teaching subject were acquired.

Preparation and implementation of new laboratory exercises: For this subject, 14 new exercises were created and implemented in *MATLAB*. All the exercises are related to the content (case studies) in the realized publication *Intelligent Modeling and Control - MATLAB Simulations*, which is required for the successful implementation of the exercises. The textbook is available to students at the electronic learning system of the Faculty of Technical Sciences in Čačak.

Subject 4: HYDRAULICS AND THERMOTECHNICS

Acquisition of new laboratory equipment and software tools: The innovation of the theoretical content of the course Hydraulics and thermotechnics was carried out following new literature sources, some of which were purchased from the funds specified in the project budget. The subject was innovated by expanding the content of the course through the introduction of new laboratory exercises based on the implementation of the *MATLAB/Simscape Fluids* software tool used for modelling and simulating fluid systems. For this purpose, the *Eplan* software package and *MATLAB* with its additional module (*Simscape Fluids toolbox*) needed for the proposed improvements of the teaching subject were acquired. In order to create new laboratory setups, pneumatic components such as cylinders, forks, hoses, mounting profiles, connections, cables and clamps were also acquired.

Preparation and implementation of new laboratory exercises: Students' practical and research work were improved using mentioned software through the lectures and independent work. As a part of the pre-examination activities, each student finished a mini-project using *MATLAB*, *Simulink* and the *Simscape Fluids toolbox*. They modelled the hydraulic system and determined the operation parameters of the system, such as flow rate, fluid flow speed through the pipeline and necessary pump power.

As part of the course, a lecture by a business expert, Mr M. Jović, from the *Alfaco Čačak* company was conducted. The topic of the presentation was "Designing hydraulic installations using modern application software", during which students learned about solving real hydraulics problems in practice. (Fig. 3).

Figure 3. *Lecture by an industry expert at the Faculty*

In support of the realization of the exercises, the electronic publication *Practicum for Modeling and Simulation of Fluid Systems* was published and is available to students on the Moodle learning platform.

Evaluation of the effects of the innovative content implementation on the course Hydraulics and thermotechnics was carried out at the end of the semester. (Fig. 4). On a scale from 1 to 4, students evaluated all questions with an average score between 3-4. The results of the evaluation showed that the innovations of the course were positively evaluated and that the teaching content is significant for their future engineering work in controlling the industrial hydro-pneumatic systems.

Evaluation of the application of SIMSCAPE FLUIDS software in the subject of Hydraulics and Thermotechnics. 17.6.2021

No.	Question	Average (1-4)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	The teaching material is well structured and presented in an understandable way.	3.6	4	4	4	4	4	3	3	4	3	4	3	3	3	4	4	4	4	3	4	3
2	Teaching content presented through practical examples contributes to an easier understanding of the material.	3.6	2	4	4	4	3	3	3	4	4	4	4	3	4	4	4	4	3	4	4	3
3	I was introduced to how to use the SIMSCAPE FLUIDS software.	3.25	3	3	3	3	3	3	4	4	3	4	3	2	3	1	4	4	4	4	3	4
4	Using software in classes to demonstrate practical examples contributes to greater satisfaction and motivation of students.	3.5	4	3	4	3	4	3	4	3	4	4	3	2	4	4	3	4	3	3	4	4
5	The subject course on the E-learning portal was useful for the realization of pre-exam obligations.	3.4	3	3	3	3	4	3	4	4	2	4	4	4	4	4	4	4	2	2	4	3
6	I consider the subject course on the E-learning platform necessary.	3.4	2	4	3	4	4	3	4	3	2	4	3	3	3	4	4	4	3	3	4	4
7	The practicum posted on the E-learning platform was helpful in doing the homework.	3.55	1	4	4	4	4	4	3	4	2	4	3	3	4	4	4	4	3	4	4	4
8	The application of the program enabled me to gain a better insight into the professional activities of engineers.	3.35	4	3	4	3	3	4	4	4	3	4	4	3	3	2	3	4	3	2	3	4

Figure 4. *Evaluation of innovative content on the course Hydraulics and thermotechnics*

The Faculty of Technical Sciences has performed cooperation with the following companies in the field of education and professional work with the aim of active participation of students in existing projects in order to gain practical knowledge and get familiarised with new technologies: Sloboda Cpmpany Čačak, Vorwerk Autotec Serbia, Knjaz Miloš Aranđelovac, Elsat Čačak, Wieland Production Čačak, and Cemprom Čačak.

4. CONCLUSION

The world of work is currently definitely changing because of the influence of digitalization. The industry is today facing a fourth industrial revolution, which has gradually spread throughout the world, directly influencing the activities of engineers and universities. Based on today's engineering education, the needs are shown that should be reflected not only in the improved curricula but also in a realignment of teaching and learning because this is based on the new working environments. In the process of education of appropriate engineers who will be able to meet all the requirements in Industry 4.0, both universities and companies are faced with enormous challenges that they will be able to successfully implement in cooperation with various stakeholders.

In this paper, project activities, which were performed at the Faculty of Technical Sciences in Čačak, focused on the improvement of Mechatronics engineering courses are shown. The obatined results of the project enabled the improvement of education content and the development of courses primarily intended for students who plan their future professional engagement in the field of engineering. An improved and spread range of knowledge and skills in using information technologies in different engineering disciplines allows students to work professionally (either independently or collaboratively) in Industry 4.0.

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Artificial Intelligence in Education: A Review

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Abstract: *Today, there is almost no activity that is in no way related to the use of computer technology. The application of advanced technologies such as artificial intelligence (AI) opens up new possibilities, potentials, and challenges in educational practice. With the help of artificial intelligence, which simulates human intelligence in making conclusions or predictions, computer systems can provide personalized guidance, support, or feedback to students and teachers in the educational process. The paper aims to identify the impact of artificial intelligence on the educational process, present some of the applications of AI in education, and highlight the perceived benefits of the application.*

Keywords: *artificial intelligence; AI; education*

1. INTRODUCTION

Artificial Intelligence (AI) is one of many technologies used successfully in many industries today. It is attracting more and more attention every day with the successful projects in recent years. AI concept has recently begun to be accepted as the technology of the future at the global and national levels, and is nowadays considered as the driving force of computer engineering and technology. The goal of AI is to imitate human intelligence through computers, in that sense, by allowing computers to learn. It is also one of the key technologies that are ready to transform education [1]. Traditional education seems to be fixed in terms of time, place, and prescribed activities, and learning process is continuous, especially at younger students. Traditional educational systems are known to be inflexible, but they are now changing to adapt to the technological advances of today's world [2]. The use of AI in education has attracted attention in the following ways [3]:

- Automation - the simplest use of AI often brings the most immediate benefit: by automating simple tasks, such as grading, classifying digital resources, or schedule, teachers can increase their time interacting with students.
- Adaptation - today's technology is an integral part of the educational and business environment. AI in schools will help students initiate technological change.
- Integration - AI solution can be integrated with other IT initiatives, such as intelligent technology and managed IoT networks, to provide appropriate solutions for teaching students.
- Constraint - student needs and curriculum priorities are constantly changing, ensuring that the content provided by teachers is relevant and practical. AI-led analytics in education helps identify key trends, extract key markers, and help teachers develop the most effective classroom that drives digital transformation.
- Identification - data analysis allows us to understand that adaptive AI solutions will identify important areas for students.

The application of AI in education has been the subject of large number of research in the last 30 years. Experts predict that the use of AI in education will increase by more than 45% by 2024 [4]. Amid the COVID-19 crisis, the global market for AI in Education was estimated at US$1.1 billion in the year 2020, and is projected to reach a revised size of US$12.6 Billion by 2027, growing at a CAGR (Compound Annual Growth Rate) of 41.4% over the period 2020-2027 [5].

2. LITERATURE REVIEW

Based on the review and detailed analysis of available scientific and professional papers, several relevant ones from the area of AI in education have been singled out.

Sadiku et al. [2] explain the concept of artificial intelligence as the ability of a computer system to perform human tasks (such as thinking and learning) that can usually only be achieved through human intelligence. AI technology in education provides a degree of flexibility and adaptation that has never been possible before. This is revolutionizing schools and classrooms, making the job of a teacher much easier. AI is ready to

revolutionize education. The paper considers different applications of AI in education.

Joshi et al. [3] first state that the use of AI is now observed in almost all areas of our lives. Artificial intelligence is an advanced technology that transforms all aspects of our social interaction. In education, it will develop new learning solutions that will be tested in a variety of situations. Educational goals can be better achieved and managed by new educational technologies. The paper analyzes how AI can be used to improve teaching outcomes, providing examples of how AI technology can help teachers use data to improve equity and education rankings in developing countries. It aims to examine the perception of teachers and students about the use and effectiveness of AI in education. Further research on the generational and geographical diversity of teacher and student perceptions can contribute to the more effective implementation of AI in Education (AIED).

[6] describes how artificial intelligence can be used and how it is used in the education sector. According to the 21st International Conference on Artificial Intelligence in Education held in 2020, AIED is one of the currently emerging areas of educational technologies. The use of AI by teachers remains unclear on how to achieve pedagogical advantage on a broader scale and how AI can influence teaching and learning in higher education. The paper presents the impact of AI in education and its advantages and disadvantages. The author also describes a specific way of developing a platform for education based on AI, and finally the additional effects of AI in education.

[7] states that the use of AI in education is no longer science fiction, but is becoming a reality in these times of unprecedented dynamic change. This field encompasses a wide range of techniques, algorithms, and solutions that can solve current adversities and problems in today's classroom. The paper discusses how an existing world-supporting AI can be extended to the fields of education and addresses the existing challenges of using AI in classrooms across Singapore.

[8] assess the impact of AI on education. Assuming a narrative and assessment framework for the AI identified from the preliminary analysis, the scope of the study was limited to the application and effects of AI in administration, teaching, and learning. A quality research approach, which used literature review as a design and approach to research, was used and effectively facilitated the achievement of the purpose of the study. AI is a field of study and resulting innovations and developments that have culminated in computers, machines, and other artifacts that have human-like intelligence characterized by cognitive abilities, learning, adaptability, and decision-making ability. The study found that AI was largely adopted and used in education, especially in educational institutions, in various forms. AI was initially in the form of computers and computer technologies, moving to intelligent education systems based on the web and network, and finally with the use of embedded computer systems, along with other technologies, the use of humanoid robots and web chat. Using these platforms, instructors were able to perform a variety of administrative functions, such as reviewing and grading student assignments more effectively and efficiently, in achieving higher quality in their teaching activities. On the other hand, since the systems support machine learning and adaptability, the curriculum and content are adapted and personalized following the needs of students, thus improving the student experience and the overall quality of learning.

[9] enables stakeholders in the education sector to understand the extent to which artificial intelligence will be used in education and its perceived benefits. The paper offers examples of the use of AI in education, especially in developing countries such as India, where education for all is considered one of the goals of sustainable development. First, the paper gives the reader an overview of artificial intelligence. It has been observed that AI has evolved from simple rule-based systems, through data-based systems, to context-based systems that have advanced capabilities. Next, the paper discusses the approach of using AI in education to improve learning outcomes. As a new technology, artificial intelligence in education will bring about changes in the "learning experience" by having an adaptable learning environment that creates a "personalized learning experience". Finally, the paper presents some examples of the use of AI technology in the education sector to improve the learning experience and the quality of learning.

Huang et al. [10] emphasize that the emergence of innovative technologies has an impact on teaching and learning methods. With the rapid development of AI technology in recent years, its use in education is becoming increasingly apparent. The article first describes the application of AI in the field of education, such as adaptive learning, evaluation of teaching, and virtual classroom. Then its impact on teaching and learning is analyzed, which has a positive impact on improving teaching levels and learning quality. Finally, the challenges that AI applications may face in education in the future are presented and references are given to AIs to promote education reform.

3. METHODOLOGY

When choosing scientific and professional papers, the emphasis is placed on narratives, because they are more suitable for achieving the ultimate goal - to see the presence of artificial intelligence in the field of education. The main research questions to be answered are:

- How does artificial intelligence affect the education process?
- What are the applications of artificial intelligence in education?
- What are the benefits of using artificial intelligence in education?

Electronic databases were used to search for papers that will be the subject of analysis as the most efficient way to search the necessary literature, specifically, ResearchGate, Google Scholar, and ScienceDirect. The focus is on papers published in the period from 2018 to 2021 in journals and collections of papers, papers written in English and based on qualitative and quantitative methods. To narrow the search for papers to only relevant ones in the desired field, the phrase "Artificial intelligence in education" was used for the search.

After the search, fifteen papers suitable for analysis and answering the research questions were selected. Selected papers were synthesized based on the title of the paper, the name of the author, the year of publication, the purpose of the paper, and the aspect of the research.

4. RESULTS AND DISCUSSION

All fifteen papers presented in Table 1 are closely related to the subject of research. The papers analyze the data using mainly qualitative methods. Years of publication of papers indicate a gradual and stable pace of research on the application of artificial intelligence in education.

Table 1. *List of selected papers*

Title	Author(s)	Year	Purpose of work	Research aspect
Artificial Intelligence in Education [2]	Sadiku M., Ashaolu T., Ajayi-Majebi A., Musa S.	2021	Consider different applications of AI in education	• Application of AI in education
A Review on Artificial Intelligence in Education [10]	Huang J., Saleh S., Liu Y.	2021	Describe the application of AI in education, analyze its impact on teaching and learning, and present the challenges that AI applications may face in education in the future	• Application of AI in education • Influence of AI on the education process
Artificial intelligence in education: The three paradigms [11]	Ouyang F., Jiao P.	2021	Explain the paradigmatic changes that *AIED has gone through* in its short history	• Influence of AI on the education process
Artificial Intelligence in Education [12]	Flogie A., Aberšek B.	2021	Answer many general social and ethical questions such as: do AI models systematize existing prejudices? What will AI do when he enters education?	• Application of AI in education
Artificial Intelligence in Education [6]	Kengam J.	2020	Present the impact of AI in education and its advantages and disadvantages, describe the specific way of developing a platform for education based on AI, and finally the additional effects of AI in education	• Influence of AI on the education process • The benefits of applying AI in education
Artificial Intelligence in Education (AIEd) [7]	Lee AVY	2020	Consider how existing world-supporting AIs can be extended to the fields of education, and what are the current challenges of using AIs in classrooms across Singapore	• Influence of AI on the education process
Evaluating Artificial Intelligence in Education for the Next Generation [3]	Joshi S., Rambola RK, Churi P.	2020	Analyze how AI can be used to improve learning outcomes, providing examples of how AI technology can help teachers use data to improve equity and education rankings in developing countries	• Application of AI in education
Use of Artificial Intelligence in Education [9]	Panigrahi A., Joshi V.	2020	Give an overview of artificial intelligence, explain the approach to the use of AI in education to improve learning outcomes, and present some examples of the use of AI technology in the education sector to improve the learning experience and learning quality	• Application of AI in education
Artificial Intelligence in Education: A Review [8]	Chen L., Chen P., Lin Z.	2020	Assess the impact of artificial intelligence (AI) on education	• Influence of AI on the education process
Vision, challenges, roles and research issues of Artificial Intelligence in Education [13]	Hwang GJ., Xie H., Wah B., Gasevic D.	2020	Present the definition and roles of *AIED* studies from the perspective of educational needs, and propose a framework that will show considerations of the application of *AIED* in different learning and teaching environments	• Application of AI in education
Artificial Intelligence in Education: Current Insights and Future Perspectives [14]	Goksel N., Bozkurt A.	2019	Examine current insights and future perspectives of artificial intelligence in different contexts, such as natural language processing, machine learning, and deep learning	• Application of AI in education
Artificial intelligence in education - A promise, a threat or a hype? [15]	Humble N., Moselius P.	2019	Analyze and discuss *AIED* from a teacher's perspective	• The benefits of applying AI in education
Artificial Intelligence in Education [16]	Guo Y., Xiao Y.	2019	Clarify what artificial intelligence is and why it is needed for education, what artificial intelligence would bring to education and how people in different industries should help apply artificial intelligence in education	• The benefits of applying AI in education
Artificial Intelligence trends in education: a narrative overview [17]	Chassignola M., Khoroshavin A., Klimova A., Bilyatdinova A.	2018	Present a possible picture of how artificial intelligence (AI) will reshape the educational landscape	• Influence of AI on the education process
Artificial Intelligence and its Implications in Education [18]	Subrahmanyam V. Swathi K.	2018	Consider the role of artificial intelligence in the education sector, its impact on education, and case studies of its current presence in education (smart content, intelligent, and teaching systems, virtual learning environments, etc.)	• Influence of AI on the education process

A detailed analysis of selected papers was performed using the descriptive analysis technique. The papers were analyzed from the aspect of the impact of AI on the educational process, the application of AI in education, and the benefits of the application of AI in education. The results of the analysis are translated into answers to research questions, which are presented in the form of special subheadings in the continuation of the paper.

4.1. Influence of artificial intelligence on the educational process

AI is slowly entering almost every area of human life and work, including the education. AI tools have already been implemented to some extent in many parts of the educational process, including content development, teaching methods, student assessment, and communication between teachers and students, so AI technology is obviously changing traditional education and teaching and presenting educational institutions and teachers new ideas for teaching reform.

The application of AI in education, in different forms and with different functions, has had a great impact on the performance of administrative and managerial functions in education. Namely, it enabled teachers to perform their administrative functions, such as assessment, and to provide more efficient feedback to students. Also, AI has facilitated the performance of many tasks and improved the effectiveness and efficiency of teachers in providing instructions and guidance to students. Furthermore, intelligent teaching systems provide a wide range of functionalities that allow teachers to perform tasks such as assessment, promotion, plagiarism checking, and giving students feedback on areas for improvement. AI has significantly reduced the paperwork and workload of teachers by enabling them to focus on their core tasks and improving content and materials in line with the curriculum.

The use of AI for educational purposes or as a pedagogical tool has improved the effectiveness, efficiency, and quality of teachers' work. Efficiency and quality, in this context, are measured by the delivery of relevant content by the curriculum and following the specific needs and abilities of students, while effectiveness is assessed by students' implied acquisition and retention or achievement. AI has ensured improved dissemination of course content, from the curriculum development phase to the actual delivery of content or instructions, and more online and web-based learning platforms. It has also enabled the monitoring of learning progress, including knowledge and understanding, and uses reports to improve the system's ability to adapt content to the needs and abilities of students. It is important to emphasize that shortly, AI will be able to work as an assistant who adapts to a wide range of learning styles to help teachers and students.

AI can assess students' daily and test performance based on large amounts of data and machine learning, and provide personalized teaching guidelines, shortening student learning time and improving learning efficiency. Adaptive learning technology can help implement individual teaching between machines and students. Artificial intelligence in education can reduce the burden on teachers and make them more efficient, because most of the time teachers spend evaluating homework and exam papers. These repetitive tasks take up teacher time and teacher-student interaction time. Intelligent tutoring systems, intelligent grading systems, and educational robots can help teachers solve many mechanically repetitive daily tasks. In general, AI technology is changing traditional education and teaching methods.

4.2. Applications of artificial intelligence in education

Most research on artificial intelligence in education focuses mainly on the application of AI technology. AI technology is driving several changes in the field of education, improving the efficiency of teachers 'work and students' learning experience. Some of the applications are discussed below [2] [3].

- Classroom application - AI can allow teachers to teach all AI assessment tasks so that teachers can spend more time with students. Also, artificial intelligence is useful for teaching. Since teachers cannot be available to students all the time, they need tutors.
- Personalized education - AI can provide a level of differentiation that adapts learning specifically to each student. Artificial intelligence helps to build a personalized learning schedule for each student, thus adapting learning to the specific needs of students. This opens up new ways of interacting with students with learning disabilities.
- Administration - AI can simplify administrative tasks. The technology can be used to automate assessment tasks where multiple tests are involved. This means that teachers would have more time for students.
- Universal access to global classrooms - AI can help remove boundaries, making it easier to learn any course from anywhere, anytime around the world. Artificial intelligence tools can help make global classrooms accessible to everyone, including those who speak different languages.
- Medical education - The speed with which new health AI technologies are being developed is being introduced into clinical practice.
- Marketing education - AI is transforming the marketing profession. These include sales

forecasting, personalizing your website experience, speech recognition, content creation, and chatbots.

Other applications include personalized guidance, support, feedback, assessment tools, virtual assistants, mobile games, intelligent teaching systems, educational robots, smart education, and engineering education.

The application of AI in education can be viewed in a slightly different way through adaptive learning, teaching evaluation, virtual classroom, smart campus, and intelligent teaching [10].

- Adaptive learning – AI promotes the development of adaptive learning, in which adaptive learning applies data mining, intelligent education systems, learning analytics, and real-time analysis.
- Teaching evaluation - AI technologies such as image recognition, prediction system, and computer vision provide convenience for teaching assessment.
- Virtual classroom - The development of virtual reality, augmented reality, hearing, and sensory technology is conducive to the reform of the teaching environment.
- Smart Campus - AI plays a key role in managing campuses and services. Face, hearing, and sensor recognition technologies are used to build a smart campus.
- Intelligent teaching robots - Educational robots have been specially developed for the educational field, to cultivate analytical, creative, and practical skills.

4.3. Benefits of using artificial intelligence in education

Because artificial intelligence is becoming more sophisticated, the machine reads the student's facial expressions or gestures and uses them to find out if the student is trying to understand the lecture or needs to change the lesson so the student can easily continue to follow. Adaptation of the academic curriculum can be done using machines based on AI. Artificial intelligence tools can enable global classrooms, including those with impaired vision or hearing. Also, AI can help students who cannot attend classes due to illness. It also provides several resources for people who speak different languages or has hearing or vision problems. AI can help students with homework or prepare for home testing. For the needs of education, applications of artificial intelligence are being developed, such as mentors for students. These applications can also immediately evaluate student essays. Voice assistants help students to talk directly with the educational material that is present on the Internet and installed devices, without any participation of teachers. The use of this technology is expected to escalate in the coming years [6].

The application of artificial intelligence can effectively increase the individual attention of students, because it can provide students with personalized diagnosis and analysis. It can also provide data support for more efficient teaching management. AI is an iterative and progressive technology that can achieve real-time data processing and feedback in the interaction between teachers, students, and the system [16].

5. CONCLUSION

By comprehensive analysis of selected works, conclusions are drawn that indicate the factual situation described below. The facts are in line with the research issues addressed in this paper.

Schooling today is not as flexible as that which will be supported shortly by the use of artificial intelligence. Traditional learning methods are becoming obsolete and various educational institutions are slowly rejecting them. Smart systems are rapidly changing educational institutions at all levels of education, to help people learn effectively and meet their learning goals.

AI in Education is a computer technology that provides personalized, adaptable, and insightful teaching. It plays an important role in promoting personalized teaching and learning. AI changes the way teachers teach and the way students learn. You will be able to respond to a range of learning styles shortly. Thanks to artificial intelligence, teaching, and learning programs are becoming more advanced.

The wave of investment and increased interest in artificial intelligence will affect the education process in the times to come. AI is changing and reshaping the educational landscape, although it will not completely replace the traditional education system. It is wrong to try to completely replace it with AI, but AI technology should be added to the traditional learning process.

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Big Data Analytics Process Implementation on a Educational Data Set Extracted from Online Testing System

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Abstract: *The paper presents an application of the big data analytics process on a data extracted from the educational system for online testing. The procedure of data migration to a non-relational system was implemented. Big data analytics process was realized through query processing in MongoDB and analysis results visualization in Microsoft Power BI. The contribution of the research presented in this paper refers to the importance of applying the big data concept for analyze data set extracted from educational systems in order to discover information and knowledge important for improving the efficiency of the educational process.*

Keywords: *big data; education system; data analytics; MongoDB; Power BI visualization*

1. INTRODUCTION

The rapid expansion of information and communication technologies has significantly influenced the change in the way data is transmitted and stored, and therefore it conditioned the continuous development of various areas of modern life and business. The field of education is one of the areas on which these changes have had a great impact. The most significant result of the strategic process of technology implementation in education is reflected in the development of various systems and platforms that have the ability to collect a large amount of data. The concept of new educational environments for e-learning, based on a three-tier architecture enables flexible design of the learning process [1]. Course management platforms, learning management systems (LMS), open online courses (MOOC), Open-CourseWare (OCW), Open Educational Resources (OER), personal learning environments (PLE) enable the automatic collection of heterogeneous types of data that can be analyzed and used to improve the educational process.

Considering the application of educational platforms and systems, it is evident that huge amounts of data are constantly being generated in different formats from different sources. The volume, variety and speed of data generated daily lead to the big data concept [2], [3].

The emergence of the concept of Big data systems has an increasing influence on various domains of business and social life, including the field of education [4]. The processing and analysis of big educational data enables the discovery of information and knowledge that is useful to teachers, students and the entire education system. In recent years, there has been an increasing need for the application of various methods of analyzing big educational data, with the aim of improving performance in the learning process, discovering and analyzing learning patterns, improving teacher efficiency. The importance of these data analysis is also reflected in the discovery of the reasons that influence the realization of worse outcomes of the learning process. With the removing the weak links from the educational process, the efficiency of the parts of the process that function less well, is significantly improving.

The architecture of Big data technologies enables storing data generated from a wide range of different distributed sources. The information system of some educational institution, as one of the sources, enables storing: student's personal data, data about subjects and achieved grades and all other data related to the study process.

Learning management system provides a database that stores systemic, user information and accumulates large amounts of data from activities such as: access and use of learning materials, testing, performance of various tasks, communication with other participants [5]. Based on predefined input parameters, these systems generate several types of reports. Considering the way of presentation and the amount of data, the process of analyzing the generated reports and

extracting useful information is an extremely difficult and time-consuming task. Therefore, tools that would help these systems to perform the mentioned tasks easier, are necessary. Although some e-learning platforms offer specific tools for creating reports, when there are a large number of students, the process of extracting useful information is complicated. One of the most popular LMS system is Moodle (*Modular Object Dynamic Learning Environment*) [6], which is open source system. It's main advantages are open access and very flexible working method.

Most of the automatically generated educational data is unstructured or poorly structured, and that makes impossible to use traditional tools for their analysis. As existing database management techniques have limitations in the case of using concept of large sets of heterogeneous data, it is necessary to explore new types of technologies, both for storing unstructured data and for their analysis and extraction of useful information and knowledge.

This paper describes a case study of the implementation of big data technologies in the process of analyzing automatically generated educational data. The data analyzed are from the online system designed for entrance exam preparation, and data are stored from 2017 to 2022. The data was migrated from the MySQL relational system to the MongoDB non-relational document-oriented database. Monitoring and visualization of migrated data was performed using the Microsoft Power BI environment for Big data analytics.

2. RELATED WORKS

During the last few years, researches started searching for the implementation of different environments of big data systems and infrastructures, in the process of collecting and analyzing educational data.

In the [7] authors suggesed distributed architecture for processing large educational data. Authors of the paper [8] described an architecture based on the Apache Hadoop cloud environment, intended for the analysis of educational data extracted from the Moodle system.

In the paper [9] authors suggested environment based on map-reduce algorithm for processing data from educational system and HDFS system for storing large amount of data.

Based on results of comparison of three systems, authors in [10] suggested intelligent educational system for large amount of data analysis.

Authors of the paper [11] identified sources of big data in educational environments and they suggest working methods for dealing with those data. In this paper the procedure for projecting appropriate architecture for using the concept big data is also shown.

In the paper [12] authors are discussing the importance of data science, the phenomenom of big data and Learning Analytics in education. A platform whose benefit and importance is reflected in the application of big data techniques in the field of education, has also been considered.

In [13] authors have provided an overview of implemented big data technologies in the field of education. The paper shows the importance of the application of big data analytics methods used in the function of improving the educational process efficiency, the productivity of the higher education institution with the aim of maintaining a competitive advantage on the education market.

3. BACKGROUND

3.1. The theory of Big data

It is difficult to establish a precise and unequivocal definition for the term Big Data, and there is no consensus about the fact from whom and when it was first used. According to some sources, first was John Mashey, one of the experts at The Silicon Graphics, Inc. It is believed that Mashey coined this term during the nineties of the twentieth century [14]. Translated literally, Big Data means "a large amount of data", but this cannot be considered as a definition of this term because it represents a much more complex phenomenon. Economist Francis X. Diebold from the University of Pennsylvania presented scientific article in which he mentions this term in paper's title [15].

Big Data can be defined as a set of technologies used for the process of combining huge amounts of data from various external sources and their analysis, using complex algorithms for making decisions based on knowledge and information that cannot be extracted in a traditional way, using conventional procedures and tools [16].

Big Data enables the management of large sets of different data, at a reasonable speed, in order to be able to analyze them in real time [17]. Also, Big Data implies situations in which existing software tools are not the most suitable for storing and processing targeted huge amounts of data, of different semantic types and structures, in a defined time and with the required accuracy, at a reasonable price [18].

Common for most definitions of this term are three significant aspects of big data that go beyond the capabilities of traditional data processing technologies. These are Volume, Velocity, Variety better known as 3V.

The amount of stored data (Volume), on a global level, is increasing every day at an exponential rate. The growing trend in the amount of available data is accompanied with the need to process it in an adequate manner, in order to reach new

conclusions and make better decisions. Some of the factors that contribute to this growth include: banking transactions, purchases (in retail and online), social networks, smart devices that contain various sensors, scientific projects, medical data (it is estimated that almost 30% of the world's data is some type of medical data, and it is expected that this trend will continue to grow in the coming period).

The challenge of achieving the highest possible speed (Velocity) in Big Data technology has two aspects: the speed with which new data is created and the speed with which existing data is processed and updated. Bearing in mind the importance of this aspect, it is clear that data must be collected, processed and analyzed in real time in order to gain insight into their essence as soon as possible. Since it is crucial for making business decisions to have timely and up-to-date data, it is clear the importance of the fact that it is available at the moment of decision-making. An example of this is sending customized personalized offers to consumers based on their previous purchase history, current location, and the like.

Variety is caused by the fact that data is collected from heterogeneous sources, in which data can be of different formats and models. The problem that needs to be solved is the extraction of different types of data, in such a way that will enable the connection of their meanings. According to its structure, data can be: unstructured, quasi-structured, semi-structured and structured. Most of the data is unstructured, which complicates the process of processing (because it requires a lot of knowledge and time). Unstructured data basically does not have a predefined model (images, text, video, sound, etc.). Structured data has a clearly defined format and structure and they are most often found in databases or data warehouses. They can be used multiple times and they are suitable for automatic processing. Sources of structured data can be machine-generated (generated by the devices themselves) or human-generated (generated by human-device interaction). Quasi-structured data are textual data that are given in a non-standard format so that they can be formatted, It takes a lot of time, tools and knowledge to do so. Semi-structured data can be defined as structured data that does not fit into the formal structure of the data model. Most often, they do not contain tags that separate semantic elements and do not have a common structure. Unstructured, quasi-structured and semi-structured data can basically be seen as a nominal type of data that requires different and much more complex methods of processing and analysis than in the case of structured data types. In practice, advanced statistical analysis techniques (cluster analysis), artificial intelligence methods (machine learning), etc. are most often applied. Structured data has a clearly defined type, or format, and can be categorized as metric or numerical types whose processing, analysis and interpretation is very precisely defined and relatively simple. However, storing and keeping large amounts of structured data can be problematic. It is important to keep in mind that growth is present in all types of data, but the speed of their generating is evidently different, which can be seen in Figure 1. The growth of structured data has a linear trend, and the growth of unstructured data is exponential function.

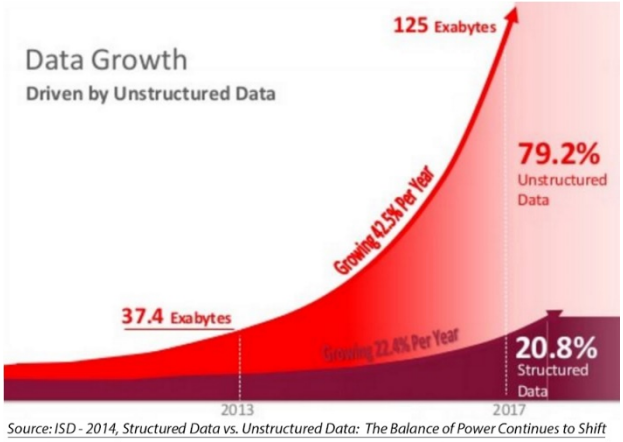

Figure 1. *Display of growth of structured vs. unstructured data [19]*

In recent times, four more Vs are added to the mentioned three important aspects: Veracity, Value, Verification, Visibility.

Veracity and controlling data reliability are a big challenge for Big Data analysts. Data is collected from a wide range of different sources and can be in different formats. Data accuracy is extremely important in the era of continuous and extremely fast generation of huge amounts of data, since huge amounts of data result in a certain amount of inaccurate data, which needs to be extracted in some way. Social media data often contains typos, abbreviations, and colloquial speech. Advanced methods of Big Data analytics, implemented through modern tools, are also adapted to such a structure, relying on the volume of data. Namely, the lack of quality and accuracy is compensated by the amount of available data.

Data collection should not be an end in itself, but the usefulness of the data (value) and the information derived from it is important. Value refers to the ability to convert data into profit. It is believed that, regardless of the activity, Big Data always has the potential to bring profit. An example of how the usefulness of the collected data can be used for making business decisions can be illustrated with the example of sending the nearest available delivery vehicle at the time of ordering (less fuel consumption, less mileage and less time spent).

It is clear that big data cannot be managed using traditional technologies, because in the absence of appropriate software and hardware support, big

data cannot be adequately exploited. The application of artificial intelligence (AI) algorithms and appropriate machine learning methods, which enable automated decision-making, have enabled more efficient and better insight into big data and its better understanding and analysis.

In today's time of growing attempts of various abuses of the weaknesses of computer systems, data verification is an extremely important and actual topic. When clients give permission for storing and processing their data, trust plays a very important role because companies today must do everything in their power to protect data and verify its accuracy. An example of the importance of data verification is reflected in the process of performing online banking transactions, where it is extremely important to check who forwards the request for the transaction, and in order to prevent potential fraud.

Data visibility (Visibility) implies the observability of data, and it is of crucial importance that they are not free accessible to systems and processes, but only to those who have permission to manage them. This dimension additionally emphasizes the importance of data security in information systems.

3.2. Big data concepts

The most important concepts [18] of Big Data domeins are:

- infrastructure,
- storage of large data sets,
- data extraction methods,
- technologies and software for preprocessing, set preparation, analysis and visualization, using systems for business and artificial intelligence, with the aim of making decisions based on significant information extracted from data.

Big Data infrastructure includes data sources, data collection tools and systems, physical data storage medium (servers), data transmission network, data analysis software tools and their working environment, data backup infrastructure, as well as supporting software and results processing.

The basic tasks of Big Data infrastructure include: storage, search, sharing, transfer and analysis of data [20]. Data is stored in databases, found and called from them, and according to the type of data, required security of transactions and types of requested queries, we differentiate:

- relational SQL databases, designed primarily for reliable transactions and ad hoc queries and
- NoSQL databases, which enable: the storage of diverse data, greater speed and flexibility in work. NoSQL databases are non-relational, distributed, open source, horizontally scalable databases. Many of them were developed by companies that tried to find more convenient ways to store or process data for large websites or social networks. There are various solutions, and some of them are: MongoDB, Amazon's Dynamo, Cassandra, CouchDB, Redis, Hbase, BigTable, Hypertable, Voldemort, Riak, ZooKeeper, etc. [21].

3.3. Big data analytics

Big data analytics is a complex process of examining large and diverse data sets, which is carried out with the aim of discovering important information, useful knowledge, hidden patterns, unknown correlations, all in the function of making the best decisions. The three basic phases of Big Data analytics are:

- collecting,
- analysis,
- data visualization.

The data collection phase involves the identification and filtering of relevant data. The collected data is mostly unorganized and inconsistent, contains errors and may be only partially incomplete. The process of collecting raw data from various sources, creating, processing, standardizing, creating an integrated set for analysis is realized within the pre-processing phase and is a complex task. The success of the mentioned phase affects the efficiency of the subsequent application of appropriate methods for detecting legality in the data.

The phase of data analysis involves finding correlations in the data, connecting them in order to discover certain regularities that are not visible at first glance. Data mining methods are used to carry out data analytics processes. Data mining is the process of discovering patterns in large sets that includes machine learning methods, statistics and the use of database systems.

The third phase involves visualization, the method of displaying and analyzing the results of data, in a form suitable for understanding and interpretation. Data are most often displayed in the form of bars, histograms, pie charts, dot charts, Gantt charts, infographics, and the like. The Big Data concept relies on visualization, which is part of Big Data analytics and refers to the graphical, i.e. visual display of the results of processing a large amount of data for easier and more accurate interpretation. It is believed that adequate visualization of big data, in a way that is adapted to the users of that data, will be one of the most important factors in the further development of this technology.

Considering the scale and heterogeneity, the analysis of big data sets is a challenging and complex task. Data integration plays a key role, whereby, differences in data structure and semantics are expressed into a format that can be represented in a computer system.

Considering diversity, variability, occurrence of missing values and redundancy, big data query processing is significantly different from the traditional approach. The existence of redundancy

is reflected in the interconnectedness of big data for solving the problem of missing data, checking conflicting cases and identifying hidden relationships. The lack of connectivity of NoSQL database systems with analytical packages for analysis is a problem associated with big dataa.

4. CASE STUDY

The use of analytics on large data sets extracted from educational environments is a relatively new area of research. The main goal of the conducted research was focused on the analysis and visualization of data generated in the environment of the system for online preparation of the entrance exam in the period from 2017 to 2022.

System for online preparation of the entrance exam at the Department of Electrical Engineering and Computer Science, (hereinafter Odsek VIŠER)[22] is based on the principles of three-layer MVC (Model-View-Controller) architecture and integrated within the UPIS section of the official Internet presentation, which is intended to inform future students. Access data and test attempts were stored in a MySQL database in the *test_reception* table, which reached a size of 15.6MiB with 146848 records. Executing queries and generating responses over the *test_reception* table is significantly slowed down, due to its size and number of records.

For the purposes of the described case study, in the data collection phase, the MySQL relational database was migrated to MongoDB [23] document oriented database. MongoDB is an open source NoSQL database written in C++. Unlike relational databases, MongoDB provides weak guarantees of consistency, but that is why it's characteric is better performance in the management and analysis of large data compared to traditional relational models. [24]. Data migration was performed by establishing a connection with the MySQL system using 3T studio GUI for MongoDB. [25]. Data from table *test_prijemni* are migrated into collection *tie_22_analiza*ni, and the relational record format is transformed into a JSON document.

The structure of the JSON document is defined based on the schema of the table *test_prijemni*. The MongoDB system generated a unique identifier for each document*, field _id*, ObjectId of BSON data type. Field *_id* uniquely identifies each collection document, is always 12 bytes long, and contains timestamp information (timestamp), client machine ID, client process ID, 3-byte increment counter. An example of a JSON document is given below.

```
{"_id":ObjectId("62d0bc4a92d3d4646aa1c668"),
    "id" : NumberInt(255),
    "broj_pokusaja_matematika": NumberInt(4),
    "broj_pokusaj_oit": NumberInt(9),
    "godina": NumberInt(2017),
    "IP": "93.87.148.30",
    "grad": "Београд",
    "skola": "Електротехничка школа \" Никола Тесла\""
}
```

Insight into the contents of the collection was made by quiry *db.tie_22_analiza.find({})* with implemented method find().

By displaying the contents of the collection *tie_22_analiza* it was determined that there were irregularities in the data and missing values for the city and school fields, which were manually filled in by the pupils who were tested. The identified irregularities were eliminated by implementing the data preprocessing process. A method of eliminating documents was implemented in which the occurrence of missing values in important fields (city, school) was determined. Irregularities in the data (typing errors in the name of the school and city, additional empty spaces, etc.) were eliminated by applying data cleaning methods. The data in the fields id, number_of_attempt_mathematics, number_of_attempt_oIT, year, IP were automatically generated after each realized test attempt, so that no errors and irregularities were found in them.

In the analysis phase, the pipeline processing procedure was implemented using queries with the aggregation method. In the first step of the pipeline processing, the $match aggregation operator is included to extract documents based on criteria for a specific year. The extracted documents are passed to the next aggregation step where the grouping operator $group is applied. Grouping of data was done by the IP address of the computer from which it was accessed, and then by city and school. In this step, the cumulative aggregation operator $sum is also defined in order to summarize the access from one IP address. The grouped data was forwarded to the next step, where another grouping was performed with the aim of structuring the data in the documents and summarizing access by school. In the last step of the pipeline processing, the operator $out was applied to save the results by year in separate collections. Figure 2 shows the query used to create document collections by year.

```
db.tie_22_analiza.aggregate([{$match:{godina:2022}},
{$group:{_id:{IP:"$IP",grad:"$grad",skola:"$skola"},
    broj:{"$sum":1}}},
 {$group:{_id:"$_id.grad",
    podaci:{"$push":{skola:"$_id.skola",
                     IP:"$_id.IP",
                     brojPristupa:"$broj"
                     }
            },
          brojPristupa:{$sum:"$broj"}
        }
},
{$out:"analiza_2022"}
])
```

Figure 2. Query to create collections by year

After the analysis, the third phase, visualization, was realized. The visual display of data for each year included the display of the number of accesses by city and school. The analytical software Microsoft Power BI (desktop version) was used for data visualization. Generated collections were exported from MongoDB and imported into the Power BI environment.

Graphic interpretation of the data was performed using grouped bar and grouped bar histograms.

Figure 3 shows the visualization of the number of accesses by city.

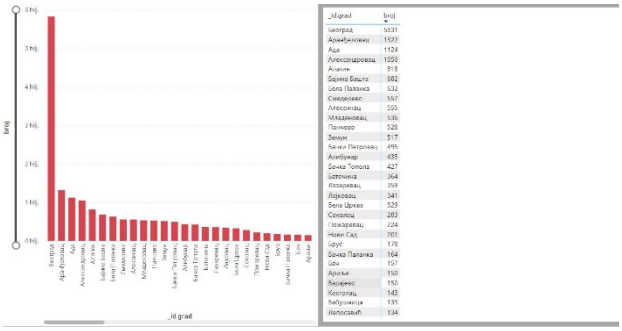

Figure 3. *Number of accesses per cities for the year 2022.*

Figure 4 shows the visualization of accesses by city and school.

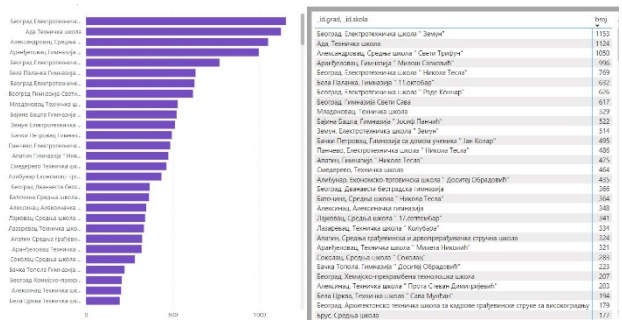

Figure 4. *Number of accesses per cities and per schools for the year 2022.*

Both graphical interpretations are for year 2022.

4. 1. Results and discussion

In this paper, we have presented a study that investigateed educational system for online education using the big data analytics.The system is primarily designed for the higher education students, in order to improve their interest in studying at the Department VIŠER of The Academy of Technical and Art Studies. The volume and structure of the stored data exceeded the capabilities of the relational model, which made the process of extracting data for analysis more complicated. It has been made migration and transformation of data from relation to non-relation database. Queries and aggregation framework implemented in MongoDB document – oriented database management system were used for processing large – scale data. Visualization of the processed data was realized using the Microsoft Power BI tool.

Figure 3 shows that the highest number of accesses was recorded by the students of Belgrade secondary schools. A slightly smaller number of accesses, but not insignificant, was recorded from the students from: Aranđelovac, Ada, Aleksandrovac. On Figure 4, first rows in table legend indicate that in addition to the expected interest of the students from technical schools, the Department VIŠER is also a choice for the students from other secondary schools.

The related studies mentioned in the second section were made to discover architecture and environment for processing a large amount of educational data in different ways, by using different methods. Proposed system for analyzing factors affecting student's performance and dropout by Alblawi and Alhamed [7] is based on implementation Apache Spark analytics engine and HBase column-oriented non-relational database management system. Machova, Komarkova and Lnenicka [8] described methodology for processing Moodle log files, which store information about all users, no metter what role is the user's role (the instructor, course editor, student) and their mutual interactions. They proposed model in the cloud with the use of the Apache Hadoop cluster. Swathi et al. [9] proposed framework for data analysis and student's performance in education system using map reduce algorithm for processing large–scale data stored in Hadoop Distributed File System (HDFS). Based on comperative investigation of Education Big Data Analysis System architectures, Chen et al. [10] proposed framework for analysis and educational data model to achieve better performace in education process. Michalik et al. [11] have been focused on determining and identifying data sources from education enviroment. Authors have proposed methodology for work with large–scale education data, based on environment arhitecture from the technical perspective. Klašnja-Milićević et al. [12] have developed framework for processing and analyzing education data, based on Apache Hadoop architecture which contain: Map – Reduce programming model, Hive non-relational database management system, Pig client – side application in Java and machine learning algorithms as Mahout library.

In the related studies mentioned in the second section, a big educational data processing framework, based solely on the Apache Hadoop architecture, was proposed, but it did not include any visualization process. The authors had analyzed the data extracted from the educational process of teaching and learning, but they had not analyzed data using variables, like city and secondary schools of potential prospective students. In this paper, a study was conducted with

the intention of measuring these data using the proposed framework, based on the implementation of the MongoDB database management system integrated with the Microsoft Power BI visualization tool.

The Big Educational Data analytics framework presented in this paper includes:

- Data set extraction tool and techniques,
- aggregation enviroment for querying data,
- management tool for visualization of results.

Figure 5 provides a indication of all phases proposed Big Educational Data analytics framework.

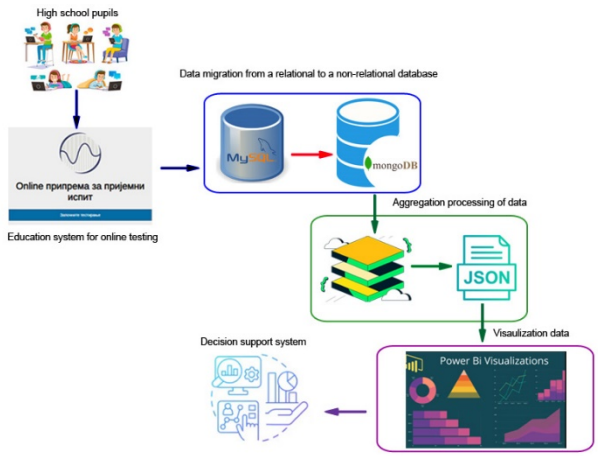

Figure 5. *Model of Big Educational Data analytics framework.*

We have developed proposed model according to the essesential aspects for the implementation of big data analytics process in the domen of education: extracting data from data source, programming environment, and presentation results to the end user. In this paper, we have described the big data concept, infrastructure, techniques, and analytical process, that can be used for achieveing better performance of educational systems.

We would like to highlight the importance of the concept of big data and the implementation of analytical processes in education, as for the improvement of the teaching and learning process, but also for profiling basic demographic data about potential future students. This research also points to the development of a framework that can support data sets created by integrating multiple different educational sources, in addition to developing the key presentation and performance techniques for the collection and processing of large amounts of data.

The limitation and obstacle to the conducted research is the lack of appropriate technical infrastructure for the realization of the theoretical concept of big data analytics process. The expansion of the proposed framework can be realized by horizontal scaling, i.e. by adding additional clusters for storing and processing large - scale data. A distributed environment would enable a more flexible and faster integration of several different data sources, and thus the possibility of monitoring basic data about: students, the learning process, achieved and unrealized results, from their enrollment to the end of their studies.

5. CONCLUSION

Big data analytics undoubtedly occupies a significant role in the future of education.

The paper presents research focused on the application of the process of big data analytics to data extracted from the educational system for online testing. Due to the large amount of data stored in the MySQL database of the system, the procedure of data migration to a non-relational system was implemented.

The process of big data analytics was realized through three phases. Data sets were generated by year and the necessary groupings were performed, in order to prepare for the graphical interpretation of the data. By identifying the unique IP addresses of the computers, the visual access involved displaying the number of accesses by cities and schools.

The results of the analysis provided a better insight into the interest of secondary school students in studying at the Department VIŠER helped in making the right decisions, in order to improve interest where the number of accesses was lower.

In the further continuation of the research, it is planned to apply the big data concept to data extracted from several educational systems (learning management system, information system), with the aim of achieving better efficiency of the educational process.

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Comparison of regression methods and tools using the example of predicting the success of graduate master's students in different fields of education

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Abstract: *With the rapid development of ICT, the fields of Artificial Intelligence and Machine Learning and data mining techniques, there is a need for research in which they are applied, in various domains. In this paper, the analysis of the data set was conducted using regression methods, as one of the "Data mining" and prediction techniques, in order to predict further development in the future, ie. number of graduate master's students in all fields of education. The aim of this research is to monitor the current number of students and compare them with the previous one - in academic education of the second degree, in order to predict the number of students annually and possible factors affecting academic university education in the Republic of Serbia. The obtained results related to the number of master's degree students in the field of education in all territorial parts of the Republic of Serbia, may, also indicate the implementation of certain reforms in academic education in the future, adding innovative ideas, student exchange and others.*

Keywords: *regression; data mining; master studies; education*

1. INTRODUCTION

Artificial intelligence represents a way of reasoning and acting on derived conclusions, with the application of logic, whereby reasoning and acting is not carried out by man or any other living organism, but by machines in the broadest sense of the word [1]. Machine learning, as a branch of artificial intelligence, deals with techniques and methods that enable computer systems, ie. machines learn from experience, ie to react to changes in the external environment, without explicit programming [2]. One of the important applications of machine learning is in data research, ie in the field of "Data mining". "Data mining" is a process of "mining" large databases and extracting new and useful information that can contribute to better and more successful business

[3].

Through research in the field of application of regression methods [4], an adequate way of using these methods is presented, as well as the goal of implementing these methods in the future. The techniques used in this study were simple linear regression and multiple linear regression. The authors [4] came to the conclusion that the percentage of reliability using these methods is about 95%, which is extremely important, but that more predictive analyzes should be performed in future work, such as: logistic regression, decision trees, neural networks and dr.

The paper [5] focuses on the implementation of the regression method in a case study where it was shown that regression algorithms for prediction of outgoing traffic and a model based on the "decision tree" algorithm give the best results, while other algorithms have a problem of excessive matching.

The authors [6] conducted research in the field of education, ie research in which linear regression methods, decision trees, SVR ("Support Vector Regression") and "Random Forest" algorithms are applied in order to enable postgraduate students the most reliable and efficient choice of university where he will attend master's studies. The results obtained in this research are given on the basis of student profiles, while students would not decide to conduct similar analyzes, first decide on the basis of consultants' programs and previous admissions, which is not the most reliable and personalized solution.

Similar research [7] applies the linear regression method to predict student academic performance, which aims to help instructors develop a good understanding of how well or poorly students in their classes will adapt and master material from mechanics and dynamics. Based on the results

obtained, instructors can adopt proactive measures to improve student learning.

The results of the previously presented related research indicate the need to apply regression methods and other methods for the purpose of forecasting in order to make safe decisions in the future, but also to point out possible mistakes in business, work and the like.

The aim of this paper is to analyze a set of data on the topic of graduate students of second degree (master students) in the fields of education. Data analysis was conducted using regression methods, as one of the techniques of machine learning and the task of prediction, in order to predict further development in the future, ie. number of graduate master's students in all fields of education.

In the following chapters, data mining techniques will be explained in detail, with an emphasis on regression methods and their application.

2. DATA MINING TECHNIQUES

Data mining is an extremely useful methodology, which aims to obtain information from a multitude of data that is crucial for strategic decision-making. As a systematic, interactive and iterative process of data and information analysis, it enables better business decision-making and management whose main area of application is business [8]. In order to extract the obtained information from a huge amount of data, it is necessary to apply certain techniques [9].

The following is a list of all Data Mining techniques [10]:

- Classification - This technique is used to classify data into different classes according to certain criteria, such as: according to the type of data source, according to the included database, according to the type of knowledge discovered, etc.
- Clustering - Clustering is the division of information into groups of related objects, ie. this technique represents the grouping of data based on their similarities.Regression - Regression analysis is a predictive data mining technique used to identify and analyze the relationships between variables due to the presence of another factor. Used to define the probability of a particular variable. Regression is a method that primarily represents a form of planning and modeling.
- Association Rules - This data search technique helps detect a connection between two or more items.
- Outer detection - A technique that refers to observing data items in a data set that do not match the expected pattern or expected behavior.
- Sequential Patterns - A data mining technique specialized for estimating sequential data to detect sequential patterns, ie. similar patterns.
- Prediction - A technique that uses a combination of other data mining techniques, such as regression, clustering, classification, etc. to analyze past events and phenomena, in order to predict future events and happenings.

3. REGRESSION TECHNIQUE AND REGRESSION METHODS

Predictive analytics includes a number of techniques of statistics and data mining, which analyzes current and historical facts, in order to predict future events. Regression analysis can be used to model the relationship between one or more independent variables and dependent variables. The regression technique consists of methods on the basis of which data analysis can be performed, as follows: Linear regression, Simple linear regression, Multiple linear regression, Nonlinear and multiple nonlinear regression, Logistic regression, Decision tree, etc. [11].

3.1. Linear and simple linear regression

Linear regression is one of the regression methods used to predict results. Model the relationship between an independent variable and a dependent variable. The simplest form of regression is a simple linear regression that contains only one predictor. The relationship between the input and output variables can be mapped to two-dimensional space. Simple linear regression can be applied using several different methods, and one of the chosen ones is the least squares method. This method is a form of mathematical regression analysis that is used to determine the line that best suits the data set, providing a visual representation of the relationship between data points, ie. the relationship between a known independent variable and an unknown dependent variable [6].

3.2. Nonlinear regression

Nonlinear regression models approximate the relationship between dependent and independent variables by a nonlinear function. The data consists of independent variables that do not contain errors - x, and related experimental dependent variables - y. Each value of y is modeled as a random variable with the average given in the form of a nonlinear function f (x, β).

3.3. Multiple linear regression

Multiple linear regression represents the relationship between two or more variable explanations and the response variable by adjusting the linear equation over the observed data. Each value of the independent variable X is related to the value of the dependent variable Y [12]: y = a1x1 + a2xa + a3x3 + ... + anxn.

The main goal of multiple regression is to discover as many independent variables as possible that affect the dependent variable. The degree of correlation between variables, ie correlation analysis, is extremely important for this method of regression and provides information such as the relative importance of each independent variable in predicting or influencing the dependent variable and the degree to which all independent variables explain dependent variable variations.

4. RESEARCH METHODOLOGY

The main research problem in this paper is the comparison of regression methods and software using the example of predicting the success of graduate master's students in different fields of education. The number of second-degree graduates can vary by field of education as well as by year. As the regression analysis obtained the prediction and results of future development and flow, it was conducted in three different matre for each of the regression methods, namely:

- Linear and simple linear regression was performed in "SPSS" and "RapidMiner" software,
- Nonlinear regression was performed in the "NCSS" software and
- Multiple linear (complex) in "NCSS" software.

"SPSS" is an IBM product designed for statistical analysis, predictive analysis, text analysis, open source extensibility, big data integration, and offers a vast library of machine learning algorithms [13].

"NCSS" software is intended for statistics, graphics and sample size. It is dedicated to providing services to researchers, researchers, academics, scientists and other professionals [14].

RapidMiner is an open source software platform that provides an integrated machine learning environment, Data Mining, Text Mining, and business analytics. It is used for business and commercial purposes, as well as for research, education, training, and supports all steps of the data mining process, including data preparation, visualization, validation and optimization of results [15].

In the analysis, a set of data named "Number of graduates by fields of education", which was taken from the open data portal [16] was used. The downloaded data set is in .xlsx format. It stores data collected in the period from 2016 to 2019. The pre-transformation data set contains information given in only eight columns: "indicator", "IDTer", "nTer", "mes", "god", "IDISCEDF", "nISCEDF" and "value".

By transforming the data set, the "indicator" column was renamed "id", the "nTer" column was renamed "Territory" and the "year" column was renamed "year". As the values of the "nISCEDF" column for one instance in the table were dates in several rows with certain numerical values, it was necessary to transform the data set so that instead of that one column "nISCEDF" create twelve different columns with date values under the following names"Total", "Generic programs and qualifications", "Education", "Arts and humanities", "Social sciences, journalism and information", "Business, administration and law", "Natural sciences, mathematics and statistics", "Information and Communication Technologies (ICT) ","‟ Engineering, Production and Construction ","‟ Agriculture, Forestry, Fisheries and Veterinary Medicine ","‟ Health and Social Assistance "and the‟ Services "column. These twelve columns represent the fields of education of students, while the values represent the number of graduates for that period (year) and a certain territory in a given field.

Figure 1. *Demonstration sample from the data set*

id	IDTer	Територија	година	UKUPNO	Генерички програми и квалификације	Образовање	Уметности и хуманистичке науке	Друштвене науке, новинарство и информисање	Пословање, администрација и право	Природне науке, математика и статистика	Информационе и комуникационе технологије (ИКТ)	Инжењерство, производња и грађевинарство	Пољопривреда, шумарство, рибарство и ветерина	Здравство и социјална помоћ	Услуге
1104020202IND01	RS	РЕПУБЛИКА СРБИЈА	2016	14841	0	1352	1525	1086	2583	688	633	2959	399	2545	1071
1104020202IND01	RS1	СРБИЈА – СЕВЕР	2016	11352	0	847	1298	862	1997	536	474	2461	339	1795	743
1104020202IND01	RS11	Београдски регион	2016	7591	0	374	851	591	1386	345	377	1516	253	1396	502
1104020202IND01	RS12	Регион Војводине	2016	3761	0	473	447	271	611	191	97	945	86	399	241
1104020202IND01	RS2	СРБИЈА – ЈУГ	2016	3489	0	505	227	224	586	152	159	498	60	750	328
1104020202IND01	RS21	Регион Шумадије и Западне Србије	2016	1593	0	327	108	33	254	68	109	220	25	377	72
1104020202IND01	RS22	Регион Јужне и Источне Србије	2016	1896	0	178	119	191	332	84	50	278	35	373	256
1104020202IND01	RS	РЕПУБЛИКА СРБИЈА	2017	14122	0	1399	1325	983	2265	877	567	2746	351	2489	1120
1104020202IND01	RS1	СРБИЈА – СЕВЕР	2017	10769	0	915	1067	798	1711	702	426	2129	308	1887	826
1104020202IND01	RS11	Београдски регион	2017	7498	0	487	786	547	1174	491	315	1447	231	1401	619
1104020202IND01	RS12	Регион Војводине	2017	3271	0	428	281	251	537	211	111	682	77	486	207
1104020202IND01	RS2	СРБИЈА – ЈУГ	2017	3353	0	484	258	185	554	175	141	617	43	602	294
1104020202IND01	RS21	Регион Шумадије и Западне Србије	2017	1417	0	271	116	30	218	76	72	252	16	290	76
1104020202IND01	RS22	Регион Јужне и Источне Србије	2017	1936	0	213	142	155	336	99	69	365	27	312	218
1104020202IND01	RS	РЕПУБЛИКА СРБИЈА	2019	11889	0	908	1153	752	2083	756	692	2191	321	2222	811
1104020202IND01	RS1	СРБИЈА – СЕВЕР	2019	9353	0	568	981	604	1662	586	552	1722	311	1742	625
1104020202IND01	RS11	Београдски регион	2019	6541	0	358	696	418	1228	429	329	1240	205	1233	405
1104020202IND01	RS12	Регион Војводине	2019	2812	0	210	285	186	434	157	223	482	106	509	220
1104020202IND01	RS2	СРБИЈА – ЈУГ	2019	2536	0	340	172	148	421	170	140	469	10	480	186
1104020202IND01	RS21	Регион Шумадије и Западне Србије	2019	1047	0	208	82	43	181	72	55	221	10	153	22
1104020202IND01	RS22	Регион Јужне и Источне Србије	2019	1489	0	132	90	105	240	98	85	248	0	327	164

Columns "mes" and "IDISCEDF" were not of great importance for this type of analysis, so they were removed. By creating new columns, the number of rows is reduced, and numeric values are added to empty fields in order to reduce the possibility of problems during analysis.

The created separate columns enable the achievement of better results, because they leave the possibility of analyzing the data according to several dependent and independent variables, ie. variables (X and Y). Figure 1 shows the data prepared for regression analysis. Regression analysis by linear simple, multiple and nonlinear in this paper, were conducted to predict the number of graduate master's students in the different education fields.

5. RESULTS

The results obtained using linear, multiple linear and nonlinear regression methods are presented in this chapter.

5.1. Results of linear regression analysis

The results of linear regression analysis that illustrate the prediction of the number of graduate master's students in the field of Health care and social assistance in relation to years are shown in Figure 2. The graph depicts the movement of the number of graduate master's students in the field of Health care and social assistance in relation to the year from the period 2016 to 2019. The independent variable X is defined as "years", while the dependent variable Y is defined as "Health care and social assistance" which represents the number of graduate master's students in this field. It can be concluded that linear regression predicts a reduction in the number of graduate students of the second degree in the previously mentioned field based on the period from 2016 to 2019.

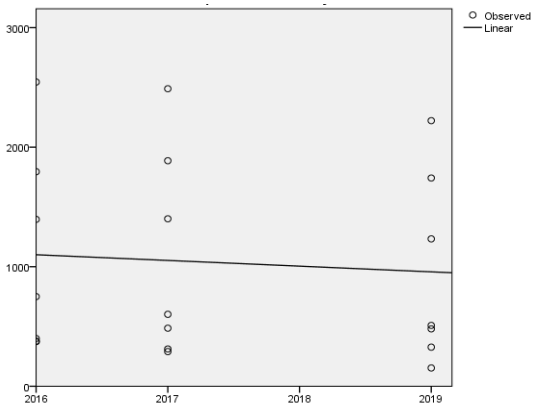

Figure 2. *Number of graduate master's students in the field of Health care and social assistance in relation to the year*

A graph that presents the movement of the number of graduate master's students in the field of ICT in relation to the years is shown in Figure 3. The independent variable X is defined as "years", while the dependent variable Y is defined as "ICT" which represents the number of graduate master's students in this field. It can be concluded that linear regression predicts a reduction in the number of graduate students of the second degree in the ICT field based on the period from 2016 to 2019.

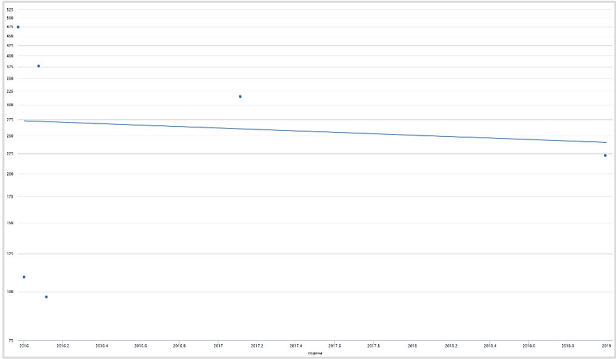

Figure 3. *Number of graduate master's students in the field of ICT in relation to the year*

A graph showing the movement of the total number of graduate master's students in relation to years is presented in Figure 4. The independent variable X is defined as "years", while the dependent variable Y is defined as "total". It can be concluded that linear regression predicts a reduction in the total number of graduate students of the second degree based on the period from 2016 to 2019. It should be noted that the decrease is more pronounced in the field of Health care and social assistance than in the field of ICT. This could be caused by the rapid development of information and telecommunication technologies which led to changes in society and thus affects student choices.

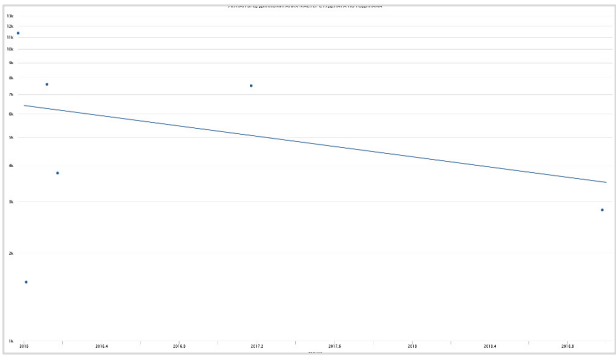

Figure 4. *Number of graduate master's students in relation to the year*

5.2. Results of nonlinear regression analysis

Nonlinear regression analysis was conducted using the NCSS tool. The independent variable X is defined as "ICT" which represents the number of graduate master's students in this field, while the dependent variable Y is defined as "years". This analysis was conducted for 2016 and 2017 separately.

A graphical representation of the movement of the number of graduates in the ICT field during 2016 is shown in Figure 5. Nonlinear regression predicts an

increase in the number of graduate master's students in the ICT field of over 90%, i.e. up to 200 students per year.

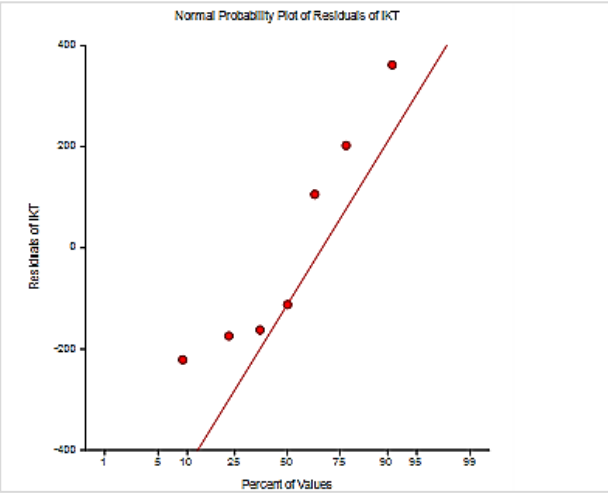

Figure 5. *Number of graduate master's students in the field of ICT during 2016*

A graphical representation of the movement of the number of graduates in the ICT field during 2017 is shown in Figure 6. Nonlinear regression predicts an increase in the number of graduate master's students in the ICT field of over 90%, i.e. up to 100 students per year. The growth trend compared to 2016 has declined which is a result of an overall reduction in the number of graduates.

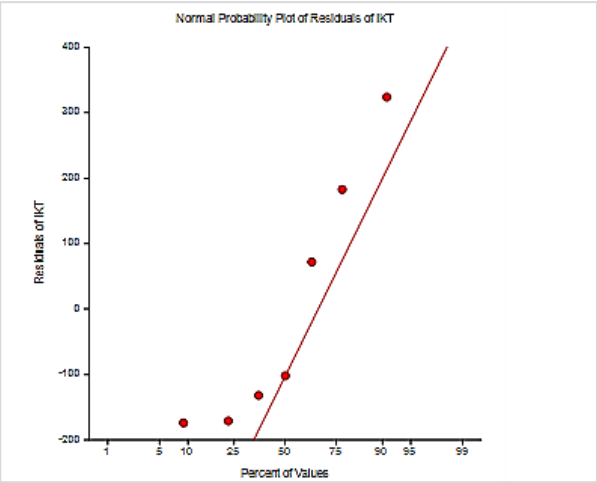

Figure 6. *Number of graduate master's students in the field of ICT during 2017*

5.3. Results of multiple linear regression analysis

The prerequisite for the analysis using multiple linear regression is to select two independent variables X, namely the number of graduates in the ICT field and the number of graduates in the field of Health care and social assistance, as well as one dependent variable Y, i.e. years. Based on the data in the period from 2016 to 2019, multiple linear regression predicts an increase in both variables, as presented in Figure 7. The results show the growth of the number of graduates in the previously mentioned fields with a slight stagnation in 2019 and in future years. As in the introductory part, an overview of related research is given, after the analysis in this paper, there is a need to compare the methods, data, results obtained in this research with related research. According to research [4], the authors concluded that the most reliable results were obtained using multiple regression methods using SPSS software, predicting growth in business profits in 95% of cases, while the results in the example (Figure 7) predict growth in 90% of cases.

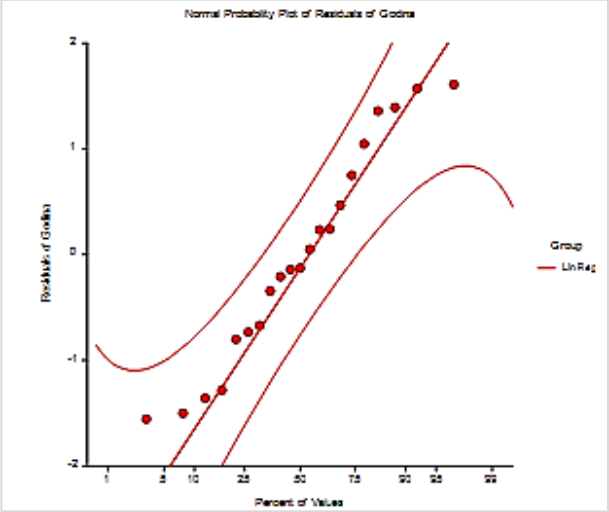

Figure 7. *Number of graduates in the ICT and Health care and social assistance fields in relation to the year*

6. CONCLUSION

With the rapid development of technology, numerous software is being developed that enables the solution of potential problems in various spheres of life. Thanks to the already mentioned: "NCSS", "RapidMiner" and "SPSS" software, which were used for the purpose of this research, and various regression methods, it is possible to predict further trends, such as number of graduate master's students in different fields, according to this research, but also potential problems and risks that can be thus solved (if it is about another field). The results obtained by the method of simple linear regression through "SPSS" software indicate that the prediction is excellent with an error percentage of ±10%. In comparison with the results obtained by the "RapidMiner" software, the same prediction was also achieved, however, the only drawback is that the error percentage is not specified. The prediction made by the non-linear regression method came to an identical prediction - which indicates a general decrease in the number of students in the fields of education. When it comes to the multiple linear regression method using "NCSS" software, the results showed a general growth of the number of graduates in the previously mentioned fields with a slight stagnation in 2019 and in future years. As the authors [7]

state, a good prediction is defined as one with a prediction error of ± 10%, which was the case with them and in this work. The research [5] uses linear regression methods (which proved to be an exceptional prediction method) as well as the decision tree method - which from the perspective of the future course of research in this work, may be a method that will also be implemented.

This research itself found that the number of graduate master's students in the different fields of education is generally decreasing in all territorial parts of the Republic of Serbia, which, unfortunately, does not give a positive outcome, but also indicate to the fact that in the future certain measures could be implemented in the form of possible reforms in academic education, adding innovative ideas, student exchange, etc.

The future flow of research could be reflected in further data collection and monitoring of the current situation and comparison with the previous, in academic education of the second degree (postgraduate education), in order to predict annually what are the factors influencing this area of research, ie. to academic university (postgraduate) education in the Republic of Serbia.

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Comparative analysis of ISO/IEC and IEEE standards in the field of Internet of Things

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Abstract: *In this paper, standardized knowledge sources (standards) and statistical analysis of published standards in the field of the Internet of Things by the IEEE and ISO (International Organization for Standardization), are presented. The purpose of the study is to compile various knowledge sources from the listed fields, employ a qualitative and quantitative methodology, and statistically compare them using the T-test method. The analysis's findings show parallels and contrasts between the two groups of standards, ISO/IEC and IEEE, in terms of cost and page count (two crucial dependent variables). It was determined that the organization should participate more in the creation of standards for the Internet of Things, in order to achieve maximum quality of future products and services.*

Keywords: *comparison; ISO/IEC; IEEE; standards; statistical analysis; Internet of Things.*

1. INTRODUCTION

The Internet of Things involves connecting different types of devices to the Internet, most commonly sensors and actuators. Using these devices allows you to create smart environments that can automate the execution of everyday tasks. Sensors are devices that can respond to stimuli from the physical environment, such as heat, light, sound or pressure. Actuators are devices that perform physical tasks. They often have a switch function and are used to control lighting, air conditioning, heating systems and more.

Smart environments rely on sensor networks that are used to monitor physical conditions such as temperature, sound, vibration, pressure, movement, and pollutants. Such networks are arranged in space and consist of sensors and other devices that communicate with each other. Communication between smart devices (Machine to Machine communication, M2M) is a critical element for the realization of the Internet of Intelligent Devices. M2M communication allows devices to bidirectionally exchange information with business applications over a communications network. HTTP is most often used as a communication protocol in combination with web services based on the REST architecture. A special CoAP (Constrained Application Protocol) has been developed, which is similar to the HTTP protocol, but is optimized for device communication. CoAP defines simple message formats that can also be processed on resource-limited devices, such as wireless sensor network nodes [1].

The integration of embedded devices into the Internet introduces several new challenges, since many of the existing Internet technologies and protocols were not designed for this class of devices [2].

As authors in [3] point out, the development and wide application of Internet of Things requires standardisation. As 'things' are connected with each other the interfaces between the 'things' must be defined at technical and at application levels in order to achieve the full benefits from the Internet of Things. Standards should be designed to support a wide range of applications and address common requirements from a wide range of industry sectors as well as the needs of the environment, society and individual citizens [4]. Standardization plays a significant role in how fast the general approach and the industrial internet technologies will be taken into use [3].

Authors in [5] emphasizes that international standards provide general methods by listing protocols, rules, guidelines, and characteristics that are defined and approved by authorized organizations, helping develop and manage systems efficiently by applying these standards. Therefore, the adoption of international standards is required to overcome the barriers in Internet of Things.

As the number of Internet of Things products as well as platforms keeps growing, the number of professional security organizations, initiatives and standards for IoT have also started to emerge, because they are essential for enabling the fast growth of Internet of Things [6].

By studying reality, collecting different data and accessing different sources of knowledge, we come to expand scientific knowledge in existing fields, and create new information and knowledge.

The aim of this paper is to collect, qualitative and quantitative approach and analysis of various sources of knowledge in the field of Internet intelligent devices.

1.1 Related work

By studying reality, collecting various data, and accessing various sources of knowledge, new information is created, and, first and foremost, scientific knowledge is expanded in certain areas. There are a number of related studies that deal with standardization and standard analysis in specific areas.

A statistical analysis of standards in the field of e-learning was performed in the paper [7], and the obtained comparison results show significant differences in terms of the number of published standards and their prices between the analyzed sets of standards, i.e. between the national standards of Serbia and nearby countries such as Bosnia and Herzegovina, Croatia, Macedonia, Montenegro, Albania, Hungary, Romania, and Slovenia, as well as internationally.

A related study [8] examines existing knowledge bases in the field of expert systems and artificial intelligence, including published standards, eKspertise2Go web pages, and standardized and non-standard dictionaries. According to the results, the International Organization for Standardization has published the most standards, while the eKspertise2Go website has the most consistent information on the use and construction of expert systems.

In [9] the author presents a comparative analysis of ISO and regional standards in the field of e-learning. The survey results show similarities and differences in terms of publishing trends as well as the price of the standard.

The following chapters will present standardization organizations as well as sources of knowledge in the fields of Internet of Things.

2. ORGANIZATIONS FOR STANDARDIZATION IN THE IoT AREA

A standard is an established norm or requirement for a repeatable technical task which is applied to a common and repeated use of rules, conditions, guidelines or characteristics for products or related processes and production methods, and related management systems practices. Technical standard includes definition of terms; classification of components; delineation of procedures; specification of dimensions, materials, performance, designs, or operations; measurement of quality and quantity in describing materials, processes, products, systems, services, or practices; test methods and sampling procedures; or descriptions of fit and measurements of size or strength. It is usually a formal document that establishes uniform engineering or technical criteria, methods, processes, and practices.

A technical standard may be developed privately or unilaterally, for example by a corporation, regulatory body, military, etc. Standards can also be developed by groups such as trade unions and trade associations. Standards organizations often have more diverse input and usually develop voluntary standards: these might become mandatory if adopted by a government (i.e., through legislation), business contract, etc. [10].

Standardization is the process of establishing and applying certain rules in order to regulate and regulate activities in the field, for the benefit and with the participation of all stakeholders, and especially to achieve overall optimal savings, taking into account the functional purpose and technical safety requirements [11].

Three basic levels of standardization by geographical scope are defined, namely: international, regional (European) and national level of standardization [12].

International standardization organizations are:

- ISO - International Organization for Standardization,
- IEC - International Electrotechnical Commission,
- ITU - International Telecommunication Union,
- IEEE - Institute of Electrical and Electronics Engineers,
- European standardization organizations are:
- CEN - European Committee for Standardization,
- CENELEC - European Committee of Electrical Engineers,
- ETSI - European Telecommunications Institute,

State organizations for standardization are:

- ISS - Institute for Standardization of Serbia,
- BAS - Institute for Standardization of Bosnia and Herzegovina,
- DIN - German Institute for Standardization,
- BSI - English Institute for Standardization,
- AFNOR - French Institute for Standardization,
- NEN - Dutch Institute for Standardization,
- ON - Austrian Institute for Standardization,
- SIST - Slovenian Institute for Standardization,
- HZN - Croatian Institute for Standardization.

ISO/IEC JTC 1, entitled "Information Technology", is a joint technical committee (JTC) of the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). Its purpose is to develop,

maintain and promote standards in the field of information and communication technologies (ICT).

The JTC/SC41 Committee was established by JTC 1 at its plenary session in November 2016 in Lillehammer, Norway. Standardization in the field of Internet of Intelligent Devices serves as the focus and advocate of the JTC 1 standardization program. Internet of Intelligent Devices is a system concept that uses many technologies that are standardized by other JTC 1 entities and SDOs. IoT systems are software-intensive and can be quite complex, ranging from simple architecture to multi-layered distributed computing cyberphysical systems. IoT systems are the key drivers of "smart everything" [13].

With the development of the Internet of Intelligent Devices, the requirements for new standards and revision of existing ones will be more pronounced. The next chapter presents important standards, ie sources of knowledge in the field of Internet intelligent devices.

3. KNOWLEDGE SOURCES

Sources of information can be formal or informal, depending on whether scientific information is obtained through formal or informal channels of communication. Standards, scientific journals, textbooks, monographs, dictionaries, etc. represent formal sources of information (knowledge).

International Standards in the Field of Internet of Things, published by the International Organization for Standardization (ISO), are [14]:

Table 1. *Overview of published international ISO / IEC standards in the field of Internet of Things*

Standard title
• ISO/IEC 20922:2016 Information technology — Message Queuing Telemetry Transport (MQTT) v3.1.1
• ISO/IEC 21823-1:2019 Internet of things (IoT) — Interoperability for IoT systems — Part 1: Framework
• ISO 19079:2016 Intelligent transport systems — Communications access for land mobiles (CALM) — 6LoWPAN networking
• ISO/IEC TR 22417:2017 Information technology — Internet of things (IoT) use cases
• ISO/IEC 23093-3:2019 Information technology — Internet of media things — Part 3: Media data formats and APIs
• ISO/IEC 23093-2:2019 Information technology — Internet of media things — Part 2: Discovery and communication API
• ISO/IEC 30162:2022 Internet of Things (IoT) — Compatibility requirements and model for devices within industrial IoT systems
• ISO/IEC 30163:2021 Internet of Things (IoT) — System requirements of IoT/SN technology-based integrated platform for chattel asset monitoring supporting financial services
• ISO/IEC 30161:2020 Internet of Things (IoT) — Requirements of IoT data exchange platform for various IoT services
• ISO/IEC 30118-1:2021 Information technology — Open Connectivity Foundation (OCF) Specification — Part 1: Core specification
• ISO/IEC TR 30166:2020 Internet of things (IoT) — Industrial IoT
• ISO/IEC TR 30164:2020 Internet of things (IoT) — Edge computing
• ISO/IEC 30165:2021 Internet of Things (IoT) — Real-time IoT framework
• ISO/IEC 5055:2021 Information technology — Software measurement — Software quality measurement — Automated source code quality measures
• ISO/IEC 21823-3:2021 Internet of things (IoT) — Interoperability for IoT systems — Part 3: Semantic interoperability
• ISO/IEC 21823-2:2020 Internet of things (IoT) — Interoperability for IoT systems — Part 2: Transport interoperability
• ISO/IEC TR 30148:2019 Internet of Things (IoT) — Technical requirements and application of sensor network for wireless gas meters.
• ISO/IEC TR 30167:2021 Internet of Things (IoT) — Underwater communication technologies for IoT
• ISO/IEC 30147:2021 Information technology — Internet of things — Methodology for trustworthiness of IoT system/service
• ISO 19731:2017 Digital analytics and web analyses for purposes of market, opinion and social research — Vocabulary and service requirementsISO/IEC 30141:2018 Internet of Things (IoT) — Reference Architecture
• ISO/IEC/IEEE 42030:2019 Software, systems and enterprise — Architecture evaluation framework
• ISO/IEC TR 29181-9:2017 Information technology — Future Network — Problem statement and requirements — Part 9: Networking of everything
• ISO/IEC TR 30174:2021 Internet of Things (IoT) — Socialized IoT system resembling human social interaction dynamics
• ISO/IEC TR 30176:2021 Internet of Things (IoT) —- Integration of IoT and DLT/blockchain: Use cases

• ISO/IEC 30118-9:2021 Information technology – Open Connectivity Foundation (OCF) Specification — Part 9: Core optional specification
• ISO/IEC 23093-4:2020 Information technology — Internet of media things — Part 4: Reference software and conformance
• ISO/IEC 23093-1:2020 Information technology — Internet of media things — Part 1: Architecture
• ISO/IEC 29161:2016 Information technology — Data structure — Unique identification for the Internet of Things
• ISO/IEC 21823-4:202 Internet of things (IoT) — Interoperability for IoT systems — Part 4: Syntactic interoperability
• ISO/IEC 20924:2021 Information technology — Internet of Things (IoT) — Vocabulary
• ISO/IEC 30071-1:2019 Information technology — Development of user interface accessibility — Part 1: Code of practice for creating accessible ICT products and services
• ISO/IEC 30141:2018/COR 1:2018 Internet of Things (IoT) — Reference Architecture — Technical Corrigendum 1

The IEEE Institute of Electrical and Electronics Engineers has set the following standards in the field of Internet Intelligent Devices [15]:

Table 2. *Overview of published international IEEE standards in the field of Internet of Things*

Standard title
• 2144.1-2020 IEEE Standard for Framework of Blockchain-based Internet of Things (IoT) Data Management
• 1528.7-2020 - IEEE Guide for EMF Exposure Assessment of Internet of Things (IoT) Technologies and Devices
• 2413-2019 - IEEE Standard for an Architectural Framework for the Internet of Things (IoT)
• 802.11ba Battery Life Improvement - IEEE Technology Report on Wake-Up Radio: An Application, Market, and Technology Impact Analysis of Low-Power/Low-Latency 802.11 Wireless LAN Interfaces
• P1924.1/D14, 2021 - IEEE Draft Recommended practice for developing energy efficient power-proportional digital architectures
• 2857-2021 - IEEE Standard for Wireless Smart Utility Network Field Area Network (FAN)
• White Paper - Pre-Standards Workstream Report: Clinical IoT Data Validation and Interoperability with Blockchain
• 802.15.4-2020 - IEEE Standard for Low-Rate Wireless Networks
• P2144.1/D3, Aug 2020 - IEEE Draft Standard for Framework of Blockchain-based Internet of Things (IoT) Data Management
• P1528.7/D1.00, Feb 2020 - IEEE Draft Guide to Assess the Electromagnetic Fields (EMF) Exposure of Internet of Things (IoT) Technologies/Solutions
• IEEE 1901a-2019 IEEE Standard for Broadband over Power Line Networks: Medium Access Control and Physical Layer Specifications -- Amendment 1: Enhancement for Internet of Things Applications

4. RESEARCH METHODOLOGY

Standards, or standardized sources of knowledge, can be distinguished by comparing the values of specific characteristics (price, status, publication date, etc.) in relation to the group of standards to which they belong (ISO/IEC or IEEE standards).

The differences between the previously mentioned groups of standards - ISO/IEC and IEEE standards - were statistically analyzed.

SPSS software was used for the standard analysis. SPSS is an IBM platform for statistical analysis, text analysis, open source extensibility, big data integration, and it includes a large library of machine learning algorithms [16].

A t-test is a statistical test that is used to compare the means of two groups. It is often used in hypothesis testing to determine whether a process or treatment actually has an effect on the population of interest, or whether two groups are different from one another. The independent-samples t-test is a test used to compare the mean of a continuous variable in two different groups of subjects [17].

Standard.sav, a database containing standards from the categories ISO/IEC and IEEE, was the source of the data set used in the analysis. Figure 1 illustrates the display of variables, where one variable is categorical Group and denotes a group of standards (1-ISO/IEC or 2-IEEE), two variables are continuous dependent variables – Price (denotes the price of the standard) and NumberOfPage (denotes the number of pages), while other variables are nominal.

	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure	Role
1	Group	Numeric	8	0	Grupa	{1, ISO/IEC}...	None	20	Left	Nominal	Input
2	Name	String	200	0	Naziv standarda	None	None	20	Left	Nominal	Input
3	Price	Numeric	8	2	Cena	None	None	20	Right	Scale	Input
4	Status	String	100	0	Status	None	None	20	Left	Nominal	Input
5	PublicationDate	Date	10	0	Datum objavljivanja	None	None	20	Right	Unknown	Input
6	NumberOfPa...	Numeric	8	0	Broj strana	None	None	20	Right	Scale	Input

Figure 1. *Review of variables used in standard analysis*

1	ISO/IEC 21823-2:2020 Internet of things (IoT) — Interoperability for IoT systems	88.00	Published	18
1	ISO/IEC TR 30148:2019 Internet of Things (IoT) — Technical requirements and	138.00	Published	28
1	ISO/IEC TR 30167:2021 Internet of Things (IoT) — Underwater communication	178.00	Published	60
1	ISO/IEC 30147:2021 Information technology — Internet of things — Methodolog	138.00	Published	31
1	ISO 19731:2017 Digital analytics and web analyses for purposes of market, op	88.00	Published	17
1	ISO/IEC 30141:2018 Internet of Things (IoT) — Reference Architecture	198.00	Published	77
1	ISO/IEC/IEEE 42030:2019 Software, systems and enterprise — Architecture eva	178.00	Published	77
1	ISO/IEC TR 29181-9:2017 Information technology — Future Network — Probler	118.00	Published	23
1	ISO/IEC TR 30174:2021 Internet of Things (IoT) — Socialized IoT system resen	138.00	Published	28
1	ISO/IEC TR 30176:2021 Internet of Things (IoT) —- Integration of IoT and DLT/b	158.00	Published	39
1	ISO/IEC 30118-9:2021 Information technology – Open Connectivity Foundation	198.00	Published	100
1	ISO/IEC 23093-4:2020 Information technology — Internet of media things — Pa	58.00	Published	8
1	ISO/IEC 23093-1:2020 Information technology — Internet of media things — Pa	118.00	Published	20
1	ISO/IEC 29161:2016 Information technology — Data structure — Unique identif	88.00	Published	18
1	ISO/IEC 21823-4:202 Internet of things (IoT) — Interoperability for IoT systems -	158.00	Published	38
1	ISO/IEC 20924:2021 Information technology — Internet of Things (IoT) — Vocat	58.00	Published	10
1	ISO/IEC 30071-1:2019 Information technology — Development of user interface	158.00	Published	50
2	2144.1-2020 IEEE Standard for Framework of Blockchain-based Internet of Thi	53.00	Published	18
2	1528.7-2020 IEEE Guide for EMF Exposure Assessment of Internet of Things (I	92.00	Published	88
2	2413-2019 IEEE Standard for an Architectural Framework for the Internet of Thi	184.00	Published	264
2	802.11ba Battery Life Improvement - IEEE Technology Report on Wake-Up Rad	398.00	Published	11
2	P1924.1/D14, 2021 - IEEE Draft Recommended practice for developing energy	75.00	Published	64
2	2857-2021 - IEEE Standard for Wireless Smart Utility Network Field Area Netwc	149.00	Published	177
2	White Paper - Pre-Standards Workstream Report: Clinical IoT Data Validation a	.	Draft	.
2	802.15.4-2020 - IEEE Standard for Low-Rate Wireless Networks	269.00	Published	800
2	P2144.1/D3, Aug 2020 - IEEE Draft Standard for Framework of Blockchain-base	.	Draft	18
2	P1528.7/D1.00, Feb 2020 - IEEE Draft Guide to Assess the Electromagnetic Fie	.	Draft	.
2	IEEE 1901a-2019 IEEE Standard for Broadband over Power Line Networks: Me	439.00	Published	1586
2	IEEE 1451.7-2010 IEEE Standard for Smart Transducer Interface for Sensors a	141.00	Published	99

Figure 2. *View a data set for analysis*

Statistical analysis by the T-test method in this paper was conducted to determine the differences in price and number of pages in these two groups of standards.

5. RESULTS AND DISCUSSION

Using the t-test approach, this chapter compares the test findings for the ISO/IEC and IEEE standards in terms of cost and the number of pages.

5.1 Comparison of price test results with ISO/IEC and IEEE standards

During the conducted t-test statistical analysis, a brief overview of the first t-test of independent samples was given, and a research question was asked: Is there a statistically significant difference in the price of standards between Group 1 standards (ISO/IEC) and Group 2 standards (IEEE)?

The results of testing the price of ISO/IEC and IEEE standards were compared. The analysis requires two variables, namely:

- One category (indicates a group of standards)
- One continuous dependent variable (indicates the price of the standard)

Assumptions and hypotheses set during the analysis are as follows:

H0: The difference between the two groups of standards in price is not statistically significant.

H1: The difference between the two groups of standards in price is statistically significant.

Table 3. *T-test results - comparison of difference in the price of ISO/IEC and IEEE standard*

Group Statistics

	Grupa	N	Mean	Std. Deviation	Std. Error Mean
Cena	ISO/IEC	31	143.1613	42.72946	7.67444
	IEEE	9	311.1111	424.44241	141.48080

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						95% Confidence Interval of the Difference	
		F	Sig	t	df	Significance One-Sided p	Significance Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
Cena	Equal variances assumed	18.239	<0.001	-2.236	38	.016	.031	-167.95	75.12764	-320.04	-15.86
	Equal variances not assumed			-1.185	8.047	.135	.270	-167.95	141.68880	-494.35	158.45

Table 3 represents the results of the t-test, which compares the results of testing the differences in the price of ISO/IEC and IEEE standards.

The value of significance level of the Levene test Sig. (<0.001) is less than 0.05, which implies that the assumption of equality of variance is violated, and to reach the final conclusion we take t-value of the second order t (-1.185). How is the value of Sig. (2-tailed) (0.270) greater than 0.05, the difference between the two groups of standards is not significant but accidental, thus confirming the null hypothesis - H0.

The final conclusion is, as follows: There is no statistically significant difference between the mean values in the price of ISO/IEC (Mean = 143.16, Std. Deviation = 42.73) standards and IEEE standards (Mean = 311.11, Std. Deviation = 424.44), t (-1.185). The table also contains the mean value of the difference between the two groups (Mean difference = -167.95), as well as the lower (Lower=-494.35) and upper (Upper=158.45) limit, which with a probability of 95% contains the actual size of this difference.

5.2 Comparison of page number test results for ISO/IEC and IEEE standards

The second conducted T-test compared the results of testing the number of pages of ISO/IEC and IEEE standards. The analysis requires two variables, namely:

- One category (indicates a group of standards)
- One continuous dependent variable (indicates the number of pages of the standard).

Assumptions and hypotheses set during the analysis are as follows:

H0: The difference between the two groups of standards by the number of pages is not statistically significant.

H1: The difference between the two groups of standards in the number of pages is statistically significant.

Table 4 represents the results of the t-test, which compares the results of testing the differences in page number of ISO/IEC and IEEE standards.

The value of significance level of the Levene test Sig. (<0.001) is less than 0.05, which implies that the assumption of equality of variance is violated and for the final conclusion is taken t value of the second order t (-1.591). How is the value of Sig. (2-tailed) (0.146) greater than 0.05, the difference between the two groups of standards is not significant but accidental, thus confirming the null hypothesis - H0.

The final conclusion is as follows: There is no statistically significant difference between the mean values in the number of standards of ISO/IEC (Mean = 57.38, Std. Deviation = 62.336) standards and IEEE standards (Mean = 312.5, Std. Deviation = 505.774), t (-1.591). The table also contains the mean value of the difference between the two groups (Mean difference = -255.125), as well as the lower (Lower = -617.27) and upper (Upper =

107.02) limit, which with a probability of 95% contains the actual magnitude of this difference.

Table 4. *T-test results - comparison of difference in the page count of ISO/IEC and IEEE standard*

Group Statistics

	Grupa	N	Mean	Std. Deviation	Std. Error Mean
Cena	ISO/IEC	32	57.38	62.336	11.020
	IEEE	10	312.50	505.774	159.940

Independent Samples Test

		Levene's Test for Equality of Variances				t-test for Equality of Means				95% Confidence Interval of the Difference	
		F	Sig	t	df	Significance One-Sided p	Significance Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
Cena	Equal variances assumed	25.974	<0.001	-2.861	40	.003	.007	-255.125	89.160	-435.325	-74.925
	Equal variances not assumed			-1.591	9.086	.073	.146	-255.125	160.319	-617.272	107.022

6. CONCLUSION

As more products and services in the field of the Internet of Intelligent Things (IoT) are developed, the necessity for standardized sources of knowledge is inevitable.

The data set used for the statistical analysis in this work includes worldwide standardized knowledge sources such as ISO/IEC and IEEE, in the field of IoT.

The aim of this paper was to collect, qualitative and quantitative approach and statistical analysis of different sources of knowledge in this area, to determine potential differences in price and number of pages (as key dependent variables) between two groups of standards - ISO/IEC and IEEE.

Based on the findings of this study, it was concluded that the differences in the cost of standards produced by ISO/IEC and IEEE organizations are not statistically significant. Differences in the amount of pages between these two groups of standards were also discovered. According to the T-test method of independent samples, the differences in the number of pages are not statistically significant.

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Determining the number of doctoral students in the Republic of Serbia using regression algorithm

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Abstract: *The term data mining itself implies mining, i.e. the process of sorting, organizing or grouping a large amount of data, which enables the extraction of relevant information. More precisely, data mining leads to flexibility in data, discovery of relationships, regularity, legality and other structures where data can be organized into databases or can be textual, unstructured, derived from the Internet or data organized into time series. A significant change was made in the Bologna process with the introduction of doctoral studies, whose primary goal was to realize the link between education and research. As doctoral studies represent an important level of education, this paper is based on determining gender differences as determinants of the number of doctoral students in the Republic of Serbia. After downloading and installing the NCSS software tool, the downloading, transformation and preprocessing of data originating from the open data portal began. The result of this research is the analysis of data through regression methods, where the given regression mining technique with its set of methods made it possible to predict trends in gender differences as determinants of the number of doctors of science in the Republic of Serbia. The conducted research opens many possibilities for further research.*

Keywords: *mining; regression; doctoral students in the Republic of Serbia; gender.*

1. INTRODUCTION

In addition to the two already existing levels of higher education, undergraduate and graduate studies, the Bologna Process also introduced a third level-doctoral studies. It represented a significant change whose primary goal was to realize the link between education and research. In order to develop a society based on knowledge, the need for creative workers, who will meet in the future meet the changed requirements of all sectors of the economy and society as a whole, is becoming increasingly important in European countries. As the necessary skills are acquired primarily through experience in research, it was necessary to develop a new concept of doctoral studies, the basis of which would be the acquisition of professional experience through the management of original research projects in a high-quality scientific environment. In this way, this level of higher education is significantly and qualitatively different from the two firstly introduced levels. In this way, instead of training for research work, the university implements training through research work. Therefore, the new concept of doctoral studies basically views the doctorate as a professional experience gained on research projects, and the training during doctoral studies represents a whole.

2. APPLICATION OF THE REGRESSION ALGORITHM THROUGH RELATED RESEARCH

Namely, the idea of conducting research on the number of doctoral students in the Republic of Serbia, using the statistical regression method, arose from the very fact of the existence of a large number of conducted research on the same topic, as well as the relevance of the education system of the Republic of Serbia and the application of data mining. During the research by Vilotić and colleagues on the success of doctoral academic studies at the Faculty of Technical Sciences in Novi Sad, it was determined that up to year 2015 / 2016 (including that academic year), 1141 students were enrolled at doctoral academic studies, and only 146 candidates, i.e. 16, 33% gained the PhD degree. The best result in terms of the number of students, who completed doctoral studies, indicates that they were achieved in the interval of study length from 8 to 10 years. The assumption was that the duration of studies is affected by the workload, which refers to students of doctoral academic studies employed at the Faculty of Technical Sciences, which was denied pointing out the conclusion that the workload does not affect the duration of studies. Also, the assumption about the influence of the average grade of students of

doctoral academic studies from previous studies is not significant for success [1].

Ojerinde et al.'s research proposes a framework for administering the prediction of student academic performance using learning analytic techniques. The research illustrates how this model is effectively used on secondary data collected from the Department of Computer Science, University of Jos, Nigeria. The study succeeded in achieving the goal of building a model to predict student academic performance. Analysis has shown that students who have good results in mathematic subjects have a higher chance of achieving excellence in other computer science subjects [2].

Mustapasha sought to conduct a more detailed investigation using web mining techniques to examine two well-known approaches to improving student success – the index of learning styles and learning strategies, in terms of self-confidence, learning aids, motivation, self-motivation, attitude, and the like. The results of linear regression indicated that the scales for selecting main topics, learning aids, self-motivation, self-confidence, goal, self-learning and information processing were significant with a relevance value of less than 0.05 [3].

Since doctoral studies represent an important level of education, this paper is based on gender differences as determinants of the number of doctoral students in the Republic of Serbia.

The development of modern technique and technology indicates an increasing use of digital tools, both in education and in other areas. In today's business, most data resides on the web. So all technologies related to data processing are very important for their success. Because of that, web mining represents an extraordinary technique for gathering useful information from the web, and precisely for the realization of research on gender differences as a determinant of the number of doctoral students in the Republic of Serbia.

3. BASICS OF WEB MINING

The term mining itself means mining. Data mining is the process of sorting, organizing or grouping large amounts of data and extracting relevant information. We could also define data mining as finding patterns in data. These data can be organized into databases, but they can also be textual data, unstructured data from the Internet, or data organized into time series. Data mining leads to logicality in the data, that is, the discovery of relationships, regularities and other structures among the data.

Web mining is also the use of techniques for extracting useful information from the web. Web data refers to web content (text, images, etc.), web structure (links), and web usage (http logs, server logs, etc.).

3.1. Categories of web mining

As already stated in the introductory part, there are three categories of web mining and they are as follows:

- Web content mining – This is the process of handling useful information from the content of web pages and web documents, which are mainly text, images and audio / video files. The techniques used in this discipline were drawn heavily from natural language processing (NLP) and information retrieval. It is mainly performed through a web browser, with the help of a web crawler and is used for the purpose of indexing websites.
- Web structure mining – This is the process of analyzing the nodes and structure of a web page through the use of graph theory. There are two things that can be gained from this: the structure of the website in terms of how it is linked to other sites, while the second is the structure of the website itself, that is, how each page within the site is linked.
- Web usage mining – This is the process of removing form and information from server logs to see user activities, including where users are from, how many clicks there are on which items on the site, and the types of activities performed on the site, [4].

4. STATISTICAL REGRESSION MODEL

In a large number of researches, one of the goals is to describe the connections between the phenomena that surround us. This can be achieved by finding a formula or equation that relates the quantities we observe. In statistics, regression analysis deals with finding statistical connections between phenomena. Regression is of great importance, both in economics and business, and in other natural sciences, such as: chemistry, physics, biology, pharmacology, toxicology, biochemistry and forensic medicine and so on, [5].

Thus, regression analyzes the relationships between variables. Regression is a data mining technique used to predict a range of numerical values (also called continuous values), given a particular set of data. For example, regression can be used to predict the cost of products or services, given other variables. Regression is used in many industries for business and marketing planning, financial forecasting, environmental modeling, and trend analysis.

Regression is one of the methods within the methods that make up statistical learning - a large set of methods, techniques, statistics tools for modeling and understanding complex data sets. Regression is one of the ways to build a model for predicting and evaluating one or more dependent

variables based on one or more independent variables. In regression, there is an output, unlike other statistical techniques that deal with problems in which there is no dependent variable [6].

5. RESEARCH METHODOLOGY

5.1. Data analysis software tool "NCSS"

The software provides a complete and easy-to-use collection of hundreds of statistical and graphical tools for analyzing and visualizing your data. This data analysis software comes in complete with integrated documentation, free training videos, and full phone and email support from a team of PhD statisticians. With a few simple steps, meaningful numerical results and clean, clear graphics can be obtained. In order to perform the necessary data analysis, it is necessary to download the software tool from the web address: Free Trial | NCSS Statistical Software | NCSS.com. This is followed by program installation and data download.

5.2. Data for analysis

The data that will be analyzed in this paper were taken from the open data portal, provided by the government of the Republic of Serbia, from the following web address: Број доктора наука по полу - студије III степена - Отворени подаци (data.gov.rs).

5.3. Data transformation and preprocessing

After the successful collection of data in .xlsx format, the next step related to data preprocessing and transformation was approached. Therefore, the data in its original form looks like in Figure 1. Data preprocessing represents one of the most important tasks of data mining and includes the preparation and transformation of data into a suitable template, which is suitable for research methods. The mentioned preprocessing activity tends to reducing the amount of data, finding connections between data, normalization, as well as eliminating redundancies and extracting new data. Techniques such as cleaning, integration, transformation and removal of redundant data are included in the preprocess After preprocessing the data, the downloaded set must correspond to a template that is suitable for research, so that the appropriate method, the regression method, can be applied, which is the case in this paper.

idindikator	IDTer	nTer	mes	god	IDPol	nPol	vrednost
1104020301IND01	RS	РЕПУБЛИКА СРБИЈА	0	2016	0	Укупно	1539
1104020301IND01	RS	РЕПУБЛИКА СРБИЈА	0	2016	1	Мушко	656
1104020301IND01	RS	РЕПУБЛИКА СРБИЈА	0	2016	2	Женско	883
1104020301IND01	RS1	СРБИЈА – СЕВЕР	0	2016	0	Укупно	1230
1104020301IND01	RS1	СРБИЈА – СЕВЕР	0	2016	1	Мушко	506
1104020301IND01	RS1	СРБИЈА – СЕВЕР	0	2016	2	Женско	724
1104020301IND01	RS11	Београдски регион	0	2016	0	Укупно	830
1104020301IND01	RS11	Београдски регион	0	2016	1	Мушко	357
1104020301IND01	RS11	Београдски регион	0	2016	2	Женско	473
1104020301IND01	RS12	Регион Војводине	0	2016	0	Укупно	400
1104020301IND01	RS12	Регион Војводине	0	2016	1	Мушко	149
1104020301IND01	RS12	Регион Војводине	0	2016	2	Женско	251
1104020301IND01	RS2	СРБИЈА – ЈУГ	0	2016	0	Укупно	309
1104020301IND01	RS2	СРБИЈА – ЈУГ	0	2016	1	Мушко	150
1104020301IND01	RS2	СРБИЈА – ЈУГ	0	2016	2	Женско	159
1104020301IND01	RS21	Регион Шумадије и Западне Србије	0	2016	0	Укупно	115
1104020301IND01	RS21	Регион Шумадије и Западне Србије	0	2016	1	Мушко	55
1104020301IND01	RS21	Регион Шумадије и Западне Србије	0	2016	2	Женско	60
1104020301IND01	RS22	Регион Јужне и Источне Србије	0	2016	0	Укупно	194
1104020301IND01	RS22	Регион Јужне и Источне Србије	0	2016	1	Мушко	95
1104020301IND01	RS22	Регион Јужне и Источне Србије	0	2016	2	Женско	99
1104020301IND01	RS23	Регион Косово и Метохија	0	2016	0	Укупно	
1104020301IND01	RS23	Регион Косово и Метохија	0	2016	1	Мушко	

Figure 1. *Unprocessed Data*

The original data set contained many rows, there were empty cells, which did not ensure accuracy during data analysis, and they were transformed. Certain columns from the above data set have been removed because they are not relevant for this type of analysis. Also, special columns have been created that enable better quality results because they leave the possibility of data analysis according to more dependent and independent variables (x, y).

After data preprocessing, a form of data is obtained that is suitable for analysis using regression methods, which can be seen in Figure 2.

indikator	IDTer	nTer	god	musko	zensko	ukupno
1104020301IND01	RS	РЕПУБЛИКА СРБИЈА	2016	656	883	1539
1104020301IND01	RS1	СРБИЈА – СЕВЕР	2016	506	724	1230
1104020301IND01	RS11	Београдски регион	2016	357	473	830
1104020301IND01	RS12	Регион Војводине	2016	149	251	400
1104020301IND01	RS2	СРБИЈА – ЈУГ	2016	150	159	309
1104020301IND01	RS21	Регион Шумадије и Западне Србије	2016	55	60	115
1104020301IND01	RS22	Регион Јужне и Источне Србије	2016	95	99	194
1104020301IND01	RS	РЕПУБЛИКА СРБИЈА	2017	567	385	952
1104020301IND01	RS1	СРБИЈА – СЕВЕР	2017	309	474	783
1104020301IND01	RS11	Београдски регион	2017	221	372	593
1104020301IND01	RS12	Регион Војводине	2017	88	102	190
1104020301IND01	RS2	СРБИЈА – ЈУГ	2017	76	93	169
1104020301IND01	RS21	Регион Шумадије и Западне Србије	2017	40	49	89
1104020301IND01	RS22	Регион Јужне и Источне Србије	2017	36	44	80
1104020301IND01	RS	РЕПУБЛИКА СРБИЈА	2018	403	420	823
1104020301IND01	RS1	СРБИЈА – СЕВЕР	2018	323	344	667
1104020301IND01	RS11	Београдски регион	2018	221	246	467
1104020301IND01	RS12	Регион Војводине	2018	102	98	200
1104020301IND01	RS2	СРБИЈА – ЈУГ	2018	80	76	156
1104020301IND01	RS21	Регион Шумадије и Западне Србије	2018	29	38	67
1104020301IND01	RS22	Регион Јужне и Источне Србије	2018	51	38	89
1104020301IND01	RS	РЕПУБЛИКА СРБИЈА	2019	344	448	792
1104020301IND01	RS1	СРБИЈА – СЕВЕР	2019	275	350	625
1104020301IND01	RS11	Београдски регион	2019	185	244	429
1104020301IND01	RS12	Регион Војводине	2019	90	106	196
1104020301IND01	RS2	СРБИЈА – ЈУГ	2019	69	98	167
1104020301IND01	RS21	Регион Шумадије и Западне Србије	2019	37	64	101
1104020301IND01	RS22	Регион Јужне и Источне Србије	2019	32	34	66
1104020301IND01	RS	РЕПУБЛИКА СРБИЈА	2020	320	399	719
1104020301IND01	RS1	СРБИЈА – СЕВЕР	2020	268	329	597
1104020301IND01	RS11	Београдски регион	2020	196	241	437
1104020301IND01	RS12	Регион Војводине	2020	72	88	160
1104020301IND01	RS2	СРБИЈА – ЈУГ	2020	52	70	122
1104020301IND01	RS21	Регион Шумадије и Западне Србије	2020	26	27	53
1104020301IND01	RS22	Регион Јужне и Источне Србије	2020	26	43	69

Figure 2. *Transformed data*

6. RESULTS

6.1. Results and discussion using simple linear regression

After the imported data and applied filters, a simple linear regression was applied. In order to conduct a simple linear regression, it was necessary to choose two dependent and one independent variable, namely h(year) and u(male and female).

Based on the data on the number of completed doctoral studies, taking into account only the female gender, i.e. the defined columns for X and Y, using simple linear regression, a graphic representation was created that shows the flow of completed doctoral studies of female individuals in relation to the years from 2016 to 2020, which can be seen in Figure 3. The graph clearly indicates that a simple linear regression predicts a lower number of female PhD graduates starting in 2016 and ending in 2020.

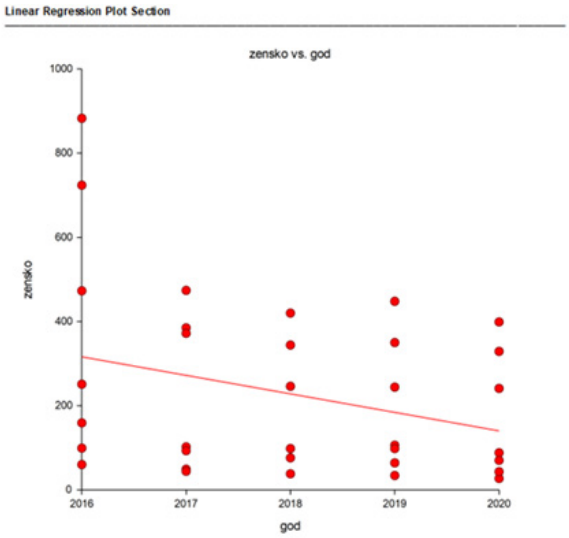

Figure 3. *The results of the analysis achieved by applying a simple linear regression for the females*

Then, a further analysis for the male sex was undertaken. The graph clearly indicates that a simple linear regression predicts a lower number of male PhD graduates starting in 2016 and ending in 2020, which can be seen in Figure 4.

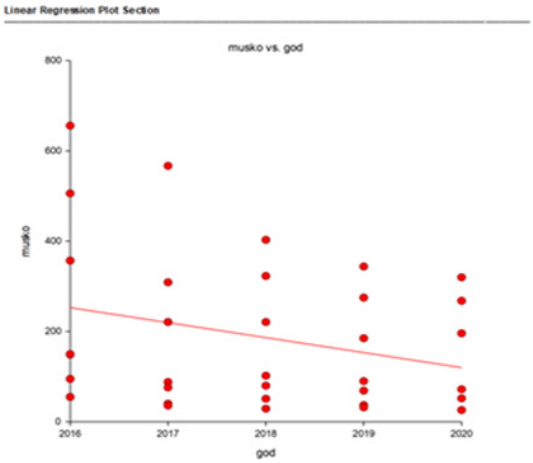

Figure 4. *The results of the analysis achieved by applying a simple linear regression for male*

6.2. Results and discussion using multiple linear regression

By applying multiple linear regression, a graphic representation was created that shows the flow of completed doctoral studies of individuals of both sexes as well as the total number (Y) in relation to the years from 2016 to 2020 (X), which can be seen in Figure 4. The graphic clearly indicates that the multiple linear regression indicates a decrease in the number of male and female individuals, as well as the total number, who end up doctoral studies, starting from 2016 until 2020.

Furthermore, the analysis was started only for individuals of the female sex, i.e. defined columns X and Y, using multiple linear regression, based on which a graphic display was created that shows the flow of the mentioned data in given period, which can be seen in Figure number 5.

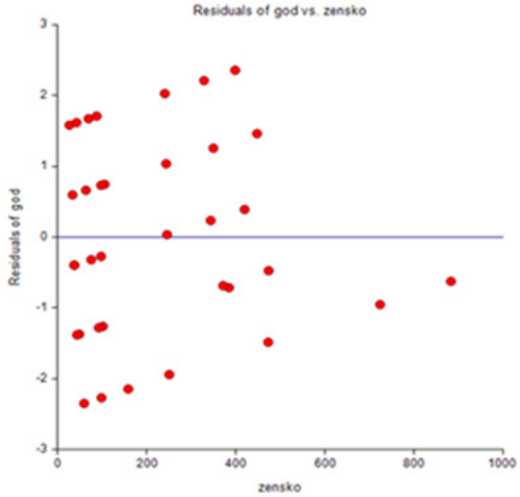

Figure 5. *The result of the analysis achieved by applying multiple linear regression for females*

After the analyzed data for the female persons, further analysis is done only for the male persons, that is, the defined columns X and Y, by applying multiple linear regression, on the basis of which a graphic representation was created that shows the flow of the mentioned data in a given period, which can be seen in Figure number 6.

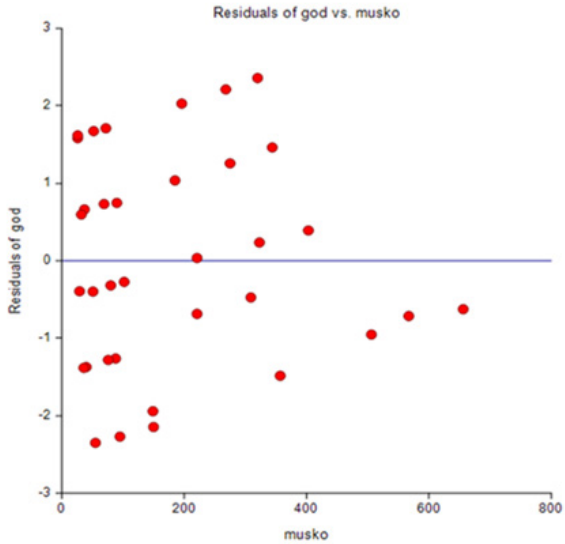

Figure 6. *The result of the analysis achieved by applying multiple linear regression for male*

After analyzing the data for men, a further analysis is made only for men and women, i.e. defined columns X and Y, using multiple linear regression, on the basis of which a graphic display was created that shows the flow of the mentioned data in a given period, i.e. forecasts an decrease in the number of male and female individuals who have completed doctoral studies, which can be seen in Figure number 7.

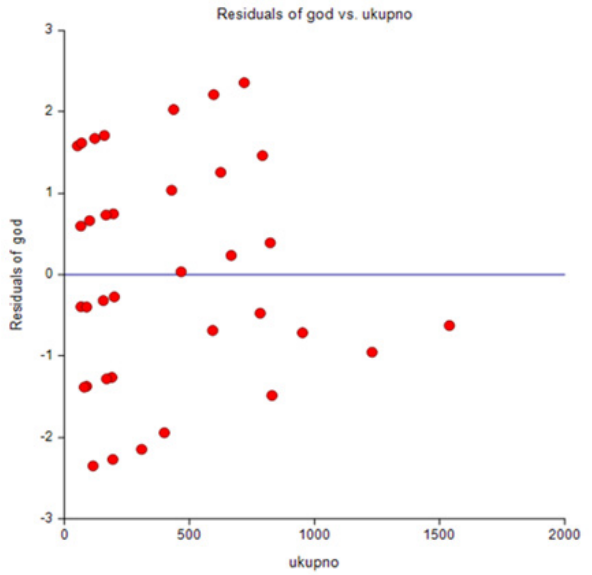

Figure 7. *The result of the analysis achieved by applying multiple linear regression for male and females*

6.3. Results and discussion using non-linear regression

Based on the data for the given period from 2016 to 2020, i.e. defined columns for X (year) and Y (female), using non-linear regression, a graphic display was created that shows the trend of the number of female individuals who completed doctoral studies in relation to the already mentioned period. Non-linear regression predicts an decrease in the number of female individuals completing doctoral studies, with 99% certainty, which is shown in Figure 8.

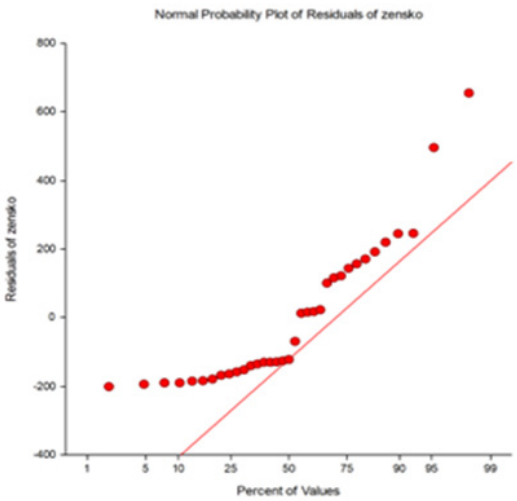

Figure 8. *The result of the analysis achieved by the application of non-linear regression for female*

While, the non-linear regression predicts a decrease in the number of male individuals completing doctoral studies, with 99% certainty, which can be seen in Figure 9.

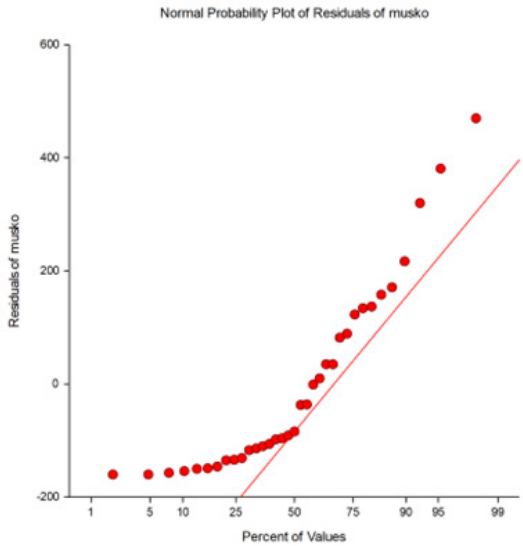

Figure 9. *The result of the analysis achieved by applying non-linear regression for male*

6.4. Correlation of results with related research

The results of the first related research paper indicate that by the end of the 2015/2016 academic year, only 16.33% of the total number of students enrolled in the third degree of academic studies at the Faculty of Technical Sciences in Novi Sad had completed their doctoral studies. It can be said that the number of doctoral students at the level of the Republic of Serbia is decreasing in the incoming period, as we can see in this paper, which talks about gender differences as a determinant of the number of doctoral students, but also about their total number. Analysis of the results indicates a decrease in the number of male and female persons, i.e. of the total number of PhDs from 2016 to 2020.

As in the research work of Ojerdindej and his associates, the multiple linear regression technique was used in this work, but not in combination with the SPSS software tool, but with the NCSS software tool. Their research illustrates how the multiple linear regression model is effectively used on secondary data and the study was able to achieve the objective of building a model for predicting students' academic performance. While in this paper the application of the multiple linear regression clearly predicted the decrease in the number of male and female doctoral students, that is, their performance.

Reviewing the research, it can be seen that the students had ten different combinations of good aspects, eight of which are on the strategy scale which is good. This can be correlated with the results of this research, which using simple and complex linear regression, as well as non-linear regression, shows an decrease in the number of PhDs from 2016 to 2020, so students should apply better aspects for learning.

7. DISCUSSION

In the modern conditions of life and work, education represents an important stage in the life of every individual, therefore it is important to promote its advancement through constant research. Advances in technique and technology have contributed to a more comprehensive application of various research opportunities and the use of various techniques, such as data mining techniques. The advantage of the research paper "Determining the number of doctoral students in the Republic of Serbia by regression algorithm", in relation to the aforementioned related research, is the application of web mining techniques, more precisely statistical methods of simple and multiple linear regression, as well as non-linear regression, to data collected from the portal, which it was not applied only to the total number of persons who completed doctoral studies. The mentioned techniques were applied especially for men, especially for women, as well as for the total number of persons who became doctors of science in the given period. The obtained results unequivocally showed that more effective modernization and more intensive application of regression methods and more realistic planning and programming of possible research can be achieved only if a sufficient amount of objective information is available on the basis of which the current situation can be diagnosed and procedures for further work can be determined. Of course, this research should initiate further, more complex and broader research, with a larger number of respondents, in a wider area, which will lead to more efficient data transformations.

8. CONCLUSION

The result of this research is data analysis through regression methods with the use of the NCSS software tool, in order to collect and predict significant information related to gender differences as determinants of the number of PhDs in the Republic of Serbia.

The data mining regression technique with its set of methods made it possible to predict in time the trends of gender differences as determinants of the number of PhDs in the Republic of Serbia, in relation to male and female gender, as well as the total number of individuals completing doctoral studies. From the research itself, an decrease in finishing doctoral studies was established when it comes to the female gender, while it is seen that the male gender is not lagging behind either. The further development of the research would be reflected in the continuation of monitoring gender differences in the upcoming period and the continuous collection of data and comparison with the previous ones, so that during a certain period of time it would be predicted which segments of information are circular for education in the Republic of Serbia.

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Data analysis for COVID-19 using regression methods

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Abstract: *With the appearance of the first registered case of corona, as one of the world's most widespread and most dangerous viral infections, the need to monitor and predict the epidemiological situation is growing, both in the world and in our country. In this paper, the epidemiological data of the Republic of Serbia regarding the Corona virus in the period from 2020 to June 2021 are analyzed. Data were analyzed by regression methods, as one of the data mining techniques. Depending on the choice of regression method (simple, multiple and linear), a number of parameters were selected that include the number of persons (positive, tested, deceased, hospitalized and respirator) in relation to the time of the pandemic to make the most accurate prediction. As a result of the research using regression methods, it was found that the trend of development of the Corona virus epidemic is decreasing, i.e. (id est.) that preventive measures as well as the process of vaccination and revaccination have had an effect in the fight against Corona virus.*

Keywords: *regression; corona; data mining; analysis; the data*

1. INTRODUCTION

With the development of computer technology in the modern business world, there is a need for a variety of ways to research data on the Internet, documents and other content, in order to increase business efficiency, the need for new information and the contribution of scientific research. One of these ways is the application of data mining techniques, through which the extraction of useful information is performed.

There are several types of data mining techniques, and one that was chosen for the purpose of research is the regression technique, which contains a number of methods by which it is possible to perform the necessary analysis of the data set. Based on the data analysis using regression methods, new perspectives are opened for further prediction of observed phenomena and events, which as such the user is not able to notice and register in the future, and which are extremely important to the business world and the general public. One of such data is the most current topic related to COVID-19, i.e. (*id est.*) the corona virus that shook the world public at the end of 2019 and the beginning of 2020.

This topic is the goal of the research, and the data collected on this topic will be analyzed using regression methods, as one of the data mining techniques, with the help of software tools, in order to provide the best information, i.e. forecasts of further pandemic development. In other words, the importance of each regression method in data analysis will be emphasized, and their individual impact on the obtained results of the research itself will be compared with other related research.

The purpose of the research is to monitor the data in order to see the current state of health at the national level and based on that to create forecasts for the further development of the corona virus pandemic by using different regression methods.

In the next part of the paper it will be presented an overview of related research by other authors, theoretical overview of the regression, research methodology and results and discussion, which is the goal of this research.

2. A REVIEW OF RELATED RESEARCH

The beginning of the research is based on the study of regression methods, but also on the review of related research by other authors in the same field. For the field of data analysis using regression methods, the following studies were selected with the authors:

- Chauhan, P. & Kumar, A. & Jamdagni, P. (2020). Regression Analysis of COVID-19 Spread in India and its Different States.
- Tenenholtz, J. & George, F. & Gulati, S. (2020). Some Multiple Regression Models for the Number of COVID-19 Cases and Deaths in the United States. International Journal of Statistics and Probability.

In the first research "Regression Analysis of COVID-19 Spread in India and its Different States", linear and polynomial regression model has been used to investigate the COVID-19 outbreak in India and its

different states using time series epidemiological data up to 26th May 2020. Authors were analyzed number of deaths and recovered people by using simple linear regression. Also, the polynomial regression model is used to predict the number of patients in next three week. Both methods gives excellent and expected results in predicting COVID-19 in India and its Different States.

In the second research "Some multiple Regression Models for the Number of COVID-19 cases and deaths in the United States", epidemiological data are analyzed by using multiple linear regression model. Authors were analyzed number of COVID-19 cases by using more predictor variables. In this research, multiple linear regression models are here to identify the significant factors affecting the number of confirmed COVID-19 cases and the number of deaths per 100000 in the states of the US. Authors identified population density as the most influential factor in all the models.

In the following chapters, the theoretical part of the data mining technique, regression as well as its methods will be presented, on the basis of which the direction towards further research methodology has been developed.

3. DATA MINING TECHNIQUES

Data mining is the process of extracting out valid and unknown information from large databases and use it to make difficult decisions in business. Data mining or data analysis with complex and large datasets brings the wealth of research and knowledge in machine learning and statistics for the task of discovering new sets of knowledge in large databases. Over the past three decades, large amounts of difficult data's of business are stored electronically and this volume will continue to increase in future. In order to manage huge volumes of data, the techniques of data mining are also becoming sophisticated and advanced, day by day [1]. Fig. 1 shows the specific process of Data Mining, from the data itself, the selection of targeted data, processing them using some of the data mining techniques and presenting them according to a business template.

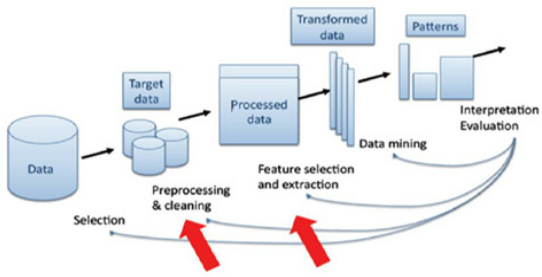

***Figure 1**. Data mining process [2]*

The difference between data analysis and research lies in the fact that data analysis is used to test statistical models and hypotheses on a set of data, e.g. (exempli gratia) when analyzing the effectiveness of a marketing campaign, regardless of the amount of data. In contrast, data research uses machine learning and statistical models to uncover secret or hidden patterns in large amounts of data [3]. It is important to emphasize that different data mining techniques are used for research, which can be seen in Fig. 2.

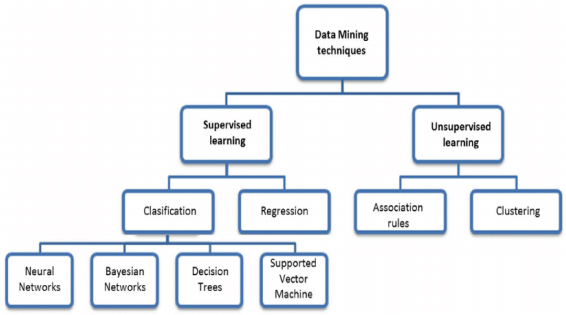

***Figure 2.** Data mining techniques [4]*

The Fig. 2 shows that Data mining techniques can be divided into supervised and unsupervised learning type. Supervised learning contains classification and regression. Unsupervised learning contains association rules and clustering.

In this research as it is mention before, regression methods will be used and the next chapter will describe technique and methods.

4. REGRESSION TECHNIQUE

Regression analysis is a collection of statistical techniques that serve as a basis for drawing conclusions on the relationships between interrelated variables. Since these techniques are applicable in almost all fields of study, including social, physical and biological sciences, business and engineering, regression analysis is now perhaps the most used of all methods of analysis data [5]. In order to determine whether and to what extent these phenomena are dependent, it is necessary make a regression model.

The regression technique contains a number of methods, on the basis of which the analysis and discussion of the achieved results over the data can be performed, and they are:

- Linear regression
  - Simple linear regression
  - Multiple (complex) linear regression
- Non-linear regression
- General linear model
  - Poisson model
  - Logistic model
- Log-linear models
- Regression tree and tree model

The following subchapters provide the theoretical basis for regression methods that will be used for further research.

4.1. Simple linear regression

The simplest form of regression is a simple linear regression containing one dependent and one independent variable, based on which a linear regression model can be created, which could be viewed as a line that minimizes the error rate between the actual prediction value and points on the line [6]. Most often, linear regression refers to a model in which the conditional mean value of Y, with a given value of X, is an affine function of X. The case with one independent variable is called simple, i.e. simple linear regression. When more than one independent variable is included, the process is called multiple (complex) linear regression [7].

The least squares method is a statistical way of evaluating regression analysis in order to predict a solution using a certain system that contains several unknown variables in a set of equations. The least squares method can be used to denote the reduction of the sum of the final solution, i.e. the squares that represent the residues made in the results of each equation [8].

4.2. Multiple linear regression

Ordinary least square method which is widely used in case of simple regression is also most widely used in case of predicting the value of dependent variable from the values of two or more independent variables. Regression equation in which dependent variable is estimated by using two or more independent variables is known as multiple regression [9].

In developing a multiple regression equation, one needs to know the efficiency in estimating the dependent variable on the basis of the identified independent variables in the model. The efficiency of estimation is measured by the coefficient of determination (R2) which is the square of multiple correlation. The coefficient of determination explains the percentage of variance in the dependent variable by the identified independent variables in the model. The multiple correlation explains the relationship between the group of independent variables and dependent variable. Thus, high multiple correlation ensures greater accuracy in estimating the value of dependent variable on the basis of independent variables. Usually multiple correlation, R is computed during regression analysis to indicate the validity of regression model. It is necessary to show the value of R2 along with regression equation for having an idea about the efficiency in prediction [9].

4.3. Nonlinear regression

In statistics, nonlinear regression is a form of regression analysis in which experimental data are modeled by a function that is a nonlinear combination of model parameters, and depends on one or more independent variables. Data were processed by the method of successive approximations. The data consists of independent variables that do not contain errors (explanatory variables), k, and related experimental dependent variables (responsive variables) y. Each value of y is modeled as a random variable with the average given in the form of a nonlinear function f (k, β). Systematic errors may be present, but their treatment is beyond the scope of regression analysis. If the independent variables contain errors, variable error models can be used [10].

5. RESEARCH METHODOLOGY

This research methodology at first starts by choosing tool for analyzing the data. After choosing the tool, it has to get the data from valid resource. After getting data, data need to be preformatted in model that is common for regression analysis. In the next chapters, it will be presented whole methodology implementation.

5.1. NCSS Data Analysis Tool

"NCSS" is a statistical package produced and distributed by NCSS, a limited liability company. It was created in 1981 by Jerry L. Hintze, as NCSS, a limited liability company, specializing in providing software services in the form of statistical analysis intended for researchers, companies and academic institutions [11]. After the tool is installed, it is necessary to download the data for analysis.

5.2. Data collected for analysis

Data for analysis were collected from the open data portal, which is provided by the Government of the Republic of Serbia. The selection of data for analysis refers to the daily report on the epidemiological situation for Covid 19 in the Republic of Serbia, which can be seen in Fig. 3.

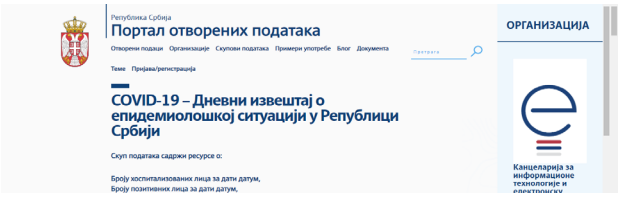

***Figure 3**. Open Data Portal – Covid 19 – Daily report of the epidemiological situation in the Republic of Serbia [12]*

5.3. Preprocessing and data transformation

After successfully collecting the data in .xlsx format, the next step is related to data preprocessing and transformation.

Data preprocessing is one of the most important tasks of Data Mining and involves the preparation and transformation of data into an appropriate template, which is suitable for research methods. The preprocessing activity strives to reduce the amount of data, find connections between data, normalize, as well as eliminate surpluses and extract new data. The process itself involves several techniques such as [13]:

- cleaning,
- integrations,
- transformations and
- removal of redundant data.

The downloaded data set must correspond to a template that is suitable for research in order to be able to apply the appropriate method, in this case the regression method. The original data set contained a large number of rows, then columns that did not fit the appropriate analytical template, as well as empty cells that had to be formatted in a way that ensures accuracy in data analysis. The original data set can be seen in Fig. 4.

Sifra	IDTeritorije	Dan	Mesec	Godina	Vrednost	Opis
COVID19k	RS	6	3	2020	0	BROJ_LICA_NA_RESPIRATORU_ZA_DATI_DATUM
COVID19k	RS	6	3	2020	1	BROJ_HOSPITALIZOVANIH_LICA_ZA_DATI_DATUM
COVID19k	RS	6	3	2020	1	BROJ_POZITIVNIH_LICA_ZA_DATI_DATUM

***Figure 4**. Original data set*

Fig. 5 clearly shows the repetition of the number of rows caused by the last column, which is a description of different categories of the epidemiological situation. Also, the penultimate two columns can be seen to be unfilled, i.e. not assigned values, where such a set of data later gives incorrect forecasts. In order to reduce the number of rows in the data set, it is necessary to create separate columns for the values from the description column.

By creating new columns, the number of rows will be reduced, because when entering data for a given date, only one row will be needed for all the listed columns. Numeric values have been added to the blank fields to reduce the possibility of computational problems. Also, separate columns are created, which enable better results, because they leave the possibility of analyzing data according to several dependent and independent variables (x and y). In this way, a successful transformation of the data itself was performed, which can be seen in Fig. 5.

Sifra	IDTeritorije	Dan	Mesec	Godina	BROJ LICA NA RESPIRATORU ZA DATI DATUM	BROJ HOSPITALIZOVANIH LICA ZA DATI DATUM	BROJ POZITIVNIH LICA ZA DATI DATUM
COVID19k	RS	6	3	2020	0	1	1
COVID19k	RS	7	3	2020	0	1	0
COVID19k	RS	8	3	2020	0	1	0

***Figure 5**. Data for analysis after transformation*

Data transformation of data favors analysis using regression methods, because the data are adapted to the appropriate template. The further course of data transformation would be reflected in the logical division of data, by column of the year, where two separate sets of data for 2020. and 2021. are created on the basis of the division.

In the next chapter, after successfully installed software, collected, pre-processed and transformed data from the open data portal, the analysis and discussion based on the achieved results using certain regression methods is approached.

6. RESULTS AND DISCUSSION

The following subsections will present the results and discussion using the above regression methods on the collected data.

6.1. Results and discussion using simple linear regression

Based on the imported data as well as the applied filters, a simple linear regression is applied by selecting the option Analysis, Regression, Simple Linear Regression. In order to perform a simple linear regression, it is necessary to choose one dependent and one independent variable, i.e. x and y.

For the analysis of results in 2020. and 2021., the following were selected:

- For x (independent variable) - months of the year
- For y (dependent variable) - number of people on respirator

Based on the data for 2020., i.e. defined columns for x and y, using simple linear regression, a graphical representation was created showing the flow of the number of persons on the respirator in relation to the months of the year, which can be seen in Fig. 6.

It can be clearly seen that simple linear regression predicts an increase in the number of people on respirators, starting from the beginning of the pandemic in March until December 2020.

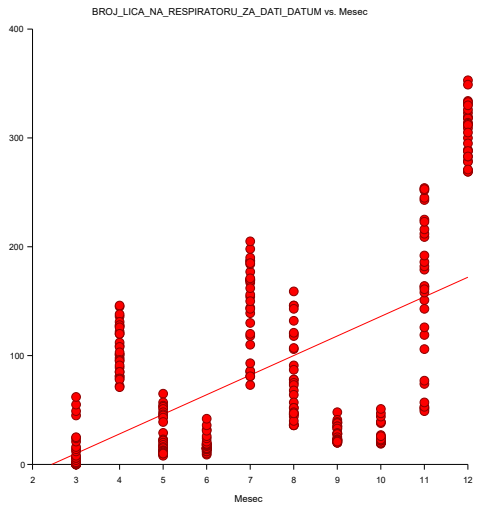

***Figure 6**. The result of the analysis was achieved by applying a simple linear regression for 2020.*

After analyzing the data for 2020, we proceed to further analysis for 2021, i.e. defined columns for x and y, using simple linear regression, based on which a graphical representation is created showing

the flow of persons on the respirator in relation to the months of the year, which can be seen in Fig. 7. From the graph it can be clearly seen that a simple linear regression predicts a decrease in the number of people on the respirator, starting from January until June 2021.

The result of the reduction in the number of people on respirators can be linked to clearly defined measures in the fight against Covid 19 virus issued by the Government of the Republic of Serbia, as well as voluntary vaccination conducted in early 2021.

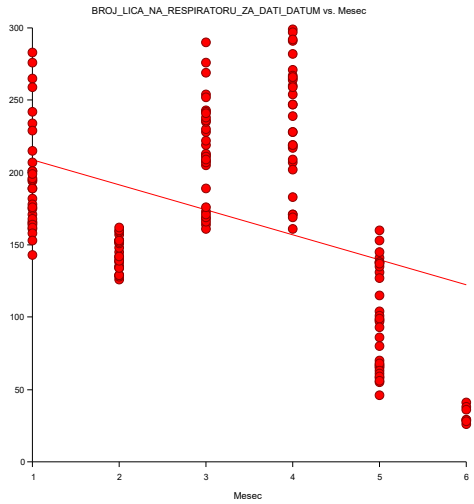

***Figure 7**. The result of the analysis was achieved by applying a simple linear regression for 2021.*

6.2. Result and discussion using multiple (complex) linear regression

Based on the imported data as well as the applied filters, multiple (linear) regression is applied by selecting the option Analysis, Regression, Multiple Linear Regression. In order to perform multiple linear regression, it is necessary to choose one dependent and one independent variable, i.e. x and y. For the analysis of results in 2020. and 2021., the following were selected:

- For x (independent variables) - number of persons on respirator, number of hospitalized persons, number of positive persons, number of tested persons as well as number of deceased persons for a given date
- For y (dependent variable) - month of the year

Based on the data for 2020., i.e. defined columns for x and y, using multiple (complex) linear regression, a graphical representation was created showing the flow of the above parameters in relation to the months of the year, which can be seen in Fig. 8. the graph clearly shows that multiple (complex) linear regression predicts a general increase in all independent variables starting from x_1 to x_5, relative to the dependent variable y, starting from the beginning of the pandemic, more precisely from March until December 2020.

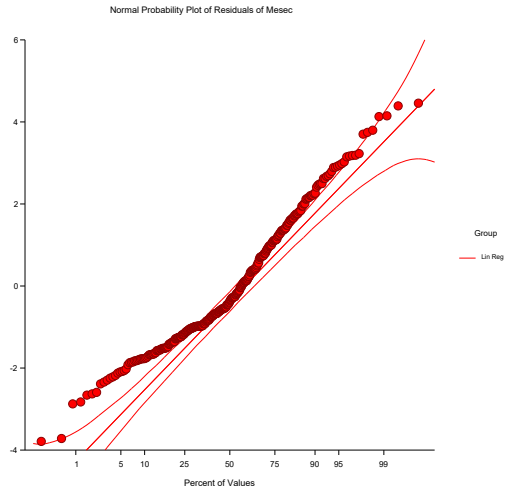

***Figure 8**. The result of the analysis was achieved by applying multiple (complex) linear regression for 2020.*

Also, from the descriptive analysis itself, it can be concluded that the variable related to the number of tested persons for a given date has the greatest significance in the prediction by applying multiple (complex) linear regression. This result shows that the prediction largely depends on the number of tested persons, because based on that number there is a possibility for a better and more accurate forecast of the further course of the pandemic, which can be seen in Fig. 9.

Descriptive Statistics

Variable	Count	Mean	Standard Deviation	Minimum	Maximum
BROJ_LICA_NA_RESPIRATORU_ZA_DATI_DATUM	300	92,74333	93,65487	0	353
BROJ_HOSPITALIZOVANIH_LICA_ZA_DATI_DATUM	300	2506,58	2757,302	1	9731
BROJ_POZITIVNIH_LICA_ZA_DATI_DATUM	300	1126,027	2060,797	0	7999
BROJ_TESTIRANIH_LICA_ZA_DATI_DATUM	300	7652,723	5223,326	3	22837
BROJ_PREMINULIH_LICA_ZA_DATI_DATUM	300	10,68	16,82144	0	69
Mesec	300	7,59	2,835849	3	12

***Figure 9**. Descriptive statistics achieved by applying multiple (complex) linear regression for 2020.*

After analyzing the data for 2020., we proceed to further analysis for 2021., i.e. defined columns for x and y, using multiple (complex) linear regression, based on which a graph is created showing the flow above the above parameters in relation to the months in years, which can be seen in Fig. 10.

From the graph it can be clearly seen that multiple (complex) linear regression predicts general stagnation and a slight decrease in all independent variables starting from x_1 to x_5, relative to the dependent variable y, in the time interval of January until June 2021.

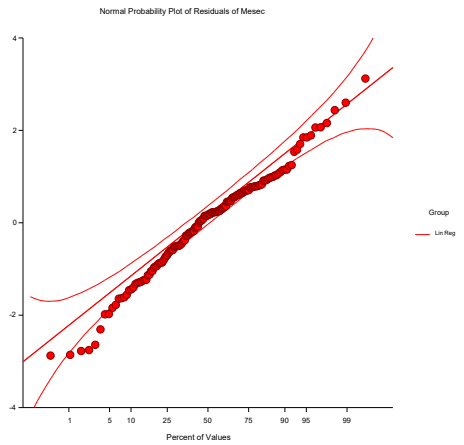

***Figure 10**. The result of the analysis was achieved by applying multiple (complex) linear regression for 2021.*

Also, from the descriptive analysis itself, it can be concluded that the variable related to the number of tested persons for a given date has the greatest significance in the prediction by applying multiple (complex) linear regression. This result shows that the prediction largely depends on the number of tested persons, because based on that number there is a possibility for a better and more accurate forecast of the further course of the pandemic, which can be seen in Fig. 11.

Descriptive Statistics

Variable	Count	Mean	Standard Deviation	Minimum	Maximum
BROJ_LICA_NA_RESPIRATORU_ZA_DATI_DATUM	156	172,6667	66,34653	26	299
BROJ_HOSPITALIZOVANIH_LICA_ZA_DATI_DATUM	156	4682,539	1978,808	531	9329
BROJ_POZITIVNIH_LICA_ZA_DATI_DATUM	156	2382,039	1459,834	116	5475
BROJ_TESTIRANIH_LICA_ZA_DATI_DATUM	156	12169,24	2993,381	5550	18528
BROJ_PREMINULIH_LICA_ZA_DATI_DATUM	156	23,65385	9,904482	7	42
Mesec	156	3,128205	1,518564	1	6

***Figure 11**. Descriptive statistics achieved by applying multiple (complex) linear regression for 2021.*

6.3. Result and discussion using nonlinear regression

Based on the imported data as well as the applied filters, nonlinear regression is applied by selecting the option Analysis, Regression, Nonlinear Regression. In order to perform nonlinear regression, it is necessary to choose one dependent variable y and one independent variable x that fits into the nonlinear expression of the function A + B * X, where A and B represent the set of all positive and negative numbers.

For the analysis of results in 2020. and 2021., the following were selected:

- For x (independent variable) - number of deaths for a given date
- For y (dependent variable) - month of the year

Based on the data for 2020., i.e. defined columns for x and y, using nonlinear regression, a graphical representation was created showing the flow of deaths in relation to the months of the year, which can be seen in Fig. 12. The graph clearly shows that nonlinear regression predicts an increase in deaths with over 90% certainty, up to 40 people per day, if the same growth trend continues until the end of 2020.

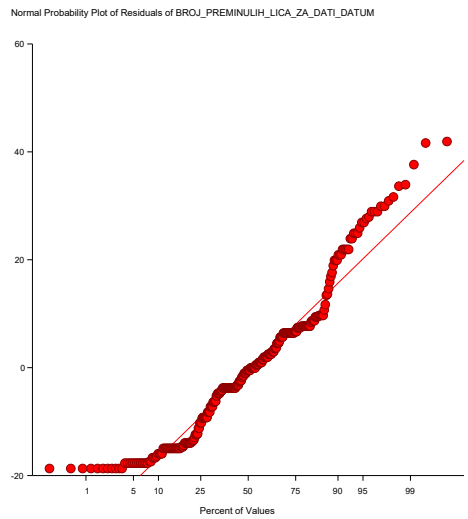

***Figure 12.** The result of the analysis achieved by applying nonlinear regression for 2020.*

Based on the data for 2021., i.e. defined columns for x and y, using nonlinear regression, a graphical representation was created showing the flow of deaths in relation to the months of the year, which can be seen in Fig. 13. From the graph it is clear see that nonlinear regression predicts a slight increase in deaths with a certainty of over 90%, in values of up to 20 people per day, if the same growth trend continues until the end of 2021. The reduced number of deaths can also be related to the fact that the Government of the Republic of Serbia has issued measures and a vaccination plan to reduce the spread of Covid 19, which will cause fewer deaths in the future.

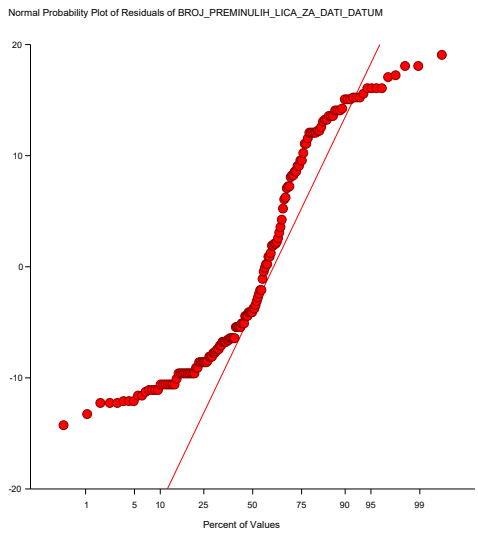

***Figure 13**. The result of the analysis achieved by applying nonlinear regression for 2021.*

7. CONCLUSION

The result of this research is the analysis of data using regression methods with the NCSS software tool, in order to collect and predict significant information related to the current epidemiological situation in the Republic of Serbia regarding the Covid virus 19.

In comparison with other related research, presented in this paper, the research results of this paper are partially similar, but there are also certain differences in which the scientific contribution itself is reflected. When it comes to linear regression, it is basically the same for all cases and the only difference would be that in this paper the data set on which the analysis was performed was wider over time and thus got a broader picture of further forecasts of virus development. When it comes to multiple linear regression, related research gives the impression that the parameters for analysis were chosen randomly, while in this paper it was taken into account that the parameters (predictor variables) are strictly correlated to make the accuracy of the multiple linear model much better. By selecting the best correlated predictor variables, the accuracy of the multiple linear model is achieved. Also, this research has a nonlinear regression model that can be identified with a polynomial regression model. In related research, the polynomial regression model was applied for a significantly shorter period of time, while in this paper, the time period of the data set is significantly longer and more objective for the forecast.

The data mining technique of regression, with its set of methods, enabled the timely prediction of trends in the further course of the development of the epidemiological situation in the Republic of Serbia. The research itself showed that the trend of the epidemic is decreasing, i.e. that preventive measures as well as the process of vaccination and revaccination have had an effect in the fight against the Covid 19 virus.

Further development of the research would be reflected in the continuation of monitoring the current epidemiological situation, and continuous data collection and comparison with the previous one, in order to predict for a certain period of time which segments of information are crucial for health in the Republic of Serbia.

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The role of Digital Twin technology in transforming engineering education

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Abstract: *Higher education institutions (HEIs) have acknowledged the significance of digital transformation in the educational environment, especially during the COVID-19 pandemic. The adoption of new technologies has enabled HEIs to change their education, research, and business models. The goal of digital transformation in HEIs is to create new, advanced, and efficient techniques and practices to further the mission of higher education. Digital Twin (DT), one of the most promising new technologies at the moment, has the ability to give engineering students learning opportunities that go beyond the confines of the classroom. This paper, with a focus on engineering education, aims to understand the underlying concept of DT technology and to emphasize the benefits that may be gained through its use in engineering education as well as the challenges associated with its adoption in HEIs.*

Keywords: *Digital Twin; engineering; education; benefits; challenges*

1. INTRODUCTION

The COVID-19 pandemic has brought attention to the importance of integrating digital technologies into education and speeding up the adoption of digital transformation in education. The process of digital transformation ultimately involves a change in the paradigm of education, altering how people think, behave, and interact with one another and the outside world [1]. In other words, significant elements of Higher education institutions (HEIs) management, engagement, education, and research operations are transforming as a result of the digital transformation. The entire educational system must adapt and change in order to benefit from new technologies and tools, as well as to create plans of action and play a proactive part in the digital transformation process [2]. Higher education is predicted to undergo reforms thanks to digital learning technologies. According to the European Commission's (EC) most recent Digital Education Action Plan (2021–2027) [3], digital education should enable more individualized, adaptable, and student-centered teaching.

Educational institutions worldwide are increasingly implementing digital transformation to make sure that the student's learning is supported by digital tools. Students, teachers, and companies can all obtain new knowledge thanks to the use of new digital technologies. One of the fundamental pillars of the digital transformation process is the Digital Twin (DT) technology. It enables the creation of a digital counterpart of a physical entity, whose behavior can be observed in real-time, resulting in enhanced productivity and efficiency [4]. Increased sensor ubiquity, product connectivity, processing power, and data storage all contribute to the viability of this idea. As a result, numerous analyses on the DT are possible, which can shed light on the real one and prompt corrective action. In this way, DT is a brand-new educational tool since it allows students to study a digital version of something rather than the actual object.

Every academic discipline, including engineering, has the ability to use DT to vastly improve the learning experience. When used properly, DT technology can improve learning and boost students' motivation to study and take responsibility for their education. This may have a significant effect on students' career opportunities [5].

This paper presents an attempt to summarize the role of DT technology in engineering education and to highlight all the advancements and challenges related to its implementation in HEIs. Therefore, the rest of this paper is organized as follows. After the introduction, the second section gives a summary of the current state of engineering education and predictions for the future. The third section presents the concept of DT technology. The use of DT technology in engineering education and related benefits and challenges are presented in the fourth section. The last section concludes the paper.

2. ENGINEERING EDUCATION FOR TODAY AND TOMORROW

The exponential growth of knowledge and innovation in science, engineering, and technology during the Fourth Industrial Revolution (Industry 4.0) era highlights the necessity of revolutionizing the educational system. The needs of today's digital, varied, global, constantly changing, and quickly evolving society must be addressed in engineering education. Engineering as a discipline will be significantly impacted by the numerous issues that the digital era will present. According to [6], most of the engineering education challenges are related to sustainability (a crucial topic in engineering education), industry demands, and digitalization. Engineering profiles will change as a result of the environment in which engineering tasks are carried out and the equipment and tools employed to do these tasks. In other words, the expected role of engineers will change as automation and digitalization spread, and the engineering profile will transform to meet the demands of the skills and competencies needed for new-generation engineering positions [7]. In addition to applying science to solve problems, engineering involves improving knowledge through study and experimentation. Along with learning how to acquire and apply their theoretical knowledge to real-world issues, engineering students must also learn to be independent, autonomous, and critical thinkers. Systems thinking, interdisciplinary thinking, creative thinking, cross-cultural communication and collaboration, and a global mindset are skills that engineers of the 21st Century must possess [8]. The success of engineering students depends not just on what they know but also on how they use advanced engineering technologies. Demonstrating technical competence is a requirement and possibly the most crucial component for all engineering students. Engineers with employability skills and quick learning and adapting abilities are needed by the industry [6]. All of these urges for the modernization of educational systems through the use of advanced technologies, the adoption of innovative teaching and learning methods in engineering education, as well as the updating of course materials in light of the digital transformation [7].

There is no doubt that engineering education will be rethought and redesigned as a result of the digital transformation trends (Fig 1.). The learning and teaching processes need to be designed and delivered in a more digitized manner. Understanding the three components of engineering learning will make it easier to decide how to support and assess a student's academic development (Fig. 2) [9]. To improve education, it is necessary to constantly revise and update course curricula, and create sophisticated, adaptive learning systems that connect students' evolving learning demands with cutting-edge practices, tools, and technologies [1, 7].

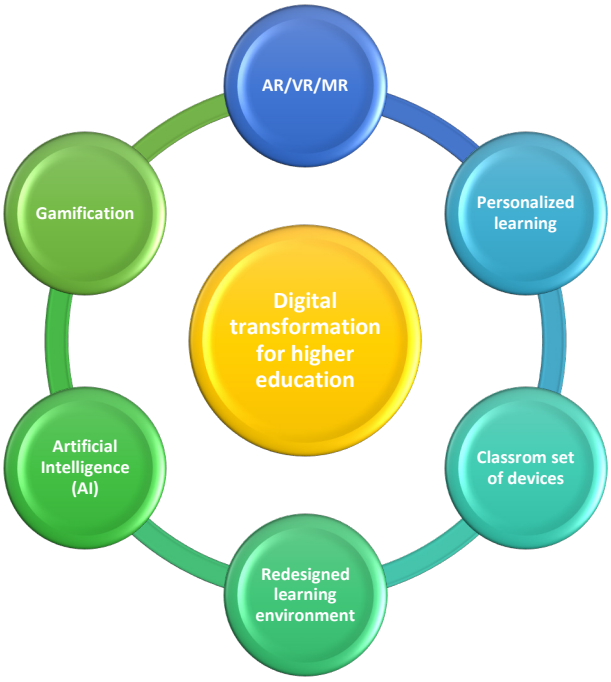
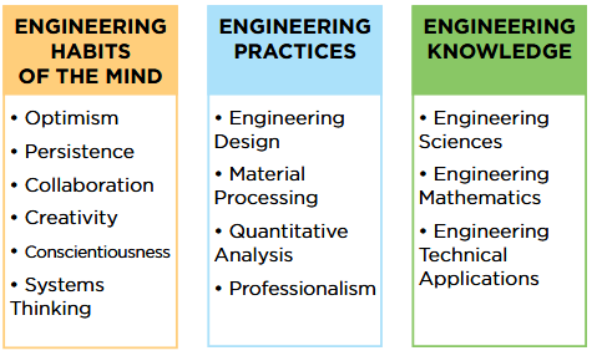


Figure 1. *Top six digital transformation trends in higher education*



In order to address the numerous issues related to engineering education, student-centered learning, contextual and practice experiences, and digital tools must be implemented [6]. This will result in increased efficiency and efficacy of engineering education, hence bridging the gap between academic engineering skills and the digital competencies needed in the industry [7].

Future engineers must be well-prepared with a wide variety of skills and competencies to be able to deal with the myriad problems that the digital era will bring. They should be self-motivated, responsible, and capable of contributing to the development of innovative approaches to the engineering and societal problems of the 21st Century [8]. The current engineering education system must be improved, and this is feasible only through the creation of new teaching and learning strategies.

3. DIGITAL TWIN (DT) TECHNOLOGY

A virtual, real-time depiction of a physical product or process is essentially what the term "digital twin" refers to. With advancements in machine learning, virtual reality (VR), augmented reality (AR), mixed reality (MR), Geographic Information System (GIS), and other technologies, DT technology is now able to duplicate and monitor real-world processes and objects, as well as more precisely forecast the results of certain scenarios [10-12]. DT incorporates both the physical structure and the dynamics of the system and is used by engineers to evaluate the behavior of already-built devices or complex systems under particular circumstances. In order to gain helpful data that can be applied to the actual physical equipment, the virtual model can be used to perform simulations, look into performance issues, and come up with potential improvements. DT is already in use across a range of application domains (i.e., manufacturing, construction, healthcare, meteorology, agriculture, education, transportation, aerospace, energy sector, etc.) [13], where it is becoming an increasingly important and informative tool.
The physical entity, virtual model, and their relationship are the three essential parts of the DT architecture [11]. DT is divided into three subcategories [14, 15]:

- Digital Model - digital representations of already-existing or future real items, without automatic exchange of data.
- Digital Shadow - one-way automated data flow that connects physical and digital objects that already exist is presented.
- Digital Twin - data is exchanged between completely integrated physical and digital items.

Data need to flow seamlessly and in both directions between a system's physical and digital realms, and a DT can automatically share data with its physical twin or can be modified by it. As a result, the DT can be thought of as the real system's controller. The physical entity must be mimicked by a DT, which must also be flexible and parameterizable [16]. DT and simulations are similar, although they differ greatly. Both use digital models to simulate a system's multiple operations, but DT is essentially a virtual world that can run as many practical simulations as necessary to analyze different processes, whereas a simulation frequently only focuses on one particular activity. Another distinction is that real-time data is frequently not helpful for simulations, while DT relies on a two-way information flow [17]. Compared to traditional simulations, DT enables the study of more topics from a greater variety of perspectives.

Fig. 3 demonstrates how to create a DT utilizing a number of supporting technologies. In other words, DT enables visualization of the situation based on data collected from a variety of sensors and devices, evaluation of the collected data using intelligent software, and, if a problem exists, searching for multiple potential solutions as well as choosing smart algorithms and implementing the most appropriate solution.

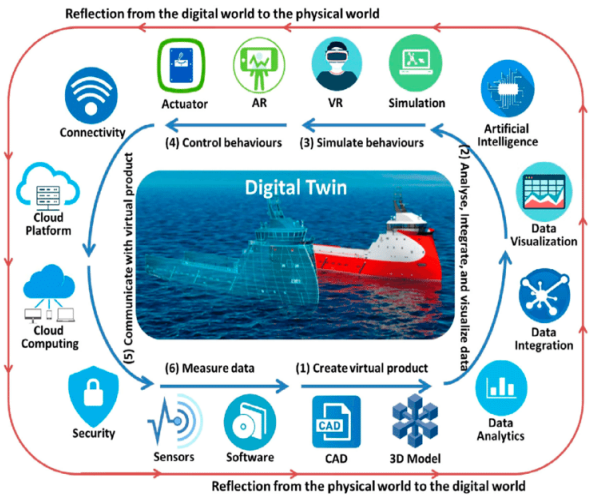


Figure 3. *The DT's enabling technologies [18]*

Implementing a DT is a labor-intensive process that requires a variety of tools and technology to function together. The following categories can be used to group the technologies that enable the creation of DT: [11, 12]:

- Technologies for physical objects,
- Technologies for data construction and management,
- Technologies for virtual modeling,
- Services technologies,
- Connection and data transmission technologies, and
- Environment coupling technologies.

DT should precisely mirror the physical entity in terms of geometry, properties, behaviors, and rules on a variety of scales or levels, and should alter at the same rate as the physical entity [19].

4. DT TECHNOLOGY IN ENGINEERING EDUCATION

Nowadays, the usage of DT technology in education is starting. The goal of DT adoption in engineering education is to advance engineering knowledge. Currently, there are a lot of ongoing projects that are intended to provide engineering learning platforms based on the DT of any system, product, or process of interest for a particular course. DT technology can be applied in the classroom to present, explore, and explain a system's structure and intended function. In the laboratory, a DT can be utilized to investigate the system's behavior and constraints under various simulated what-if scenarios, comprehend failure mechanisms, and grasp how sensitive a system is to changes in various system parameters and outside disruptions. Because system behavior may be changed more easily in a virtual representation

than in its real counterpart, students learn and understand it more quickly in a controlled, safer, and simulation-driven environment. Since they must imagine a significant portion of the envisioned system when creating simulations, students acquire valuable systems thinking skills and a learning experience [20].

Some of the examples of DT technology's inclusion in engineering education are present in [5, 16, 20-25]. In [5], the authors have chosen a Simulation in a control system design course for utilizing and studying DT technology, while [21] presents the Electric Power Drive System Diagnostics as an example of DT technology's implementation in the electrical engineers' educational process. Authors of [22] have studied the potential for DT adoption in marine technology study where they presented DT adoption within courses in mechanical engineering, hydrodynamics, and other relevant fields. Building useful DT civil engineering courses was the goal of research performed in [24]. In [25] it is stated that it is possible to generate a digital copy of a student (Fig. 4) utilizing information about their behavior, academic background, habits, and used digital learning resources. A student's DT includes this kind of information, which can be automatically gathered by a variety of technologies or manually added by the student.

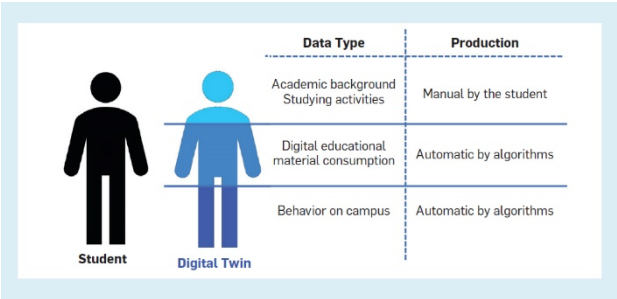


Figure 4. *The student's DT [25]*

4.1. Benefits of DT implementation in engineering education

By making it easier for engineering students to access current research topics, the main goal of DT technology adoption in education is to improve their learning results. The gap between theory and practice will thus be smaller.

The main benefits of DT technology, which can be also related to DT implementation in engineering education, can be summarized in [13, 19]:

- Reducing costs and waste: The physical equipment is costly, and many HEIs lack the resources to purchase it. DT technology enables the creation of virtual laboratories that can be used within different engineering courses. Because DTs are mostly developed using virtual resources, the prototyping is cheaper, material waste is reduced, the variety and quantity of devices can be easily changed, and testing in a variety of test settings, including destructive ones can be easily performed and without any additional costs. All of these help to create a future that is more sustainable.
- Shorter production times and more efficient product re-designing: DT can be used at various points throughout the product design process, shortening design and analysis cycles and enhancing the speed and effectiveness of prototyping and product re-design. Students benefit from this in terms of gaining learning experience and developing important systems thinking skills.
- System planning and problem prediction: DT can be used to identify problems and failures at different stages of a product's lifecycle, especially of a product that has a complex structure or is made of various materials. It is far simpler, less expensive, and faster for the students to diagnose potential equipment problems or misbehavior, as well as to fix the faults.
- Optimizing solutions and better maintenance: DT can enable the prediction of damage and defects at various stages of the product's lifecycle, which enables considerably earlier detection of system faults. This contributes to more precise predictive maintenance planning and continuous validation and enhancement of the system's process.
- More specialized products and services: To quickly respond to market trends and stakeholder preferences, more individualized products, and services can be quickly developed with the use of DT.
- Accessibility: It's often difficult, if not impossible, to get a detailed, real-time perspective of a large physical system. Making virtual copies improves system accessibility, allows for remote performance monitoring and modification, and allows for the quick detection and resolution of any problems. DT technology makes it possible for students to enroll in online courses and training programs, access learning resources, design different scenarios for the usage of real devices, perform simulations for accomplishing pre-determined laboratory tasks and study from any location. In situations like the COVID 19 pandemic, this is of immense importance.
- Safer than physical counterpart: DT can be used to create more effective, illustrative, and safe courses than traditional ones. Because DT can access its physical counterpart remotely and is predictive in nature, it can help to reduce the risk of

failures. Also, DT enables the introduction of the failures and dangerous malfunctions that can be found in real life, making it safe for students that work with the virtual replicas of systems. Students can practice how to schedule necessary maintenance in advance based on identified or projected failures. Hence, one of the major benefits of DT is that there is no risk of real device destruction as a result of improper or careless handling, which is a very real possibility during laboratory exercises.

- Personalized learning, increased motivation, and better learning experience: The main advantages of DT technology are the growth of expertise, interactive, customized, and easier learning, as well as increased interest in studying. The growth of DT technology-related skills is the obvious advantage. Both professors and students learn new things, and the enhanced enthusiasm for learning and DT technology-related abilities that students acquire have the potential to assist students to find work and succeed in their potential vocations [5].
- Teamwork: Teamwork is an important source of creativity, innovation, and change. DT ensures that all parties involved in the learning process are included and working together even if they are not physically present in the physical system. Hence, DT has the potential to support students' learning, interaction, and collaboration with others. Joint decisions foster greater commitment and a shared understanding of what must be accomplished [4, 26].

4.2. Challenges related to DT adoption in engineering education

In addition to the many advantages DT brings to engineering education, there are many challenges related to DT adoption in the educational sector [19, 27, 28]:

- Information technology (IT) infrastructure: Potential IT issues could be a barrier to DT technology adoption in education. Due to the complexity of DT tools and software, it is crucial to have resources and a well-designed and scalable IT infrastructure. It is important to have fast, reliable, and available connectivity, maintain software updated and be ready for any problems that might arise [5].
- Useful data: The accuracy of the virtual representation of the physical object increases with the amount of data available. Hence, the adoption of DT requires the collection and management of a large amount of heterogeneous data (i.e., product data, system data, environmental data, network-, hardware-, and software-related data, historical data, real-world data, virtual-world data, etc.). Finding the patterns and extracting useful information from these data is crucial for performing the tasks of interest (i.e., system planning, solution optimization, system process enhancement, correcting faults, etc.).
- Privacy and security: Any HEIs can gain a lot from DT technology, but only if privacy and security are adequately addressed. In other words, systems, assets, and data must be effectively protected for DT technology adoption in education to be beneficial.
- Trust: The adoption of DT in education will depend on building trust. The main concern is whether the data from a DT can be relied upon. HEIs can only use a DT to its full potential if they are confident that it will perform as expected.
- Expectations: Despite the fact that the usage of DT in education is expanding, more understanding of the concept and prudence on the expectations related to DT implementation are still needed. If an HEI has a well-designed and scalable IT infrastructure and a better understanding of the data necessary to execute analytics, it is expected that it will adopt DT technology. Today's higher education students are accustomed to using digital technology in their daily lives and will increasingly demand educational approaches that make the most of the opportunities provided by digital learning tools [29].
- Standardization and regulations: Since modeling is essential for the practical application of DT, it is necessary to follow a consistent process from the initial design stage to the simulation of the DT. Standardization of modeling, interfaces, protocols, and data is essential.
- Teaching skills and teaching content: Teachers may not always have fast answers to all of the issues as a result of working with new technology and using it in this manner [5]. Therefore, insufficient teacher skills are one of the main obstacles to incorporating DT technology into engineering education. As technology is advancing quickly, continuing education and course curriculum updates are required.

5. CONCLUSION

We have witnessed significant technical advancements during the past 20 years, including

new and disruptive developments in hardware and software. These modifications are resulting in the phenomenon known as digital transformation. HEIs all around the world have recently gone through rapid, significant changes that are a result of digital transformation. New educational strategies and tools must be introduced and put into practice in order to adequately educate students for today and the future. Therefore, HEIs have led various programs to investigate novel digital technologies to improve students' learning experiences. The digitalization of education is just one of the many factors that have an impact on education globally. During the COVID-19 pandemic, the pace of reform in the educational system has had to accelerate.

In this new digital era, engineering graduates must be able to move from technology to solutions and from those solutions to operations. Future electrical engineers will have to deal with a rise in IT-related issues that involve fault diagnostics and predictive maintenance. Wide-ranging skills are needed for this.

Knowing that learning is a laborious process, and that physical equipment is expensive, DT adoption in education gives a lot of flexibility and opportunities to improve field competencies. The aim of this paper is to highlight all the benefits and challenges associated with DT technology's implementation in HEIs. As has already been mentioned, DT has numerous advantages such as simple experiment or training preparation (hardware installation or testing is not necessary), real-time monitoring, control, and data collection support for informed decision-making, predictive maintenance and efficient scheduling, enhanced efficiency, improved risk analysis, safer work, contribution to the fulfillment of sustainability goals, increased accessibility, personalized learning and the ability to adapt and extend based on the course objective, etc. On the other hand, implementing a DT takes time, necessitates a certain level of expertise, and requires a variety of tools and technologies that must work together. Another drawback is the high price of software licenses but in general, the overall costs are reduced. DT should be created with some caution, but due to its many benefits, it becomes an essential tool in today's technological and academic environment.

The development of DT technology is anticipated to have a significant impact on engineering education. This is the reason why engineering education has embraced DT technology. With the use of DT technology, engineering classrooms will enable students "learn by doing" approaches. The students will be able to resolve the complex diagnostics problems thanks to these and play a crucial role in converting academic knowledge into real-world applications, keeping up with the rapidly and continually changing environment.

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Providing dynamic adaptivity in Moodle LMS according to Felder-Silverman model of learning styles

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Abstract: *E-learning as a difficult structure contains distance learning, teaching resources in many forms and shapes, group and individual learning procedures, as well as interactive and tuition work. In order to increase the use and efficiency of e-learning systems, it is necessary to consider the individualities of students and their learning styles. Based on data collected in various ways, research methods Felder-Silverman Index of Learning Style Questionary (ILS), using the Moodle LMS, based on the subjective valuation of teachers, as well as based on data from the corporate information system, the affinities of students are determined. Then, based on this information, an adaptation is made, a process that adjusts the work of the LMS based on the learning styles of the students. The major goals that can be achieved by dynamic adaptation the e-learning system are to improve the appearance and effectiveness of the course, support in finding information about the subject, more efficient search and placement of search results in terms of student's interest, and rise students faithfulness to the educational institution.*

Keywords: *e-Learning, ILS Questionary, Learning Style, Moodle LMS, Dynamic Adaptation.*

1. INTRODUCTION

Computer-based learning has become commonplace in the modern age. Many distance learning systems distribute educational resources on the Internet and indeed entire study programs are now widely available on the Internet. Such a large amount of content and information can be intimidating for students, who may exhibit a variety of individual characteristics, such as variations in goals, interests, motivation, and / or learning preferences. This suggests that a uniform learning environment approach to delivering materials and resources to students is not appropriate and that personalizing such materials / resources should address student differences to provide a tailored learning experience, increasing its efficiency by reducing dropout rates and maintaining high student motivation [1], [2].

Over the last 2-3 decades, e-learning software systems have become the main means of achieving various goals, mostly related to supporting or even completing the learning process. Their use is already a good practice in almost all areas of education and business. They are not limited to supporting educational institutions and corporate structures, but also small and medium-sized enterprises and individuals [3], [4].

Adaptive tools built into software systems for e-learning are the main methods for achieving effective results of the offered education, i.e. providing maximum assimilation of necessary skills by students, achieving it in less time, offering an environment for lecturers to create courses, manage the whole process, etc. [5].

The development of scientific and technological progress and the processes of globalization and the removal of obstacles to the international exchange of information enable the provision of various services in education, as well as access to them. The main goal for autonomous increase of the e-learning effect is achieved by using adaptive tools. On the other hand, existing e-learning software systems offer general functionality and a small number of specific adaptive tools [6].

This paper examines the creation of a dynamic adaptive e-learning system at Moodle LMS, paying special attention to the preferred learning styles of students in accordance with Felder-Silverman model of learning styles (FSMLS).

2. FELDER-SILVERMAN MODEL OF LEARNING STYLES

In Felder-Silverman model of learning styles, students are characterized by values in four dimensions. These dimensions are based on the main dimensions in the field of learning styles and can be viewed independently of each other. They show how students prefer to process (Active-Reflective), perceive (Sensory-Intuitive), receive (Verbal-Visual) and understand information (Sequential-Global). Although these dimensions are not new in the field of learning styles, the way they describe the student's learning style can be seen as new [7].

While most learning style models, which include two or more dimensions, derive statistically predominant types of students from these dimensions, Felder and Silverman describe learning styles using scales from -11 to 11 for each dimension (including only odd values). Therefore, each student's learning style is characterized by four values between -11 and 11, one for each dimension. These scales facilitate a more detailed description of learning style preferences, while building student types does not allow for differentiation of preference strengths. In addition, the use of scales allows the expression of balanced preferences, which indicates that the student does not have special preferences for one of the two poles of the dimension. Moreover, Felder and Silverman consider the resulting tendencies to be tendencies, meaning that even a student with strong preferences for a particular learning style may sometimes act differently [7], [8].

The active-reflective dimension is analogous to the corresponding dimension in Kolb's model [9]. Active students learn best by actively working with learning materials, applying materials, and trying things out. Moreover, they are more interested in communicating with others and prefer to learn by working in groups where they can discuss the material learned. They often use various forums to study new information. In contrast, reflective students prefer to think about the material and think about it. When it comes to communication, they prefer to work alone or in a small group.

The Sensory-Intuitive dimension is taken from the Myers-Briggs Type Indicator and also has similarities to the Sensory-Intuitive dimension in Kolb's model [10]. Students with a sensory learning style like to learn facts and concrete learning material, using their sensory experiences in certain cases as the primary source. They like to solve problems with standard approaches and also tend to be more patient with details. Moreover, students who hear are considered more realistic and reasonable; they tend to be more practical than intuitive students and like to connect learned material with the real world. This type of individual prefers to solve problems with known methods whose effectiveness has already been proven and

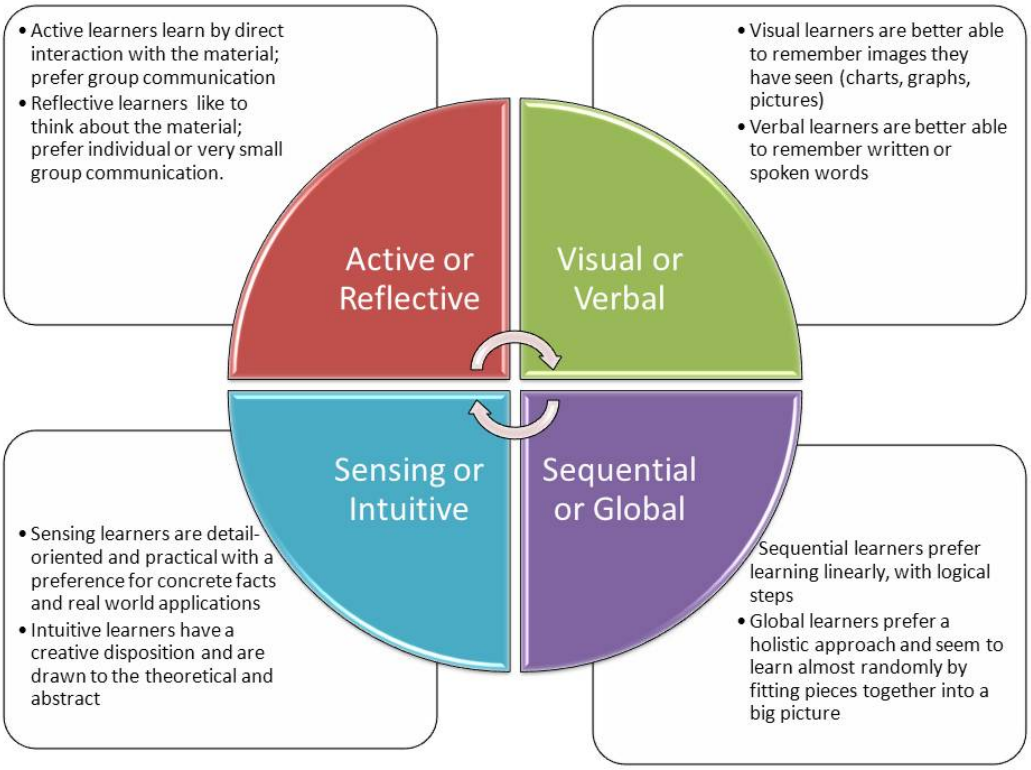

Figure 1. *Four dimensions of FSMLS* [7]

do not want to face some unforeseen obstacles and difficulties. They go into detail and try to remember more facts. In contrast, intuitive students prefer to use abstract learning material, such as theories and their basic meanings, with general principles rather than concrete examples being the preferred source of information. They like to discover opportunities and relationships and tend to be more innovative and creative. Therefore, they have a better result in open tests than in single-answer tests [11].

Third, the Visual-Verbal dimension deals with the preferred mode of input. The dimension distinguishes students who best remember what they saw (e.g., pictures, diagrams, flow charts, tables, animations, etc.) from students who receive more than textual presentations, whether written or spoken [12].

In the fourth dimension, students distinguish between sequential and global ways of understanding. This dimension is based on Pask's model of learning style [13], where sequential students refer to serial students and global students refer to holistic students. Students in this category prefer learning from smaller sequences and need templates to navigate the curriculum. The educational process is viewed as a whole consisting of small steps, and each of the steps is interconnected. In contrast, global students use the process of holistic thinking and learn by leaps and bounds. They tend to absorb learning material almost randomly without seeing the connections, but after learning enough material they get the whole picture at once. Then they are able to solve complex problems and put things together in new ways; however, they have difficulty explaining how they did it. Since the whole picture is important for global students, they are more interested in reviews and broad knowledge, while sequential students are more interested in details [7], [11], [12].

To identify based FSMLS, Felder and Soloman has developed the Learning Styles Index - ILS [14], a 44-item questionnaire. As mentioned earlier, each student has personal preferences for each dimension. These settings are expressed in values between -11 to 11 per dimension, with steps - / + 2. This range comes from 11 questions asked for each dimension [6].

ILS questionnaire is a widely used and well-researched tool for identifying learning styles. Felder and Spurlin [15] provided an overview of studies analyzing response data in the ILS questionnaire regarding the distribution of preferences for each dimension, as well as verifying the reliability and validity of the instrument. Although there are several studies [16], [17], [18] that have raised open questions such as poor reliability and validity, as well as dependencies between some learning styles, Felder and Spurlin concluded that the ILS questionnaire is reliable and valid. instrument and suitable for identifying learning styles according to FSMLS [15].

3. PROPOSED DYNAMIC ADAPTIVE ALORITHM

This section describes our automatic approach to updating student models and adjusting course delivery to their preferred learning styles. Model specifications and assessment tools will be explained in subsection 3.1. and subsection 3.2 will then show how this model is built into dynamic adaptive algorithm.

3.1. Model of Learning Style

So, we focus on FSMLS. The model describes students' preferred learning style, distinguishing between preferences in four dimensions ("processing", "receiving", "perceiving" and "understanding").

There are strong arguments for removing the bipolarity of this model, and instead the model has eight dimensions instead of four. However, we decided to use the original model as it is widely accepted and well justified in the original paper [7]. An active and reflective style is the opposite and it is believed that a person will not be both very active and very reflective. Model is similar for other dimensions.

Felder and Solomon, formed a score list for the ILS questionnaire as shown in Figure 2. and a procedure for calculating student scores consisting of the following [14]:

- Put “1” in the appropriate places in the table below, for example, if the student answered “a” to question 1, put “1” in column “a” next to question 1, but if he/she answered “b” for question 1, put "1" in column b. The answer to each question should be "a" or "b";
- Gather all the units under each column and enter the sum in the indicated spaces;
- Subtract the smaller total number from the larger one for each of the four scales;
- Enter the result of the difference, which will be a number between 1 and 11, and then write the letter "a" or "b" for which the total number is higher in the lowest order.

For example, in the column for Active-Reflective Learning Style (AST-REF) if the student answered 3 questions “a” and 8 questions “b”, the answer would be the difference between 8 and 3, which is “5” and “b "Because we have more 'b' than 'a.' Then we would write in the lowest row below the column AST-REF "5b". This means that the student has a moderate preference for Reflective Learning Style (5b) which is reflected within the AST-REF dimension.

The result of the evaluation of the ILS questionnaire is a set of four points, one for each dimension.

ACT/REF			SNS/INT			VIS/VRB			SEQ/GLO		
Q	a	b	Q	a	b	Q	a	b	Q	a	b
1	___	___	2	___	___	3	___	___	4	___	___
5	___	___	6	___	___	7	___	___	8	___	___
9	___	___	10	___	___	11	___	___	12	___	___
13	___	___	14	___	___	15	___	___	16	___	___
17	___	___	18	___	___	19	___	___	20	___	___
21	___	___	22	___	___	23	___	___	24	___	___
25	___	___	26	___	___	27	___	___	28	___	___
29	___	___	30	___	___	31	___	___	32	___	___
33	___	___	34	___	___	35	___	___	36	___	___
37	___	___	38	___	___	39	___	___	40	___	___
41	___	___	42	___	___	43	___	___	44	___	___
Total (sum X's in each column)											
ACT/REF			SNS/INT			VIS/VRB			SEQ/GLO		
a		b	a		b	a		b	a		b
___		___	___		___	___		___	___		___
(Larger – Smaller) + Letter of Larger (see below*)											
____			____			____			____		

*Example: If you totaled 3 for a and 8 for b, you would enter 5b in the space below.

Figure 2. *Score list for ILS questionnaire*

3.2. Similarity algorithm

To find similarities between the two students, we compare their data records that catalog their previous interaction with the system. We usually compare the incomplete records of the "new student" who is currently studying the object of study with the complete records of the previous student who successfully completed and passed the teaching content. There may be many "previous students" who have taken the subject. The identities of these "previous students" are kept in the "order of similarity" which is sorted according to the similarity of the record with the incomplete record of the new student to the point where the new student has reached. The order is sorted from most similar to least similar. The adaptation algorithm then searches this line to find the greatest result of the similarity between the previous and the new student in order to decide how to present the teaching content to the new student.

4. DYNAMIC ADAPTIVE LMS ARCHITECTURE

Adaptability was realized using four components: student model, content model, similarity algorithm and machine learning algorithm. When a student applies through the Moodle LMS, an ILS questionnaire is initiated that the student completes to predict their learning style. All student-specific data, learning style outcomes, current phase of learning content, average student grade, and interaction with the system are recorded in the student model. The content model approaches the learning content and presents it to the new student according to the desired dimensions of the learning style.

The teaching contents are adapted to the student's preferred learning style. After studying each concept, the student is asked to answer a series of questions in order to assess his/her understanding of the concept. If the assessment results are not satisfactory and the student does not pass the evaluation, the similarity algorithm searches the system database in search of previous learning patterns that are similar to those of this new student. Then the similarity algorithm forms a list of previous students and rearranges it, according to similarity, from highest to lowest. The similarity is not just in the student's learning style; covers the characteristics of the student, his/her time spent on the curriculum, his/her average grade and his/her learning style. Accordingly, the algorithm selects the most similar student and represents the learning content of the material adapted to his/her preferred learning style, which may not be the same as that of the previous student. This is followed by an assessment of the understanding of the newly adapted material, i.e. the presentation for the new student. If a new student passes the evaluation with a new learning style, the algorithm updates the student model with these changes. These changes will be returned to the student content model that will be used to present the next teaching material with the updated student model.

If the student does not do well the second time with the newly adapted learning styles, the algorithm selects the next student from the list of similarities. The system then presents the material to the new student with the preferred learning style of this other previous student. A new student is allowed to repeat the same material up to three times. This limits the time required for participants to participate in the experiments. If a new student does not do well in any of the three repetitions, the system chooses the best of the three outcomes to decide which learning style will be used to present the next teaching material.

Proposed adaptive system is implemented on Moodle LMS used by students attending online courses. The adaptability algorithm must be able to quickly produce an edited list of previous students in order to respond to student action and learning styles within a reasonable period of time. To achieve this, the algorithm is linked to a machine learning scheme that is able to efficiently handle student data records as the number of records grows. As the number of records of previous students increases, the efficiency of the implementation of the similarity algorithm becomes increasingly important. Algorithm must be able to process records quickly to identify similar behavioral learning styles among students. To achieve this efficiency, a classification algorithm is used to identify and parameterize similar patterns

in records. This is one of the advantages of the proposed system, i.e. increasing the performance and accuracy of the system compared to similar adaptive systems, which are complex and expensive [19].

The advantage of the proposed system over other adaptive systems is that it does not involve any additional work for students other than completing the ILS questionnaire at the beginning. Students do not have to play any role in choosing the desired learning path and are not required to give opinions or grades that may confuse and distract them. Our proposed adaptive system adapts student learning styles to suit their actions during the course and periodically updates the student model.

4.1. MySQL system database

MySQL is used to access the records of previous students. These records document the usage, behavior, learning styles, and labels stored in the Moodle LMS database. To extract student data, we used MySQL (Figure 3.), a tool for database administrators. This tool helps us to visualize, delete, edit and modify database tables.

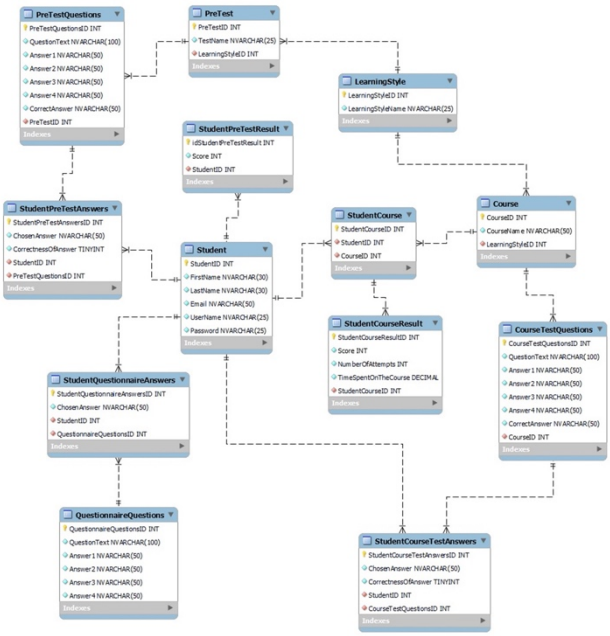

Figure 3. *MySQL diagram for adapted Moodle LMS*

4.2. User interface design

This subsection describes the user interface and guidelines that have been considered for our e-classroom design. The first interface presented to the student is the application for the e-classroom, followed by the interface for registration of class attendance and filling in the ILS questionnaire and answering the test questions. After that, the graphical user interface is customized in the teaching content section with presentation options depending on whether the system needs to be unadaptable or dynamically adapted. The graphical user interface is designed in a simple way, to help students navigate the system easily.

4.3. Adaptive Moodle LMS - Implementation phase

The implementation phase has extended the standard version of Moodle LMS. Moodle LMS has been expanded in line with the link between learning styles and educational materials, and in line with customized content, as shown in Figure 4.

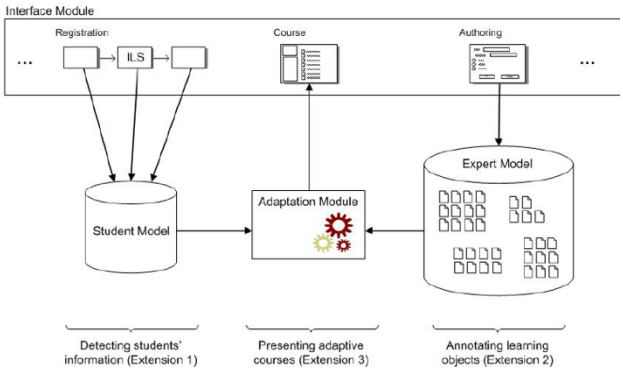

Figure 4. *Moodle LMS architecture extensions*

The first extension deals with the ILS questionnaire and test for assessing students' initial knowledge and initialization. The ILS questionnaire and test questions were added to the registration form in Moodle LMS. The results of learning styles from the questionnaire and the results of the pre-test are calculated and stored in the student model.

The second extension deals with presenting the course content in an appropriate presentation that matches the learning styles preferred by the students. While the adaptation is performed according to the adaptive algorithm. Learning content is presented through a normal user interface.

The third extension allows the system to dynamically update student profiles in a reasonable amount of time. The proposed method of adaptation is based on the similarity algorithm using the machine learning algorithm - the decision tree.

5. EXPERIMENT SAMPLE

90 students of Alfa BK University participated in our experiment, while 77 students fulfilled the conditions of the experiment, namely 33 students of Faculty of Finance, Banking and Revision, 24 students of Faculty of Foreign Languages and 20 students of Faculty for Management in Sport. According to the results for the population of 90 students at the confidence/reliability level of 95% and the margin of error of 5% is estimated at 74 participants. Therefore, the sample size of our experiment is statistically significant for testing our hypotheses.

6. CONCLUSION

Intelligent learning systems diagnose the learning process and generate instructions and learning content during the implementation of the program, mainly based on the results of students in problem solving. Building a personalized learning path is one of the areas where there is a clear link between hypermedia and intelligent adaptive e-learning systems.

If teachers have information on the way in which students learn most easily, or they have information on their learning style, they will have additional indications on how to prepare the teaching content and in what format to convey it to students. This will make the listeners more motivated and active, which leads to easier learning of the teaching content.

The adaptive learning software system aims to adapt some of its key functionalities (i.e. providing learning content, supporting navigation in the training course, etc.) to the needs and preferences of students. In that sense, adaptability can be seen as the ability of the system to adapt its behavior and provide its functionality to users according to their preferences, educational goals, learning style, level of knowledge, behavior in the system, etc.

As part of the conducted experiment, the effects of the control, static and dynamic groups were statistically examined in relation to the set research hypotheses. The results showed that there is a statistically significant correlation between the progress of students on the post-test in relation to the result achieved on the pre-test in relation to the group to which the student belongs. A significantly better result on the post-test was achieved by students from the dynamic group compared to students from the static and control groups. Also, it was determined that students from the dynamic group spend less time on the course compared to students from the static and control groups, i.e. it was determined that students from the dynamic group spend significantly less time answering questions on the final test compared to students from statistical and control groups.

The overall results of the experiment were useful and encouraging. It was confirmed that the topic of the case study was new to all participants and, being purely from the ICT field, proved to be of potential interest to them. The students' opinions about the design and implementation of the adaptive Moodle LMS were that it was clear and understandable.

It is evident from this study that dynamically adaptive LMS can motivate students and improve their learning outcomes. However, more research is needed to investigate and study the learning styles of students in an e-learning environment to find out what factors influence their achievement. A better understanding of students' learning styles may eventually lead to the widespread acceptance and use of adaptive algorithms in e-learning systems that can provide effective and practical adaptive systems.

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Implementing the AWS Academy curriculum into a cloud computing course

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Abstract: *Companies are moving towards the cloud more than ever, and startups are getting full support from cloud providers in terms of consulting and credits, with developers adopting new programming models shifting further away from traditional technologies. However, teaching cloud computing is still a major undertaking, as it is still difficult choosing the right tools, learning platforms, and creating curriculums to cover such a wide body of knowledge. One of the newest additions to teaching cloud is the AWS Academy curriculum and learner labs and long-running labs. In this paper, the results of implementing the AWS Academy with a hybrid model at Faculty of Technical Sciences are observed. Post-semester evaluation showed up that use of this initiative's resources can fully support an introductory course in cloud computing. However the proper adaptation is needed to fully utilise the platform and achieve the learning goals.*

Keywords: *AWS Academy; cloud computing; e-learning; teaching cloud*

1. INTRODUCTION

Cloud computing is a paradigm with significant impact on today's global market. Grand View Research published that "the global cloud computing market size was valued at USD 368.97 billion in 2021 and is expected to expand at a compound annual growth rate (CAGR) of 15.7% from 2022 to 2030. [1]". The need for scalable, robust and measurable service and rise of machine learning and artificial intelligence has led to increased interest in cloud models. This trend is further coupled with the urge for skilled work-force and therefore for education in the field.

A decade ago it was argued that cloud computing should be taught on a graduate level [X], but having the cloud concept intertwined with basically all other information technology features (databases, security, Internet of Things), "descended" cloud computing to undergraduate level.

A major education tool for teaching cloud computing is - the cloud platform itself. Providing a platform where the concepts can be implemented and tested is of essential importance. Moreover, having hands-on experience on a specific platform can be a solid ground for future jobs, such as DevOps and in the software industry in general. Major cloud players provide various ways of cooperation with the academy. It is also in their interest to help in training for their platform. Therefore, various academic initiatives emerged, such as Microsoft Learn for Educators [2], Google Cloud Career Readiness Program [3] and AWS Academy [4]. These programs provide educators and students with teaching resources, including the access to cloud platforms and a number of its services.

This paper deals with use of the AWS Academy platform in an undergraduate cloud computing course at Faculty of Technical Sciences Čačak. The faculty became a member of AWS Academy initiative and incorporated the AWS Academy platform and its resources into the cloud computing course. More specifically, the online course "Cloud fundamentals", which corresponds to the AWS Practitioner certificate, is positioned as a core hands-on course segment. The goal of the paper is to examine how the AWS Academy platform and its online resources were used during the course, from the student's perspective and to evaluate if this hybrid approach has helped in achieving learning goals and outcomes.

The structure of the paper is as follows. The related work is analysed, then the methodology is presented, the data is analysed and the results are shown. The conclusion and recommendations are closing the paper.

2. RELATED WORK

Introduction of cloud computing into undergraduate courses was discussed by Sommervile [5]. Author argued that the practical work should be focused on PaaS.

Authors stated project-work, using available cloud platforms as a core component in [6]. However, they emphasised the importance of keeping general concepts, which are independent from specific platforms.

Authors in [7] expressed the concern for hands-on, lab activities, as the cloud providers offered a modest capacity for education use. They proposed a multi-cloud syllabus, involving various commercial cloud platforms, and also OpenStack.

Authors described a design and pilot implementation of the DevOps and Cloud based Software Development curricula for Computer Science and Software Engineering masters [8]. They emphasised the need for qualified students in this area who are familiar with major cloud platforms.

Use of Amazon's AWS Educate in cloud computing courses is analysed in [9]. This research showed up that this concept of cloud resources provisioning was an effective resource in developing an environment to teach cloud computing for most labs.

3. COURSE DESIGN

The subject Cloud computing at Faculty of Technical Sciences in Čačak is an elective subject for undergraduate students of the IT study program. It is set with a workload of 6 ECTS. Students are introduced with theoretical concepts of cloud computing from two points: mostly as a cloud service user (IaaS, PaaS, SaaS model), but also as a cloud provider (data centre design, virtualization, cloud-native paradigms). The first point presumes introduction with commercial platforms. Although various platforms are mentioned and referred to, the focus is on AWS, for multiple reasons. First of all, AWS is a dominant cloud platform and familiarity with its services can provide benefits to the future students' professional development. Also, the academic support for AWS turned out to be very rich, equipping students and teachers with learning resources and, most importantly, with cloud services' access. Certainly, the students are aware of other options, such as Microsoft Azure or Google Cloud and of specific features these providers give.

3.1. AWS Academy

Amazon has a certain tradition in supporting academia. AWS Educate was an initiative providing academia with online access to a subset of AWS services. Students of registered education institutions got 100$ of credit by default, for free. This facilitated the way students could previously use AWS resources, when a credit card was required to claim for free credit (and would get charged eventually, after the limit is reached). This creates issues with students forgetting to terminate their cloud resources. Students would either exceed the "free tier" limitations and get charged or would leave resources in a running state and once the free tier expires, one year after the account creation, the students would get billed. In most cases, AWS drops these charges after contacting their support and explaining how the charges were incurred. AWS Educate eliminates part of this problem as charges on this platform can't occur, however, it does not solve the issue of students leaving resources in a running state or overprovisioning certain resources and burning through the assigned credit limit. AWS Educate is now open for students outside of academia as well, to individuals, no matter where they are in their education, technical experience, or career journey.

AWS academy is the next step in the evolution of Amazon-academia collaboration. An educational institution applies for the AWS academy status and goes through an interview and onboarding process. Then it is possible to use AWS resources for teaching. AWS provides access to their Academy (Canvas) platform and a set of courses with a complete curriculum, course outline, instructor guideline, videos, student guides, labs, knowledge checks, and a sandbox environment for experimenting. Labs are time limited and have predefined instructions for each lab depending on the course module that the lab is in. There are also long-running labs provided in a special Academy Learner Lab where students can experiment and create environments using cloud resources without the standard 3-hour sandbox environment limit. Instructors can get AWS badges for their qualifications and complete AWS Educator training. This includes students as well, when they successfully complete all knowledge checks, they will get an AWS badge and a significant discount on their next AWS certification exam. Courses are frequently updated by AWS to keep up with the changes with services, as well as UI changes. AWS organises live events and webinars aimed at Educators and helping them teach AWS. Each course has an educator version that aims to help educators prepare to teach those courses. There is a wide variety of courses available, from introductory to more advanced ones:

- Cloud Foundations,
- Cloud Operations,
- Cloud Developing,
- Cloud Architecting,
- Data Analytics,
- Machine Learning Foundations,
- Learner lab - Foundational services,
- Learner lab - Associate services.

AWS Academy supports several languages, but not Serbian. This poses an additional challenge for teaching, as students have to consume materials presented in English. Certain materials prepared by the teaching staff were available in Serbian, however, translating the entire available teaching material would consume too much time and would be difficult to keep up to date over time.

Having experience with both AWS Academy and AWS Educate, in an academic setting, proves AWS Academy as a suitable environment for teaching

students. While some labs may be considered too simple, custom labs can always be implemented using the sandbox environment and additional work can be assigned to students. AWS predefined labs save time by creating and setting up an environment for that module specifically, leaving out the manual initial setup of the environment and getting straight to the point.

Depending on the students' backgrounds, some written materials provided by AWS Academy may require further clarification or a stronger background in the subject at hand. This is where the hybrid model comes in, allowing the implementation of exercises and materials outside of the scope of AWS Academy, covering the prerequisites and providing further insight into certain modules.

For example, the security module demonstrates AWS Identity Access Management and explains the Shared Responsibility Model, focusing on securing the AWS side of the environment. It should be expanded into general security guidance for operating systems, firewalls, applications, etc. in order to create a complete picture and a security conscience.

4. DATA COLLECTING AND ANALYSIS

The data was collected using a questionnaire tool, implemented in the Moodle course. It is noted that the students in general do not like taking part in surveys, therefore we kept the questionnaire brief. There were 5 items with Likert 5-points scale for gathering feedback on use of AWS Academy in context of the course and its learning goals, one item (same Likert scale) related to the use of specific resources, two multiple choice items regarding certification and DevOps profession and one optional open-ended question. The full questionnaire is given in the Appendix. Total of 14 students responded, that is virtually all students active in the course.

The feedback was collected after the semester was over, from 7th June 2022 until 20th June 2022.

The descriptive statistics for the first 5 questions are presented in Table 1.

Questionnaire

1. AWS Academy enabled access to cloud computing services helped me to understand theory concepts of cloud computing.
2. Tests provided in the AWS Academy course helped me in consolidating learning.
3. Practical assignments on AWS Academy platform are on the appropriate level of difficulty
4. I did not have technical problems with AWS services available through AWS Academy.
5. Experience of working with cloud services available via AWS Academy, will help me in professional work.
6. Please indicate the level of use of particular resources (assigning 1-5)
    a. Video-clips
    b. Lab-assignments
    c. Test
    d. Pdf materials
    e. Sandbox environment
7. Do you plan to apply for a certification exam (AWS Cloud Practitioner)? (yes/no/note sure)
8. DevOps and Cloud engineer are vocations I am interested in. (yes/no/not sure)
9. Enter your observations regarding the AWS Academy platform: what suits you best, what could be improved with the platform and its use (optional, open question).

Table 1. *Statistics for leading 5 questions*

	Q1	Q2	Q3	Q4	Q5
Mean	4,571	3,714	4,643	4,214	4
St. Error	0,173	0,339	0,133	0,214	0,234
Median	5	4	5	4	4
Mode	5	4	5	5	5
Std. Dev.	0,646	1,267	0,497	0,802	0,877
Sam. var.	0,418	1,604	0,248	0,643	0,769
Kurtosis	0,951	1,725	-1,84	-1,23	-1,77
Skewness	-1,30	-1,49	-0,67	-0,44	0

This first group of items is directly related to the potential benefits of using AWS Academy. Tests (knowledge checks) are found to be least useful. These are available on the AWS platform (Canvas) for each unit and students are directed to solve these in order to assess their own knowledge and prepare for certificates. The least interest in tests is confirmed in the next item, where students indicated which resources, they found most useful. Video-lessons and the sandbox environment are indicated as most useful. Pdf-materials are also found as not very interesting for students.

The results for the 6th item are shown in Table 2.

These answers fit the model of the course, as in this hybrid setting, resources are provided beside the platform and the most useful (and necessary) feature is access to the very AWS platform and services. The resources given on the AWS academy course are tailored to match the requirements for achieving a certificate, therefore if the students' focus is on the course Cloud computing, they might neglect specific details related to the certification.

Table 2. *Questionnaire results for the 6th item*

Answers	1	2	3	4	5
Video lessons	14%	14%	29%	7%	36%
Lab-assignments	7%	14%	14%	50%	14%
Test	14%	57%	29%	0%	0%
pdf	36%	7%	21%	21%	14%
Sandbox	29%	7%	7%	21%	36%

Students get a 50% discount for first level certificates (AWS Cloud Practitioner). It is a great opportunity to gain added value from this course. However, out of 14 respondents, 4 (29%) are planning to apply for the Practitioner certificate, one does not and 9 (64%) are not sure yet. This data is fully aligned with the previous discussion on students' focus.

The last mandatory item was related to the profession plans. Even 71% (10 students) are not sure if they want to work as a DevOps/Cloud engineer and 3 students responded they see themselves in this position.

The last item was open-ended and optional and served as a qualitative input for improvement of the subject. Total of 5 students gave their inputs here. The AWS Academy platform is labelled as well organised, with easy practical assignments, which could be leveraged to the next level of complexity.

5. CONCLUSION

Delivering a Cloud computing course is virtually impossible without wide access to the commercial providers' services. On the other hand, these providers also have interest in promoting their platforms. AWS Academy is a serious project bonding academy and AWS. Although the courses provided in AWS Academy are primarily set as preparation for the certification, these can also be incorporated in the hybrid teaching model. Also, it showed up as more efficient, flexible and overall useful than the previous initiative, called AWS Educate.

It showed up that students were mostly satisfied with the AWS Academy platform and its features. The least used were documents and tests. Educators should pay attention to this indicator and possibly provide a separate way of knowledge check, for students' self-evaluation. On the other hand, for students interested in certification, it is important to keep up with the authentic resources available on the AWS Academy platform. Also, as the certification exam is in English, it is not suitable to translate tests and bring in the confusion related to the terms and language.

As this is the first time the AWS Academy is used in such a way (and this means also globally, since this platform is just set up this year), it can be concluded it is a good basis for cloud computing introductory courses. With the predefined lab assignments and sandbox environment it is possible to create additional lab-assignments and projects. The availability of different cloud services is sufficient to cover all important aspects of the cloud computing course and facilitate students' individual learning, but also make their way to the industry recognized certification much easier.

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Information Technology impact level perception of Students at Electrical Engineering Faculty in East Sarajevo

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Abstract: *The paper investigates status of Information Technology (IT) impact level perception of students studying at the Faculty of Electrical Engineering in East Sarajevo. Competitiveness on the labour market of the future graduated engineers are narrowly related to their level of competences and possible adoption of skills in teaching process. This paper includes the results of a research involving all students in the Computer Science and Informatics program at our university, starting from first year of studies up to fourth year. Three areas have been identified as additional value for the students during the teaching process at the faculty. The focus was on the student's perception of professional IT skills that they have to adopt before their first employment. Based on the research results, amending of current curriculum of the Computer Science and Informatics program at the Faculty of Electrical Engineering in East Sarajevo has been proposed.*

Keywords: *Information Technology impact level perception; On-line survey; Electrical Engineering Faculty*

1. INTRODUCTION

What is an optimal level of *Information Technology (*IT) impact perception at the first cycle of studies among students, as well as the level of required skills to be competitive on the labor market is a question that brings a whole list of answers. We could say that students should predict and recognize trends that are changing in the IT industry through education process, and related to that conclude what is an optimal level of IT skills that they should adopt. One of the answers is that systematic approach to improvement of student's knowledge is through the quality improvement of the study program at the faculty. According to Vyalikova, Erofeeva, Plekhanova, Pluzhnikova and Saveleva in [1], "Considering the formation of students general Information Communication Technology (ICT) competence from the point of view of the system-and-activity methodological approach, it is possible to characterize it as a system that consists of a number of elements, has connections with the external environment (EIES), is aimed at a certain result (students mastering an adequate level of competence)".

From the previous statement, it can be concluded that the main objective for the students is to adopt skills and competences during their university education that will be adjusted to future EIES. Highlighting the requirements for the IT engineers to be professionally enabled for solving problems based on the requests of the end users of IT applications and information systems in general on a daily basis. *Olaisen and Revang* in [2], state that "Experts knowledge is accumulated through education and practical experience enabling experts to apply his knowledge in order to be regarded as a professional". Gulatee and Combes in [3], stated that "How students really use technology for learning is very important for schools and universities, as technology is being rapidly incorporated into educational settings". Considering the opinion of students at the Faculty of Electric Engineering, it is obvious that they should predict technology and economic factors that drive towards change in society. However, the curriculum must be adjusted towards the accelerated technological development. Primarily, the focus should be on those areas with direct impact on the worlds IT market growth.

Mole, Dim and Horsfall in [4], claim that, "This also affected education in many fields resulting in the introduction of subject dedicated to ICT in existing university curriculum, and has led to reengineering and improvement of education practice to meet industrial needs".

In the interest of creating knowledge-based society, it is very important to plan development of IT professionals through the university curriculum in a systematic and unified way in line with the world standards dictated by the industrial needs. Engineering disciplines require balance between demographic, economic and social standards and daily tasks that employers expects from students to be able to carry out when they enter into labor

market as graduated IT engineers. Dahlstrom and Bichsel in [5], and Tumbleson in [6], claim that, "Users (students) demand digital content on laptops, tablets, and smartphones to enhance learning especially with library resources". Based on this assertion, authors confirmed that improvement of the existing IT skills of the students is directly related to improvement of the speed and quality of providing the latest hardware configurations and deployment of web application tools into the learning processes at the Faculty of Electrical Engineering. Mestre in [7], and Zang, Watson, and Banfield in [8] states that "The Learning Management System (LMS) offer instructors the ability to create extensive tutorials (content) that can be viewed at a self-paced administration before it becomes outdate".

Based on this statements, one or multiple web-based platforms (e.g. Moodle–open source learning platform) used at the Faculty can be identified. Due to its scalability, it may be used on any hardware configuration available to students. Through experimentation, Zhang and Zuo [9], discovered that the teacher-student interaction is influenced by the interactive environment, personal traits, events of different emotional valences, and the emotional state of students. Naturally, the teacher is required to identify and deal with such parameters through the teacher-student interaction.

Through usage of the IT solutions mentioned above, student's mobility would be ensured, enabling them to master the learning content and new IT skills, even though they are not physically in the classroom. Teacher-student interaction through use of the latest IT web platforms for distance learning will be applied if a student is not able to attend.

This research aims to identify the basic needs of students and, through their recommendations resulting on research conducted, to incorporate them into improved curriculum in the future.

Authors will identify which IT tools and skills today are the most needed to be incorporated into the curriculum in the first cycle of study in the future through web-based distance learning platforms. These results would serve as a base to upgrade the teaching process in other cycles of study, primarily, the second and third cycles on the Faculty.

The purpose of this paper is twofold:

1) Analyses the current state of the digital skills level and perception of requirements for IT improvement, so as enhancement of IT knowledge of the students on the Faculty where all students of the first cycle of studies (all four years) have been included. The analysis is given in Section 3.

2) Based on the survey we will give recommendations for the future improvement of current curriculum for the study program Computing and informatics, as given in Section 3 (Table 1).

This paper is structured as follows: After Introduction, there is a discussion about optimal level of IT skills of the first cycle studies students, so as the level of required competences to be competitive on the labor market", there is Section 2. Where authors identify the precise profile of the participants and areas of knowledge that students have in order to make certain recommendations for the improvement of the whole system of strengthening digital skills and possible update of curriculum against research results. In this section, the Methodology for the implementation of the survey is described. Section 2.1 (Research question), as the usage is concerned, is a starting base to generate the results of the survey outlined in Section 3. Section 3. contains main focus of this survey paper with technical details required for analysis and recommendations for Proposal of IT skills to be included in curriculum on the Faculty, which can be compared to similar surveys in this area. Practical analysis of the results described in Section 3 provides us with a visual means to confirm our summary and conclusion outlined in Section 4.

2. PARTICIPANTS

According to Bourke, Kirby and Doran in [10], "The first stage in Problem Based Learning (PBL) is to identify what you already know about the problem that you are trying to solve. Ideas will generate from this approach and will be reformulated based on what exactly you need to measure". First phase in our research focuses on identifying which factors most significantly impact how students perceive technology (such as demographic and economic changes) and social aspects of their own lives.

In brief, the Faculty of Electric Engineering in East Sarajevo is the oldest higher education institution in the field of electrical engineering in Bosnia and Herzegovina. The Faculty was founded in 1961 by separating from the former Technical Faculty in Sarajevo, when begins to operate independently within the University of Sarajevo. After a one-year pause in 1992, the Faculty reopened in 1993 within the University of East Sarajevo. Since academic year 2004/2005, teaching activities at the faculty are carried out based on the new curriculum which is in line with the Bologna Declaration. According to the Declaration, the studies are organized through three levels of studies: bachelor's (first cycle), master's (second cycle) and doctoral (third cycle) [11].

The headquarters of the Faculty is located in East Sarajevo and this higher education institution was chosen for our research due to several reasons. As mentioned above, this is the oldest and most prestigious educational institution that is part of a public university and where the responsibility of

students to take participation in researches is at a very high level. Moreover, the Faculty encourages the use of the latest ICT technologies in everyday teacher-student interaction. Recently, the Faculty has been constantly tracking the needs of students, which is directly related to the requirements of the labor market for IT staff in BiH, in order to attract as many students as possible to enroll this Faculty. Of course, this goal would not be met without trying to include in the teaching process as many ICT technologies that have additional value for students in the process of acquiring new skills in this area.

Therefore, this research is consisted of a range of students, encompassing the all four years of the first cycle students. The total number of participants was 105, of which 37 female students (35,23%) and 68 male students (64,77%). Regarding of the year of studies, the situation was as follows: 44.8% of participants were in the first year of the Faculty, 22.9% in their second year, 24.8% in the third year and the rest of 7.5% were in the final fourth year. There were 67.7% first and second year students studying based on the general curriculum who participated in this study while there were 32.3% of the third and fourth year participants studying according to the curriculum of the Department of Computing and Informatics. Eighty-eight (88%) per cent of the participants aged in-between 18-22 years.

2.1. Research question

This research seeks to determinate status of IT skills perception level of students. The questions in the research are divided into three groups and asked in a sequenced order. Based on that, the first group of questions are focus on area which are the drivers of change in the world when it comes to demographic, economic and social factors and what are the technological and economic factors that drive change in society.

Throughout our study, quantitative methods based on web questionnaires are used. Nancarrow, Pallister and Brace in [12], find that, "Using the Web is cost effective and time efficient, enables the researcher to gain a snapshot of the current state of affairs". Moreover, Braunsberger, Wybenga and Gates in [13], claim that, "Web questionnaire allows a fast turn-around for data collection and has been shown to be a reliable alternative to telephone surveys". Web questionnaire also provides anonymity for participants allowing them to answer the questions in a friendly environment which would not be the case if the interview method was applied, since authors have a subjective influence on the teacher-student relationship.

In order to analyze the state of affairs as regards IT skills of students who are using the University information system, the following methodology is used:

- Creation of survey questionnaires
- Filling an on-line survey questionnaire by students
- An analysis of the response set to cover topics that are of primary importance to our research.
- Collecting and analyzing the results obtained from the web questionnaire.

The questions for the questionnaire were developed using the Google Forms tool, which is an online research tool available on the Internet [14]. This tool was chosen because it enables us to collect information from students through personalized quizzes or surveys. Then, it is possible to connect the info to a spreadsheet on Sheets to automatically record the answers. The spreadsheet then populates with the responses from the quiz or survey in real time.

All questions could be answered by one of the four (4) different browsers, Mozilla Firefox, Google Chrome and Microsoft Edge version. All participants performed on machines with installed Windows operating system or smart devices with usage of Android or iOS operating system. A questionnaire is made with Google Forms tool. This free software allows us to gather data from participants.

Surveying of the students was conducted at the Electrical Engineering Faculty in East Sarajevo from 1 October 2021 to 31 December 2021. The study included all students from each of the four years study curricula of the first cycle of studies.

3. RESULTS

Survey questions on Information Technology skill level of the students at Electrical Faculty in East Sarajevo provided the following results and addressed the issues from 1 to 4 presented in Figures in Section 3.

The survey included 105 respondents from the Faculty of Electrical Engineering at the University of East Sarajevo, who answered three sets of questions about world-changing trends, and its results are:

The first set of questions referred to the trends that are changing the world today.

When asked which the drivers of change in the world are when it comes to demographic, economic and social factors, students chose one or more answers shown in Figure 1.

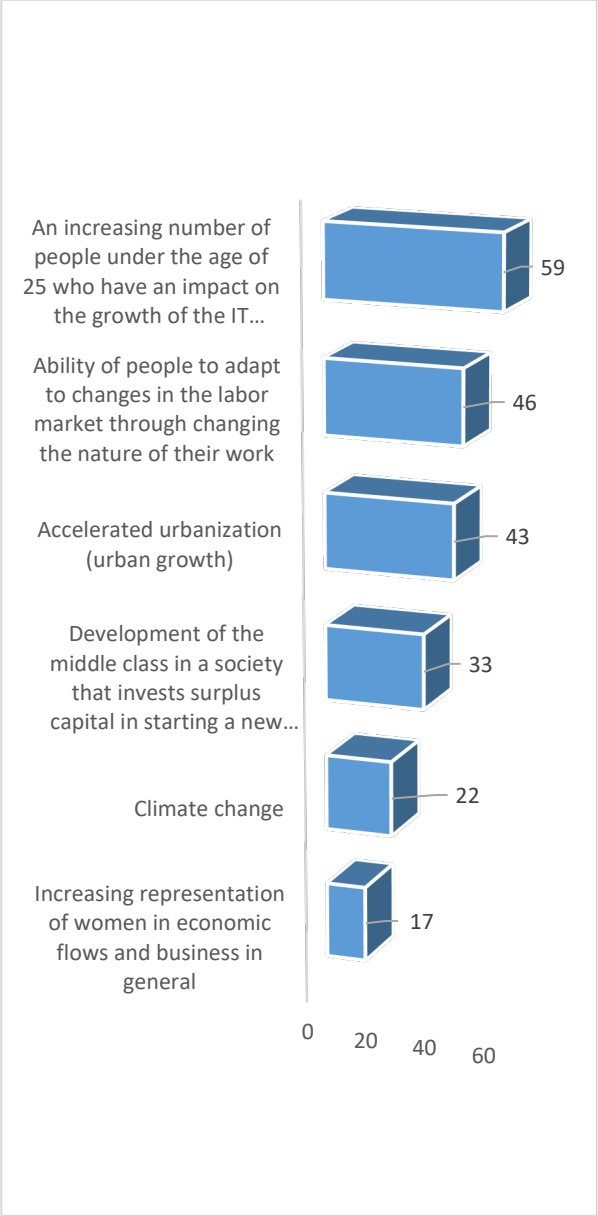

Figure 1. *Drivers of change in the world*

As seen in the Figure 1. Above, the majority of students (59 of them) think that the increasing numbers of young people under the age of 25 who have an impact on the growth of the IT market are the main drivers of change in the world. Given that this is the opinion of students belonging to this group, we can conclude that they recognize the importance and potential of technologies they use every day, as well as the way in which they can reshape the world.

When asked what are the technologically and economic factors that drive change in society, students selected one or more answers shown in Figure 2.

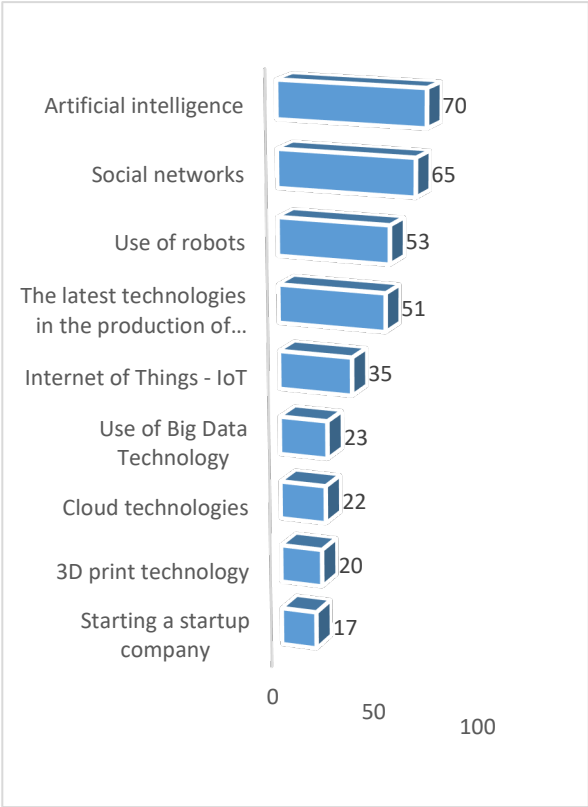

Figure 2. *Technological and economic factors*

Most students think that artificial intelligence and social networks are the technological areas that have the greatest impact on changing the world and society today. Social networks have already stabilized as a factor affecting all strata of society. As for artificial intelligence, Teselios and Sava in [16], state: "For companies that adopt technology efficiently, Artificial Intelligence brings cost savings, improving efficiency and increasing competitive advantage."

The second set of questions aimed to examine students' opinions on future trends.

When asked which of these areas is a decisive factor in the future development of the IT market, respondents gave the following answers shown in Figure 3:

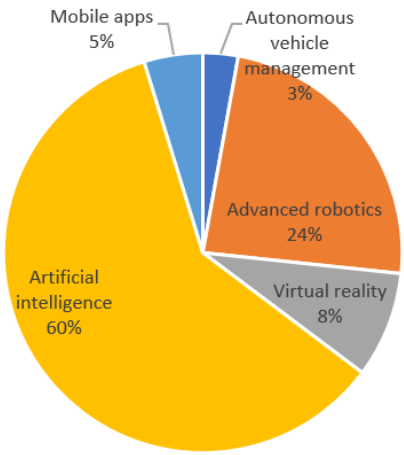

Figure 3. *Future development of the IT market*

Finally, after analyzing the previous areas, authors came to the final question in this questionnaire, and it asks about the areas of IT professional skills which are essential in the future professional work within the next five years.

Participant responses are shown in Figure 4.

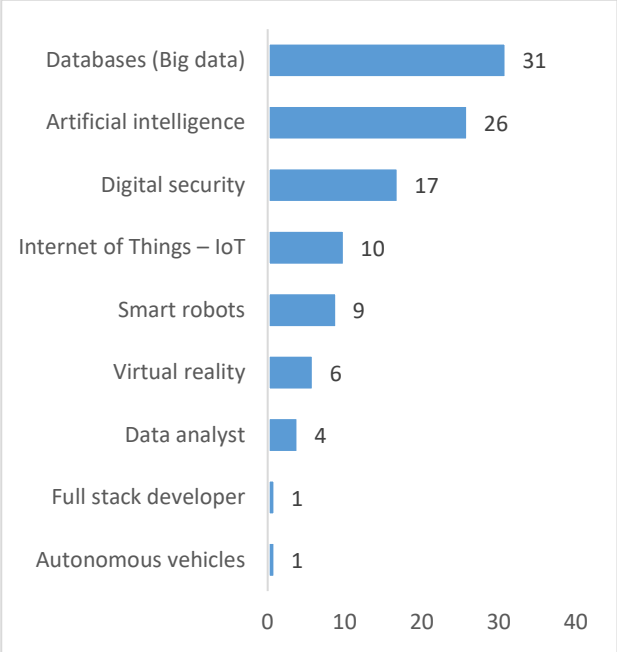

Figure 4. *IT skills perspective in next five years*

By analyzing the data in Figure 4, it is visible that, according to the answer of the respondents, Most respondents think that Big Data is the area that will be most in demand in the labour market. Kumari agrees with this in [17], stating, "The Big Data impact poses a competitive threat to businesses that ignore the trend.", and "… understanding how you can help companies and clients use Big Data will eventually be (if not already) an important element of your professional and marketplace skill set." According to the respondents, future employers will also expect knowledge from engineers in the field of artificial intelligence, which is in line with the importance that respondents gave to artificial intelligence in answering the previous questions.

Through data analysis, authors were able to identify eighth (8) new IT area for improvement IT skills that are presented in Table 1 as a direct result of the responses of the participants given in Figure 1,2,3 and 4.

Table 1. *Proposal of IT skills to be included in curricula of existing courses in ETF*

No.	IT skills
1.	Working and developing practical knowledge in Artificial intelligence
2.	Working and developing practical knowledge in social Networks
3.	Learning practical skills of server-side languages in robotics
4.	Learning practical skills about latest technologies in the production of electricity from renewable energy sources
5.	Usage of Databases (Big data) and analytics in integration of different sets of data
6.	Programing with Mobile application in area of IT
7.	Learning practical skills in Digital security area
8.	Installing, configuring, testing and maintaining cloud computing

4. CONCLUSION AND FUTURE WORK

The constant improvement of the IT skills of the target group, i.e. ETF students, is of very crucial importance in the teaching and pedagogical process of the Faculty. Through this research, the systematic approach to the process mentioned above is presented. Using a systematic approach in improving the knowledge of students, authors achieved the goal, which is to identify eight areas in IT skills and provide suggestions for reinforcement of quality of the study programs at the ETF. These eight areas should be incorporated in the curriculum of the courses which are an integral part of the ETF curriculum in order to increase the competitiveness on the market of graduate engineers. Given the current state of student workload within existing courses, it is recommended to introduce certain new optional courses that would cover eight areas of IT skills identified in Section 3.

This approach would contribute to the competitiveness of graduate electrical engineers on the labor market and contribute to their better starting position in their future professional work.

With the lessons learned and the areas identified for the improvement of teaching process oriented to target group, and it is the students themselves, the next generation of students would be able to adopt new IT skills in a simpler and faster way.

This approach will allow them to have simpler and faster mechanisms for acquiring IT skills as a basis for upgrading from some other areas not covered by the research in this paper.

This research work can be extended to more participants with more tools and different comparative parameters as i.e. survey should be executed on students of the second and third cycle of studies at the ETF.

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Stances of students on use of platform for taking exams or colloquia at the Academy of Applied Studies of Kosovo and Metohija, Department Uroševac – Leposavić

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Abstract: *Development of new technologies, especially Internet, creates conditions for electronic education. The paper presents effect of using Internet as one of the means for taking exams or colloquia in certain subjects in the field of electrical and computer engineering at the Academy of Applied Studies of Kosovo and Metohija, Department Uroševac – Leposavić. Namely, the idea for writing this paper arose due to the fact that, to some extent, this type of communication with students already existed. After taking certain subjects in the field of electrical and computer engineering, research of students was done through a questionnaire. For purposes of this research, a survey questionnaire was used, which included a sample of 58 students. The goal of this research is to examine stances of students on perceived usefulness of the platform and its upgrade for taking exams or colloquia and for other scientific areas on all study programs used in the teaching process. At the end, obtained results were analyzed, based on which conclusion was drawn that students are satisfied with this type of communication as well as with quality of the platform itself.*

Keywords: *Internet; students; platform; taking exams; taking colloquia*

1. INTRODUCTION

Information and communication technologies (ICT further in the text) during only one human generation have revolutionary changed the way of life, learning, working and fun. ICT is increasingly transforming the way people, businesses and public institutions interact. Successful development of information society presupposes an appropriate level of knowledge and skills, both among experts in various professions and among all citizens. In addition to increasing the need for ICT skills, Internet has changed the way and dynamics of disseminating knowledge and information in all areas [1].

It can be said that online education offers great opportunities, but also great challenges. It is necessary to integrate ICT in all aspects of educational process, with the aim of more effective and efficient education [1].

The changes brought about by development of technology in education, have conditioned emergence of new forms and types of tasks that virtual teachers set for students, but also new methods for conducting testing and knowledge checking of students. The issue of checking and testing students is one of the foundations of continuous process of quality improvement of educational programs conducted in online environment. Effectively organized and implemented system of testing students' knowledge directly affects the results of learning process and affects the organization and potential improvements of online education process [2].

Education is the pillar of development of every country, and therefore represents the basis of development and success of every country [3]. The need to introduce distance learning is now widely recognized as necessary in all instances of education, both in preschool and in primary, secondary and higher education institutions around the world [4], [5].

Students see the main advantage of the traditional way of studying in face-to-face communication with professors, which they consider effective when adopting materials during their studies. However, existence of Internet has changed nature of educational process, and modern network technology has improved ability of people around the world to communicate and has become a necessary educational tool [6], [7].

Testing and grading students through a platform that can be an integral part of e-learning content can be seen as a separate process. The convenience of this approach is reflected in time and space dimension, cost-effectiveness and its flexibility.

The paper is organized as follows: the first part of the paper will show the part of platform that relates (uses) for exams or colloquia in certain subjects in the field of electrical and computer engineering. The second part of the paper will deal with attitudes and experiences of students, as well as the application of this platform at the Academy of Applied Studies of Kosovo and Metohija, Department Uroševac – Leposavić.

2. PLATFORM FOR TAKING EXAM OR COLLOQUIA

Computer-oriented learning is the so-called type of e-learning. With development of Internet technologies, e-education, as one of the areas of e-business, is becoming a significant component of continuing, primary, secondary and higher education [8]. E-learning is an application or set of applications that delivers educational content via computer and includes, among other things, simulations and testing. By one name such applications are called educational software [9].

The very thought of the word education in today's world implies the use of different types of platforms (whether ready-made or newly made).

This type of testing and assessment of students' knowledge in many higher education institutions is an integral part of the teaching process [2].

The paper used a platform whose creators are authors of this paper, and which was used to take exams or colloquia in field of electrical and computer engineering. Namely, at the Academy of Applied Studies of Kosovo and Metohija, Department Uroševac – Leposavić, classes are held on accredited study programs in the following areas: electrical and computer engineering, mechanical engineering, traffic engineering, environmental engineering and occupational safety and philological sciences.

At the very beginning of this idea, it was assumed that the best is to make a platform only for the field of electrical and computer engineering. If it turns out that this idea received a positive response from questioned students who took exams or colloquia in the mentioned field, then it is possible to proceed with upgrading platform for other scientific fields in all study programs at the Academy of Applied Studies of Kosovo and Metohija, Department Uroševac – Leposavić.

The platform, which was developed for the field of electrical and computer engineering, is available on the Internet on the day of taking the exam or colloquium after the permission of the administrator and logging in the student after obtaining access codes.

After that, a dialog box will appear with the following information: name, surname, E – mail, role, date of birth, registered since, last access, as well as review of results on exams or colloquia, figure 1.

It is necessary to point out the fact that this way of taking exams or colloquia is only possible in the accredited premises of the Academy of Applied Studies of Kosovo and Metohija, Department Uroševac – Leposavić.

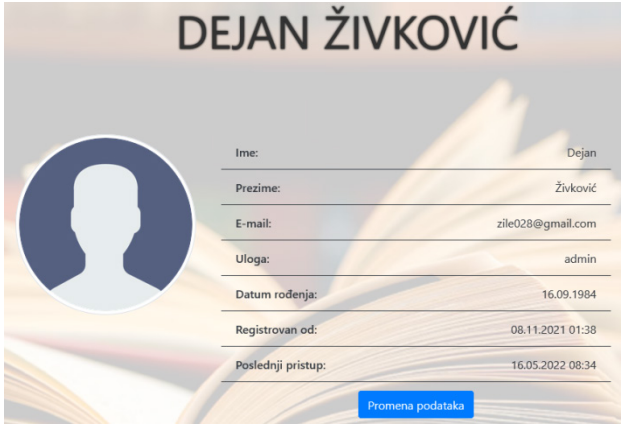
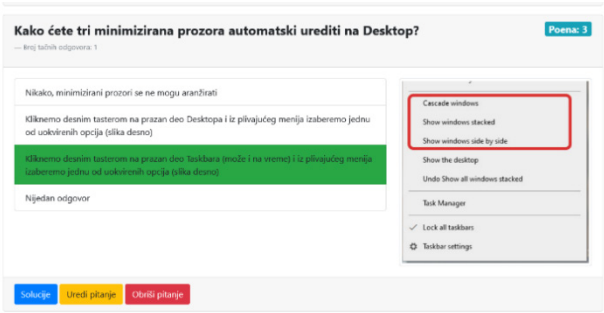
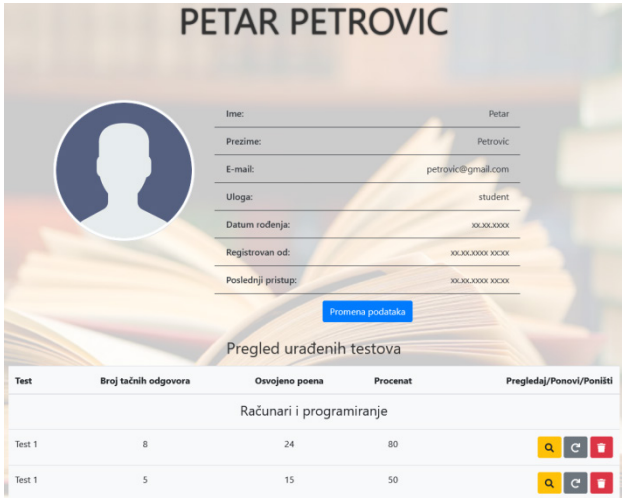


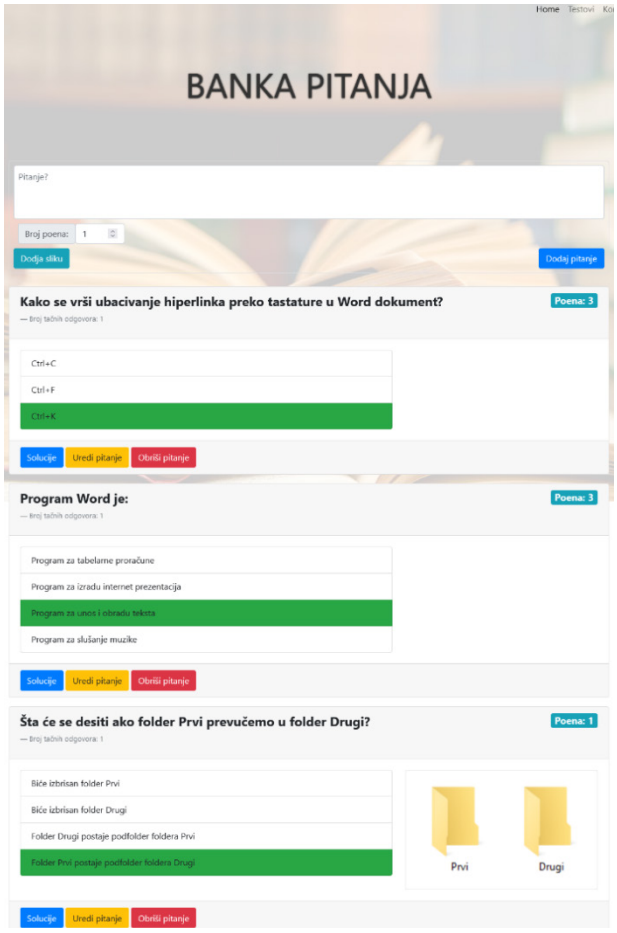
Figure 2 shows the layout of a page that contains tests to test knowledge for an exam or colloquium in a particular subject in the field of electrical and computer engineering. The process of testing knowledge is observed not only through the application of different types of tests, but also as a function of multiple assessment and student progress.

The platform can be constantly upgraded with new questions and tasks that are placed in the question bank and which are automatically redistributed by a later call to the fields of exam or colloquium and appear differently at random for each student who takes the course, figure 3. Subjects can be accessed from several computers at the same time (platform is defined so that maximum number of students to take is 20 - number of students who are allowed by the Accreditation Standards to work in computer centers).



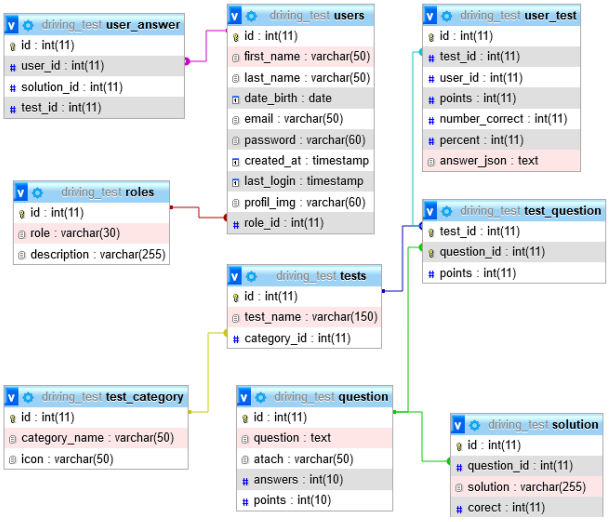
The platform can be accessed as an administrator or user. In case of access to platform as an administrator, the same has access to all parts of the platform (access to all students who took certain courses), while the user property is limited and it is possible to access only to their results of exams or colloquia, figure 4.





The exam or colloquium can be taken by filling out correct answers to questions asked (it is possible to complete one or more correct answers to the questions or tasks asked (multiple-choice questions)). After completing the exam or colloquium, clicking the END button shows results that are automatically printed on the screen of student in the form passed with or failed with a grade of five, figure 5. Exam or colloquium can be done only once in the scheduled time.

Finally, we will mention that platform was made in PHP, and MySQL was used as a database. Structure of database in which all information about users, tests, test results is stored, is shown in figure 6.



3. RESEARCH METHODOLOGY

For the purposes of this paper, a survey was conducted at the Academy of Applied Studies of Kosovo and Metohija, Department Uroševac – Leposavić, through a questionnaire. The survey was conducted anonymously, where respondents gave answers to questions by circling only one of the few offered answers or supplementing certain answers. The survey questionnaire was compiled on the basis of similar survey questionnaires used for this purpose [2], [7], [10].

The survey questionnaire was created with the aim of being rational (for use and understanding), reliable and structured through questions that do not require too much time to fill out. It took 5-10 minutes to fill out the questionnaire.

The research was conducted during the summer semester of the school year 2021/2022. year, and it included 58 students who took exams or colloquia in the school year 2021/2022. year in the field of electrical and computer engineering (20 students who took exams and 38 students who took colloquia). The research was carried out directly through the printed form of survey questionnaire.

Survey questionnaire contained 17 questions and consisted of three parts.

The first part of the questionnaire contained three questions and related to questions concerning basic data about students (gender structure, age, completed high school).

The second part of the questionnaire also consisted of three questions and related to questions that define the student's study process itself (study program, year of study, subject).

The third part of the questionnaire (11 questions) was related to the effect of using platform for taking exams or colloquiums and their advantages and disadvantages as a new form of communication between teachers and students.

Research conducted through a questionnaire using a platform for taking exams or colloquiums will reveal students' attitudes towards e-learning and use of the platform for those purposes. It can also serve as a paradigm of e-learning related to the use of ICT, i.e. new methods for conducting testing and checking their knowledge and skills (through the platform) through digital technologies.

4. RESEARCH RESULTS AND DISCUSSION

The idea for writing this paper arose because there is already communication between teachers and students via the Internet at the Academy of Applied Studies of Kosovo and Metohija, Department Uroševac – Leposavić in the form of Moodle platform and Microsoft Teams platform.

The survey questionnaire consisted of questions that were formulated in the form of closed questions (yes-no questions, circling one of several offered answers) and open questions, table 1. Open questions were questions formulated in the way, to which the respondents-students gave their opinions (example: List the advantages/disadvantages of taking exams or colloquiums via platform or How this way of taking exams or colloquiums via the platform affected you).

The first part of the survey questionnaire, table 1, which refers, among other things the gender and age structure of students, is in full agreement with data available to the Academy of Applied Studies of Kosovo and Metohija, Department Uroševac – Leposavić, which are in its information system.

Namely, of the 58 student respondents included in the survey, 82.8% were male, while 17.2% were female. It is interesting to note that age structure of students was as follows: 86.2% of students are between 18-23 years of age, 12.1% of students between 24-28 years of age and only 1.7% of students between 29 and more years of age. Based on this data, it is possible to assume that in the final report, a high percentage of student respondents

will support this way of taking exams or colloquia, given the fact that at previous levels of education they encountered communication via Internet.

Table 1. *The first part of the survey questionnaire*

No.	Question	Answers offered	Answers of students	
			Numerical data	Percentage data (%)
1.	Gender structure	male female	48 10	82.8 17.2
2.	Age of life	18-23 24-28 29 and higher	50 7 1	86.2% 12.1% 1.7%
3.	Finished secondary school	High school Technical school Other	28 26 4	48.3% 44.8% 6.9%

The second part of questionnaire, table 2, showed that all study programs and subjects from which exams or colloquia are taken in mentioned department are equally represented.

Table 2. *The second part of survey questionnaire*

No.	Question	Answers offered	Answers of students	
			Numerical data	Percentage data (%)
1.	The study program attended by the student	Opened question	-	-
2.	The year of study	The first The second The third	35 15 8	60.3% 25.9% 13.8%
3.	Subject to be taken	Opened question	-	-

The third part of survey questionnaire, table 3, was designed to deal exclusively with platform for taking exams or colloquia. From questions to which respondents- students gave an answer that is interesting for this research, we will single out a few:

To the question "Have you encountered this way of communication via computer (Internet) between teachers and students in your previous education" only 5 students (8.6%), figure 7, gave a positive answer, four of whom are satisfied with the results achieved on the test. All 5 students had a positive attitude regarding the use of computers for taking exams or colloquia.

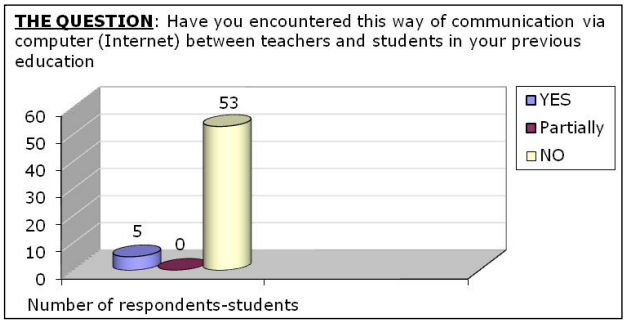


Figure 7. *Communication between teachers and students using computers (Internet)*

Analyzing the answers to the question: "Are you for taking exams or colloquia in the traditional (classical) way or for taking platforms", as many as 81% of student respondents said that platform gives priority to taking exams or colloquia. 19% of them voted for the traditional (classic) way of taking exams or colloquia (face-to-face or classic tests).

Also, this question was supplemented by additional scales of 1-4, namely: 1 - expression of knowledge, 2 - motivation, 3 - communication with teacher, 4 - availability of test results where respondents stated which criterionthey prefer over traditional (classical) way of taking an exam or colloquium or through a platform.

Figure 8 shows the answer to this question.

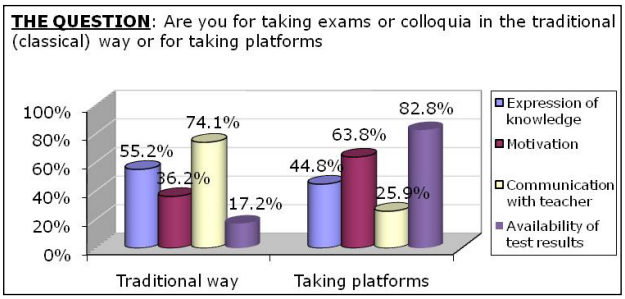


Figure 8. *The relationship between traditional (classical) way of taking an exam or colloquium or through a platform*

Table 3. *The third part of survey questionnaire*

No.	Question	Answers offered	Answers of students	
			Numerical data	Percentage data (%)
1.	Are you satisfied with the quality of the computer equipment used for taking the exam or colloquium through the platform	Yes No	41 17	70.7 29.3
2.	Have you encountered this way of communication via computer (Internet) between teachers and students in your previous education	Yes No	5 53	8.6% 91.4%
3.	Are you for taking exams or colloquia in the traditional (classical) way or for taking platforms	Traditional way Taking platforms	11 47	19% 81%
	1 - expression of knowledge	Traditional way Taking platforms	32 26	55.2% 44.8%
	2 - motivation	Traditional way Taking platforms	21 37	36.2% 63.8%
	3 - communication with teacher	Traditional way Taking platforms	43 15	74.1% 25.9%
	4 - availability of test results	Traditional way Taking platforms	10 48	17.2% 82.8%
4.	Indicate the extent to which computer skills are required to take the exam or colloquium through the platform	Open question	-	-
5.	Your suggestions on how students can be motivated for the idea of taking an exam or colloquium through platform	Open question	-	-
6.	How did this way of taking an exam or colloquium via platform affect you?	Open question	-	-
7.	List the advantages/disadvantages of taking the exam or colloquium through the platform	Open question	-	-
8.	Are you in favor of upgrading platform for taking exams or colloquiums and for other scientific fields in all study programs?	Yes No	51 7	87.9% 12.1%
9.	Can this kind of examination take root in our country?	Yes No	35 23	60.3% 39.7%
10.	Are you aware that other Academies of Applied Studies in the Republic of Serbia use this way of taking exams or colloquia	Yes No	5 53	8.6% 91.4%
11.	Questions about the quality of platform-software (average value of all three parts of question)	Yes Partially No	140 14 20	80.5% 8% 11.5%
	1 - the software is fast enough	Yes Partially No	47 3 8	81% 5.2% 13.8%
	2 - the layout of software commands is logical	Yes Partially No	42 9 7	72.4% 15.5% 12.1%
	3 - it is easy to switch from one question/task to another	Yes Partially No	51 2 5	87.9% 3.5% 8.6%

Based on the obtained results, we can conclude that the biggest difference was achieved on scale 4 - the availability of test results, where as many as 82.8% of student respondents preferred the platform. What is interesting to point out is that respondents-students for scale 3 - communication with teacher gave preference to the traditional (classical way) of taking exams or colloquia (74.1%). This is not surprising because communication with the computer is unavailable in relation to the available living words of teachers and students.

Based on figure 8, we can conclude that student-respondents have largely preferred to take exams or colloquia via platforms in relation to the traditional (classical) way. This is because online testing has significant advantages in terms of ease of use, reliability, speed of availability of test results, data management, etc.

To the question "Are you aware that other Academies of Applied Studies in the Republic of Serbia use this way of taking exams or colloquia" respondents-students in large numbers (91.4%) answered that they are not familiar, while 8.6% of respondents-students answered that they are familiar with the manner of taking exams or colloquia at other Academies of Applied Studies in the Republic of Serbia.

The last question in the questionnaire referred to the quality of platform-software used to test the

knowledge of student-respondents for taking exams or colloquia and consisted of three parts: 1 - the software is fast enough, 2 - the layout of software commands is logical and 3 - it is easy to switch from one question/task to another. Figure 9 graphically shows responses of respondents-students to this question (the graph is a sublimation of all three parts of question).

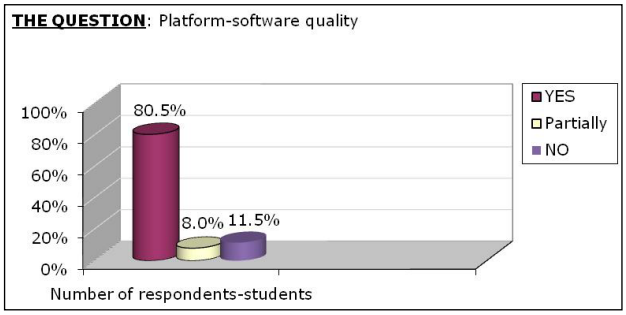


Figure 9. *Platform-software quality (average value of all three parts of question)*

Based on figure 9, we can conclude that respondents-students are very satisfied with the quality of platform-software because the highest percentage, 80.5% of them answered in affirmative. Only 11.5% of student respondents are dissatisfied with the quality of software platform, while 8% are partially satisfied.

Students gave similar answers to open questions. Based on given answers, we can draw conclusion that respondents-students highlighted as a special advantage the fact that they are already familiar with various software packages (platforms) and the use of Internet, which contributes to increasing their motivation in learning and taking courses in the field of electrical and computer engineering. ("I certainly spend a lot of time at the computer, so it's often easier for me to learn a lot").

Comparing the obtained results of this research with research of other authors [2], [11], [12], we conclude that the answers are in direct correlation. Almost the same conclusions are reached, the most significant of which is that today many tests have been developed to assess students' knowledge, which are performed with the help of computers.

The main advantages of this way of assessing students' knowledge are: individual test for each individual, increased test security (because it is not known which questions the student will get), the possibility of setting the time and setting a wide range of different types and difficulty of questions, faster testing while achieving of the same level of confidence, giving accurate results for students with a wide range of knowledge, etc.

5. CONCLUSION

Students' knowledge is usually tested in higher education institutions in the traditional (classical) way, either orally or through tests on paper. However, recently, the test of knowledge with help of computers has become topical, where many ready-made tests for taking exams or colloquia in various fields are available.

Based on the analysis of surveyed students who took exams or colloquia in certain subjects in the field of electrical and computer engineering through this type of platform, we can conclude that it has received a positive response and that it is necessary to hire more professionals to upgrade it for others scientific fields in all study programs studied at the Academy of Applied Studies of Kosovo and Metohija, Department Uroševac – Leposavić.

This reaffirmed the slogan that information and communication technologies are indispensable in today's era of informatics and that they have taken precedence in all spheres of education.

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Cyber Security in Education

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Abstract: *This paper presents an analysis of basic knowledge about cyber security in the education of high school students (from the first to the fourth grade of high school) and undergraduate students. The focus of the research is determining knowledge about cyber security, as well as identifying the desire of respondents to learn more about cyber security. The respondents were students of the Gymnasium and Technical School in Čačak and undergraduate students of the Information Technologies study program at the Faculty of Technical Sciences in Čačak, University of Kragujevac. An analysis of the conducted research on cyber security in education was carried out. Based on the results of the research, a discussion was given and conclusions were drawn in order to improve knowledge about cyber security in education.*

Keywords: *cyber security; education; survey.*

1. INTRODUCTION

Today's children have been surrounded by the Internet since childhood and have absolutely no fear of it, while, on the contrary, modern technologies cause fear in many adults. The fear of the dark, which has been characteristic of man since the paleolithic, is quite rational: our distant ancestors knew that if they went out into the forest at night, they could very likely be eaten by predators. What happens when you go online?

Children should be told about threats on the Internet, because the number of cybercrimes, is constantly increasing from year to year. Children should be taught to be "correctly afraid of the Internet" - that is, based on the knowledge of how the Internet works and how criminals can act, what stupid things they can do out of their own ignorance, and how to avoid it. The main thing that children need to understand and remember is that it is not the technologies themselves that are dangerous, but the people who use them for unscrupulous purposes. In the course of technological progress, only the tools of criminal change (improve), while their human nature remains unchanged.

New technologies are spreading so fast that textbooks and educational programs have a hard time keeping up with them, it has learned on the fly. Undergraduate students mainly use the Internet to solve the most primitive tasks - to communicate on social networks, watch videos, and much more. Just because students are constantly online doesn't mean they have a proper understanding of how to best use digital tools. Without a doubt, the digitalization of educational institutions is inevitable.

Clearly, cyber security for students is a growing concern. Do students need strict supervision when using digital devices? Do they need to be taught basic cyber security skills as early as possible? What is the students awareness of basic cyber security knowledge? These are the questions that need to be answered.

This survey aims to survey youth aged 15 to 22 to identify their knowledge and awareness of cyber security. A survey was developed on the topic "Cyber Security". 290 students of the Gymnasium in Čačak and the Technical School in Čačak and 96 undergraduate students of the Information Technologies study program at the Faculty of Technical Sciences (FTN) in Čačak, University of Kragujevac participated in the survey.

The aim of this paper includes the following:

- Investigate the basic knowledge of cyber security among students of the High School in Čačak, the Technical School in Čačak, and undergraduate students of the IT study program at the FTN in Čačak, University of Kragujevac;
- Identification of desire for respondents to learn more about cyber security.

2. RELATED RESEARCH

The ability to prevent successful cyberattacks on a nation's critical infrastructure depends on the availability of a skilled cyber-literate workforce, and thus an education system that can build such capabilities. Initiatives should include strengthening educator training and cybersecurity academic programs, as well as championing research (and development) capabilities and cybersecurity awareness. Recent revisions in the

higher education system of Ecuador and India offer a timely opportunity to advocate for the improvement of academic cybersecurity competencies [1,2].

Cyber security is of increasing importance due to the increasing reliance on digital equipment and software to manage our daily lives, including the transmission and storage of personal information. Research shows that an effective security awareness program is one of the most important steps toward increasing cybersecurity. The authors of study [3] began to monitor the current level of safety awareness among students and high school students in order to develop a module that will help raise their awareness.

There is a problem that internet users are still not aware of online risks. In one study, respondents were involved in the development of educational videos related to cyber risk topics using a storytelling approach. The participants in this study were teachers who were pursuing a master's degree in resource and information technology. The researchers came to the conclusion that it is of great importance to take into account the experience of the respondents, when planning and developing digital stories about cyber risks [4,5].

Despite the fact that the Internet has a positive effect on people's lives, there have been negative problems related to the use of the Internet. The authors found in their research that the level of awareness among Internet users is still low or moderate. One of the vital measures that should be taken is nurturing the knowledge and awareness of Internet users from an early age, i.e. from early childhood. Young children, especially, must be educated to operate in a safe manner in cyberspace and to protect themselves in the process. In the paper, the researchers analyzed why it is so critical that modern undergraduate students are educated about the risks associated with cyberspace. The researcher's proposal is to discuss how cyber security education can be implemented in schools through several strategies [6].

Awareness of cyber security is not only knowledge but also the transformation of learned things into practice. It is a continuous process that needs to be adjusted in subsequent iterations to improve usability as well as maintainability. This is only possible if the cyber security awareness program is reviewed and evaluated in a timely manner. The review and evaluation of the awareness-raising program offer insight into the effectiveness of the program on the audience and the organization, it is an invaluable piece of information for the continuous improvement of the program [7].

3. RESEARCH ORGANIZATION

This research uses a survey as a data collection tool. The survey was organized in such a way as to identify the level of knowledge about the cyber security of the students of the Gymnasium in Čačak, the Technical School in Čačak, and students of the Information technologies at the FTN in Čačak, University of Kragujevac. Research data were collected using an online survey.

The questions were created in order to achieve the previously mentioned objectives. The survey consists of 20 closed-ended questions. The other questions were demographic questions. The estimated time for filling out the survey is 15 to 20 minutes.

Questions are grouped into topics for easier identification, namely: private cyber security, cyber security knowledge, and cyber security in education. The questions were adapted to suit the age group of the respondents. In this paper, the questions of what knowledge about cyber security the respondents have been analyzed.

Figure 1 shows a schematic view of the planned research.

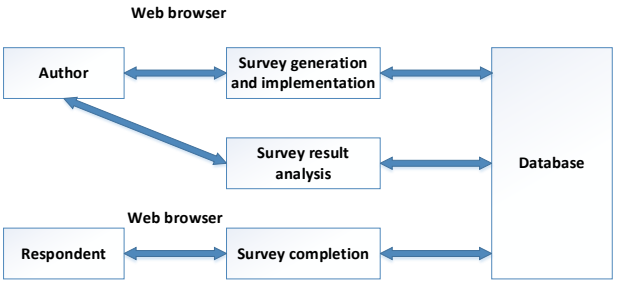

Figure 1. *Planned research*

4. RESULTS AND DISCUSSION

In order for respondents, students of the Gymnasium in Čačak and the Technical School in Čačak and students of the Information Technologies study program at FTN in Čačak, to be able to access the survey, a link to the survey was created using Google docs, and then distributed to them. The survey lasted for three months before it was closed, a total of 386 valid respondents completed the survey with no missing data. Other respondents missed the survey or left some questions blank, so they were filtered and deleted. Therefore, a total number of 386 respondents, 290 pupils, and 96 undergraduate students were used for this analysis.

4.1. Demographic data

Demographic data include age and gender, respondents are divided into two age groups:

- Group A: high school students in the final year, i.e. 4th year (born in 2003) and students (born in 2000, 2001, and 2002);
- Group B: first, second and third-grade high school students (years of birth 2004, 2005, and 2006).

Figure 2 shows the number of respondents by gender and age.

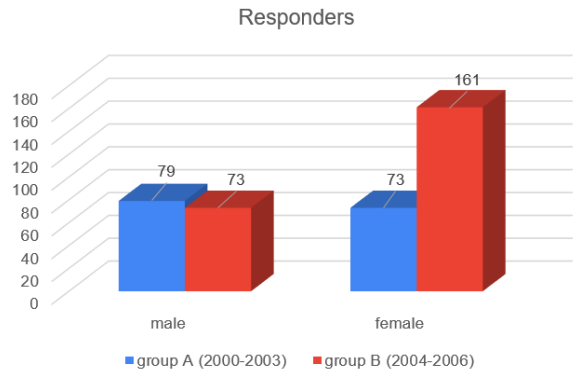

Figure 2. *Research participants by gender and age*

A total of 152 male respondents and 234 female respondents participated in the research. The number of men is similar in both groups, in the group of older respondents (group A - from 2000 to 2003) the number is 79, while in the group of younger respondents that number is 73 (group B - from 2004 to 2006), while the number of female respondents in group B is more than twice as high as in group A (161 compared to 73). Figure 2 shows that in age group A, men and women are equally as likely to learn or respond to cyber security awareness surveys (79 and 73). In the younger strict group (group B), the number of female respondents is twice as high as the number of male respondents (161 and 73), from which we can conclude that female respondents aged 2004-2006 are more interested in cyber security, that is, they want to learn about this issue.

4.2. Cyber security knowledge

The question "Do you consider yourself knowledgeable about cyber security?" was asked to find out the current level of awareness of students. Figure 3 shows the statistics of respondents' responses to this question.

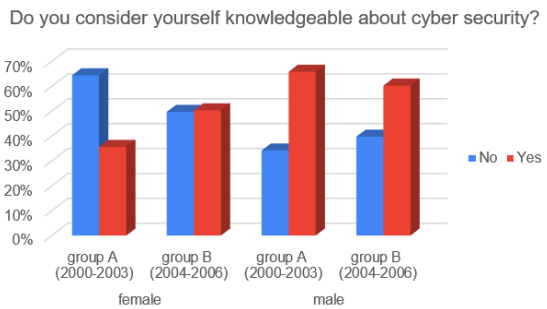

Figure 3. *Answers to Cyber Security Knowledge*

Figure 3 shows that among male respondents, almost two-thirds (63.2%) of students have some basic idea of what cyber security is, and this percentage is the same for both groups (65.8% and 60.3%). A little less than 50% of female respondents (45.7%) were informed about cyber security, while among younger students (group A) as many as 64.4% of them were not informed about cyber security, which confirms the conclusion about the greater interest of female students of this age group. groups.

With the question "Did you know the difference between using HTTP and HTTPS protocols?", the respondents had an additional explanation of what is the primary difference between these two protocols, so that they could confidently answer (Yes/No) to this question. Figure 4 shows the respondents' answers to this question.

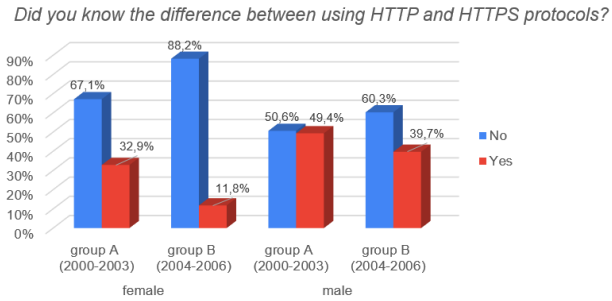

Figure 4. *Answers to the question about the difference between HTTP and HTTPS protocols*

A very small percentage of female respondents (81.6%) know the difference between HTTP and HTTPS protocols, while even 88.2% of female respondents from the younger group B do not know the difference between these two protocols. In men, the results are better, 44.7% of them know the primary difference between these two protocols, while almost 50% of group A men (50.6%) do not know the difference.

To the question "Did you know what (2FA) is and do you use it?", respondents could choose one of the three offered options: I do not know; I know what it is, but I don't use it; I know what it is, and I use it. As with the previous question, there is an explanation of what Two-Factor Authentication (2FA) is. Figure 5 shows the answers to this question.

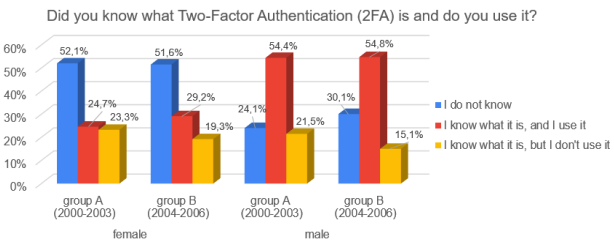

Figure 5. *Answers to the question about Two-Factor Authentication*

As with the difference between the two protocols, and with the question about Two-Factor Authentication, female respondents are much less familiar than men with this method of protection, I not know was answered by 51.7% of women, while the percentage of men was 27 %. An almost equal number of men from both groups (54.4% and 54.8%) know what 2FA is and use (I know what it is, and I use it) this protection process.

To the question "Did you know the meaning of the term phishing by now?" Have you been a victim of "phishing?" respondents could choose: I know what that means, I was not a victim; I know what that means, I don't know what that means, I wasn't a victim; I don't know what that means, I was a victim. The concept of fishing was also explained to the respondents. The answers to this question are given in Figure 6.

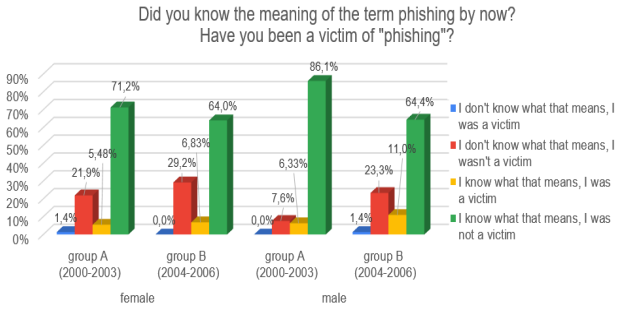

Figure 6. *Answers to the question about phishing*

Respondents of both sexes are familiar with the concept of phishing, for men that percentage is 84.2%, while for women it is 72.6%. Among them, the youngest male students (11.0%) were most exposed to phishing. A total of two people were exposed to phishing without knowing it was phishing.

To the question "Do you want to learn more about cyber security?", a large percentage of respondents declared that they want to learn more about cyber security, women slightly more than men, 75.2% compared to 66.5%. Figure 7 shows the answers to this question.

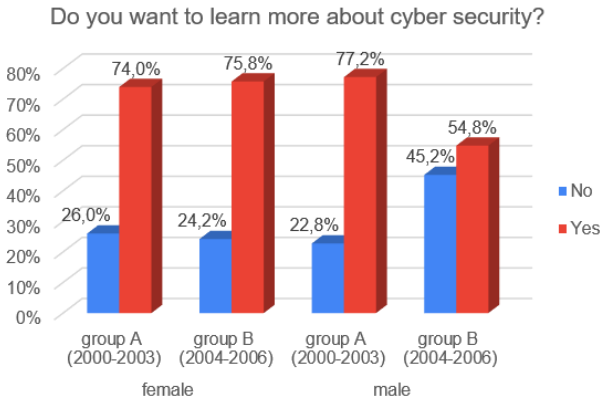

Figure 7. *Answers to the question of whether respondents want more information about cyber security*

To the question "At what age, in your opinion, can children register on social networks?" respondents could choose 4 ages: I can even 9 years ago; from 10 to 12 years; from 13 to 15 years old; over 15 years. The answers are given in Figure 8.

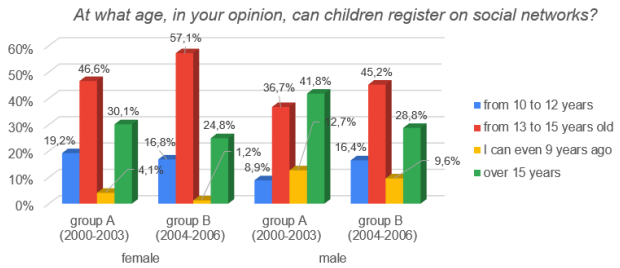

Figure 7. *Answers to the question of when children can register on social networks*

Respondents believe that the age of 13 to 15 is the best age for registering on social networks, only the male respondents of group A (younger students) believe that the limit should be moved to 15 years. A higher percentage of male than female respondents believe that children can register on social networks even before the age of 9 (11.2% compared to 2.1%).

5. CONCLUSION

Pupils and students need to understand cyber security and the most effective way to promote understanding is through active learning. Although pupils and students develop a high level of awareness of some cyber security issues, such as cyberbullying, sharing of personal information, and online banking, little information is given to them about other cyber attacks.

School administrations can establish cyber security organizations, such as various educational workshops, student clubs, or councils in the school. In this way, pupils and students can receive guidance from their teachers to learn more about cyber security. According to [8], students will learn how to navigate the learning management system. It is very important that teachers, parents, and the Government be more proactive in educating students about these areas.

Media, such as television and radio, must also play an important role in educating children through cyber security campaigns because such campaigns are more interactive and interesting for students to understand. Security awareness raising is one strategy that can promote cyber security education in school.

Based on the analysis of the research results, the following conclusions were established:

- it is very important to protect children through cyber security education,
- it is important that high school and college students are aware of the potential risks they face when using internet communication, such as social media, chat and online games.

There are several challenges to cybersecurity education. These include the level of teacher knowledge, lack of teaching expertise, funding, and resources. It is of great importance for all relevant parties, including teachers, parents, peers, and the Government, to work together to find the best

solution to protect of high school students and undergraduate students from cybercrime and cyberbullying, through cyber safety education in schools.

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Teaching and learning inspired optimization algorithms: A review

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Abstract: Social Human Behaviour algorithms are the next step in nature inspired algorithms development. In the past decade these are proved to be useful for various optimisation tasks. The paper provided a global preview of existing algorithms of this kind and focused on two specific algorithms, inspired by teaching and learning process: Teaching-Learning Based Optimization and Group Teaching Optimisation algorithms. The algorithms' structure and flow are thoroughly explained and illustrated. A preview of algorithms' application is reported, based on the recent research. It is concluded that this kind of algorithms can be aplied in various industry areas and that further research in this field is reqired.

Keywords: *TLBO; GTO; algorithm; teaching; learning*

1. INTRODUCTION

Some of nature-inspired algorithms that have been developed in the last 30 years are inspired by social human behavior and their interaction. Humans, as the most intelligent beings, perform various activities in different ways and find a problem solution. This has inspired various scientists to use it to develop different algorithms to optimize the various tasks that people solve. Some algorithms are based on the inspiration of learning and teaching that is performed in educational systems. There are different variations of algorithms and their implementations are also diverse. Applications of these algorithms are in manufacturing systems, control systems, energy systems, robotics, logistic, etc [1]. Algorithms are applied in order to optimize certain processes and there are a large number of scientific papers that show their application. Hybrid algorithms are also used, which combine several algorithms and thus improve various processes [1].

2. THEORETICAL BACKGROUND

There are a number of algorithms that are based on social human behavior. These algorithms are inspired by human interaction, walking, running, speaking, thinking, politics, teaching, learning,…

Every human has their own way of performing specific activities that affect their output. This has motivated many researchers to develop these types of algorithms [2]. Popular human based algorithms are presented in Table 1.

In this paper, we will explain two similar algorithms based on teaching and learning, Teaching-Learning Based Optimization (TLBO) algorithm and Group Teaching Optimization (GTO) algorithm. Popular human-based algorithms are presented in Table 1.

Table 1. *Social Human Behavior algorithms*

Algorithm Name	Acronym	Year
Adolescent Identity Search Algorithm	AISA	2020
Anarchic society Optimization	ASO	2012
Brain Storm Optimization Algorithm	BSO.2	2011
Bus Transportation Algorithm	BTA	2019
Collective Decision Optimization Algorithm	CDOA	2017
Cognitive Behaviour Optimization Algorithm	COA.3	2016
Competitive Optimization Algorithm	COOA	2016
Community of Scientist Optimization Algorithm	CSOA	2012
Cultural Algorithms	CA	1999
Duelist Optimization Algorithm	DOA	2016
Football Game Inspired Algorithms	FCA.1	2009
FIFA World Cup Competitions	FIFAAO	2016
Golden Ball Algorithm	GBA	2014
Global/Best Brain Storm OA	GBSO	2017
Group Counseling Optimization	GCO	2010
Group Leaders Optimization Algorithm	GLOA	2011
Greedy Politics Optimization Algorithm	GPO	2014
Group Teaching Optimization Algorithm	**GTOA**	**2020**
Human Evolutionary Model	HEM	2007
Human Group Formation	HGF	2010
Human/Inspired Algorithms	HIA	2009
Ideology Algorithm	IA	2016
Imperialist Competitive Algorithm	ICA	2007
Kho-Kho Optimization Algorithm	KKOA	2020
League Championship Algorithm	LCA.1	2014
Leaders and Followers Algorithm	LFA	2015
Old Bachelor Acceptance	OBA	1995
Oriented Search Algorithm	OSA	2008
Parliamentary Optimization Algorithm	POA	2008
Queuing Search Algorithm	QSA.1	2018
Social Behaviour Optimization Algorithm	SBO.1	2003
Social Cognitive Optimization	SCO	2002
Social Cognitive Optimization Algorithm	SCOA	2010
Social Emotional Optimization Algorithm	SEOA	2010
Stochastic Focusing Search	SFS	2008
Soccer Game Optimization	SGO	2012
Soccer League Competition	SLC	2014
Team Game Algorithm	TGA	2018
Teaching-Learning Based Optimization	**TLBO**	**2011**
Tug of War Optimization	TWO	2016
Unconscious Search	US	2012
Volleyball Premier League Algorithm	VPL	2017
Wisdom of Artificial Crowds	WAC	2011

3. TLBO ALGORITHM

The TLBO algorithm is based on the results of teacher's influence on student knowledge. Teachers

are expected to have the best knowledge of the subject they teach and to educate students with their hard work. When this interaction between teachers and students is over, students enter into communication with other students to further improve the acquired knowledge [3].

The algorithm consists of two phases (Fig. 1):

- teacher phase and
- student phase.

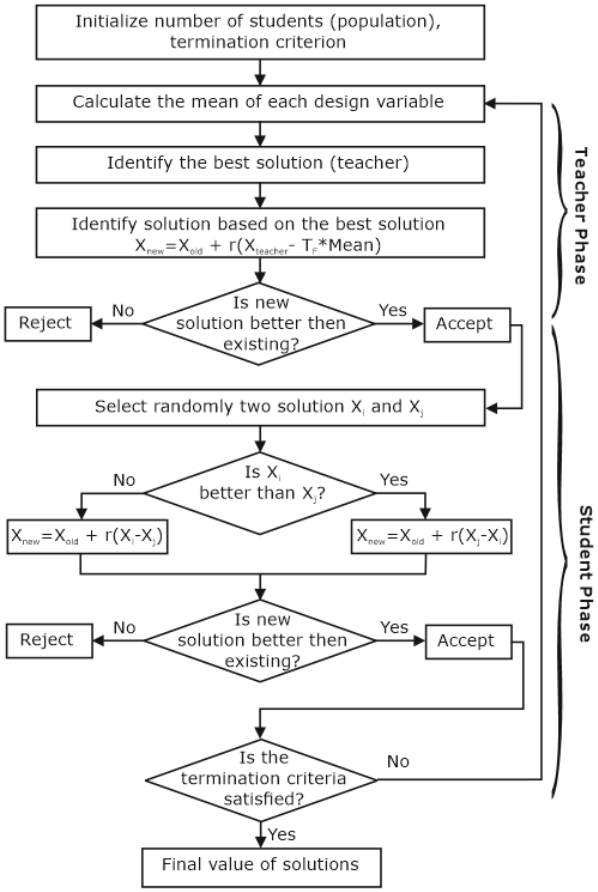

Figure 1. *Flowchart of TLBO algorithm*

3.1. Teacher phase

In this phase, students increase their knowledge during the teacher lecture. The professor tries to teach the students the material that is intended to be learned in that lecture. The professor is expected to be an expert in that field, and the students' grades will show how effective his lecture was. In this case for the i-th student is defined according to the following formula [4]:

$$Xnew_i = Xold_i + rand * (Teacher - Tf * Mean) \quad (1)$$

$$Mean = \frac{1}{NP} \sum_{i=1}^{NP} X_i \quad (2)$$

$$TF = round\,[1 + rand(0,1)] \quad (3)$$

where $Xnew_i$ = new state of the student receive in the lecture phase,

$Xold_i$ = old state of student,

$Teacher$ = best teacher,

Tf = teaching factor which will be 1 or 2,

$Mean$ = mean value of student group.

The student accepts the new state only if his/her grades have improved, if this is not the case then learning is dismiss and the student keep hold of the previous state of $Xold$.

3.2. Student phase

During this phase, students improve their knowledge by learning from each other, for example student X_i learns from randomly chosen student X_j, where i ≠ j holds. Depending on which student is better, the learning formulas apply [5]:

$$Xnew_i = Xold_i + rand * (X_i - X_r) \quad (4)$$

$$Xnew_i = Xold_i + rand * (X_r - X_i) \quad (5)$$

where $Xnew_i$ = new position of i-th student,

X_r = randomly selected student from the selected group,

$rand$ = randomly generated number in the interval [0,1].

As with the lecture phase, the better student between the selected and randomly generated student will be selected and a new teacher phase will continue when the learning phase is over.

4. GTO ALGORITHM

The GTO algorithm (GTOA) aims to improve group of student knowledge using the group learning method and is based on rules [6]:

- Each student's ability to accept knowledge is different. The greater the difference between the students in the group, the greater the challenge for teachers in producing a curriculum.
- A good teacher usually pays more attention to students with a weak ability to accept knowledge.
- The student can expand their knowledge alone during extracurricular time, or in interaction with other students.
- A good teacher allocation mechanism is very helpful in improving student knowledge.

Group teaching approach are employed by developers. It uses different formats as teaching methods, like grouping of abilities, grouping of various abilities or/and different ages, etc. Education aims to enable students (learners) not only to acquire get knowledge, but also to become able to learn throughout life. Learning is more likely to be effective when the student plays a proactive role within the learning process. Strategies are determined by the topic being taught, and based on the character of the student.

It is definitely complicated to implement group teaching in practice due to the different talents

among students. To regulate group teaching to be suitable for use as an optimization technique, we first assume that student population, fitness value, and decision variables, correspond to the worst, average, and best group of students, subjects offered to students, and student knowledge.

The GTOA tool includes a group of computer intelligence techniques that provides an interface that permits students to practice the learned theory, as well as to verify and compare the characteristics of optimization methods [7].

This algorithm consists of four phases presented in Fig. 2:

1. Ability grouping phase
2. Teacher phase
3. Student phase
4. Teacher allocation phase.

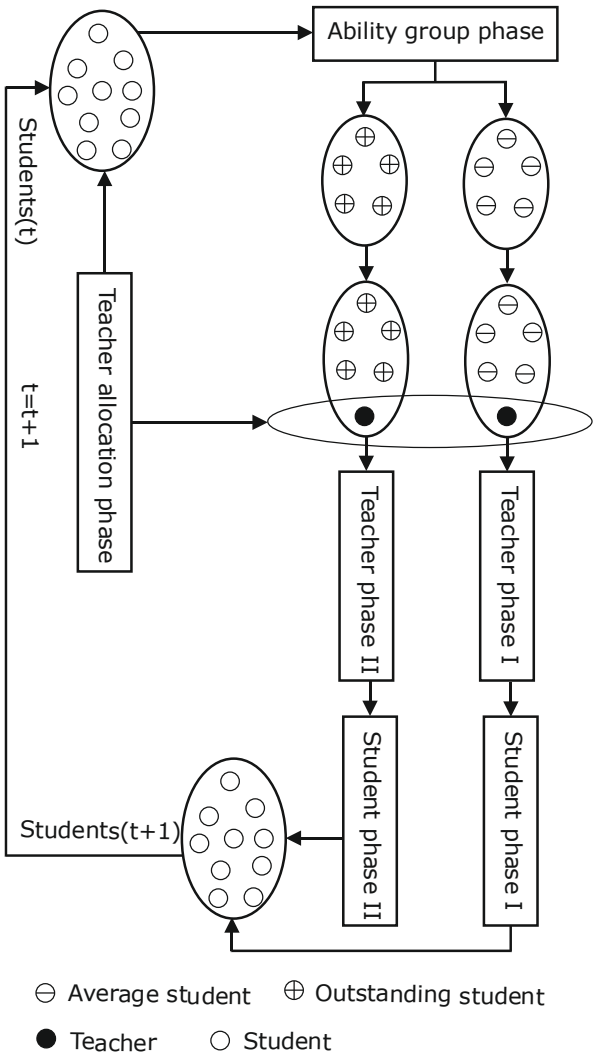

Figure 2. *Phases for implementation of GTOA*

4.1 Ability grouping phase

To better show the feature of group teaching, all students are divided into two small groups according to their ability of accepting knowledge in GTOA. These two groups are equally important in GTOA. Thus, the two groups have the same number of students. One group with strong ability of accepting knowledge can be called outstanding group. Another group with poor ability of accepting knowledge can be called average group. The proposed GTOA determine that outstanding group has more knowledge than average group. It is easier for the teacher to adopt ability grouping method rather than traditional teaching method in terms of making the teaching plan. The teaching activities are larger in average group then in outsourcing group to achieve the same results. The ability of grouping is a dynamic process in GTOA, which is performed again after a learning cycle [8].

4.2. Teacher phase

Teacher phase means one student learns knowledge from his or her teacher, which corresponds to the defined second rule. The teacher makes different teaching plans for average group and outstanding group in the proposed GTOA.

Teacher phase I: In view of the strong ability of accepting knowledge, a teacher focuses on improving the knowledge of the outstanding group as a whole in the proposed GTOA as done in TLBO [6]. More specifically, the teacher can try his or her best to improve the mean knowledge of the whole class. In additional, the differences of accepting knowledge among students also need to be considered. Thus, the student of the outstanding group can gain his/her knowledge by

$$\boldsymbol{x}_{teacher,i}^{t+1} = \boldsymbol{x}_i^t + a \times (T^t - F \times (b \times \boldsymbol{M}^t + c \times \boldsymbol{x}_i^t)) \quad (4)$$

$$\boldsymbol{M}^t = \frac{1}{N}\sum_{i=1}^{N} \boldsymbol{x}_i^t \quad (5)$$

$$b + c = 1 \quad (6)$$

Where is:
t - the current number of iterations,
N - the number of students,
$\boldsymbol{x}_i^t$ - the knowledge of student i at time t,
T^t - the knowledge of teacher at time t,
$\boldsymbol{M}^t$ - the mean knowledge of this group at time t,
F - the teaching factor that decides the teaching results of the teacher (can be either 1 or 2),
$\boldsymbol{x}_{teacher,i}^{t+1}$ - the knowledge of student i at time t by learning from teacher,
a, b and c - the random numbers in the range [0,1].

Teacher phase II: Considering the poor ability of accepting knowledge, a teacher pays more attention to the average group than outstanding group based on the second rule, who tends to improve the knowledge of the students from the perspective of individuals [6]. Thus, the student of the average group can gain his or her knowledge by

$$\boldsymbol{x}_{teacher,i}^{t+1} = \boldsymbol{x}_i^t + 2 \times d \times (\boldsymbol{T}^t - \boldsymbol{x}_i^t) \quad (7)$$

Where d is a random number in the range [0, 1]. In addition, one student may not gain knowledge by the teacher phase, which can be addressed by (take the minimum problem as an example)

$$x_{teacher,i}^{t+1} = \begin{cases} x_{teacher,i}^{t+1}, f\left(x_{teacher,i}^{t+1}\right) < f(x_i^t) \\ x_i^t,\ f\left(x_{teacher,i}^{t+1}\right) \geq f(x_i^t) \end{cases} \quad (8)$$

4.3. Student phase

The student phase including the Student phase I and the Student phase II corresponds to the mentioned third rule. During spare time, one student can gain his or her knowledge by two different ways: one through self-learning and the other through interaction with other students, which can be expressed as

$$\begin{gathered} if\ f\left(x_{teacher,i}^{t+1}\right) < f\left(x_{teacher,j}^{t+1}\right) \\ x_{student,i}^{t+1} = x_{teacher,i}^{t+1} + e \times \left(x_{teacher,i}^{t+1} - x_{teacher,j}^{t+1}\right) + g \times \left(x_{teacher,i}^{t+1} - x_i^t\right) \\ if\ f\left(x_{teacher,i}^{t+1}\right) \geq f\left(x_{teacher,j}^{t+1}\right) \\ x_{student,i}^{t+1} = x_{teacher,i}^{t+1} - e \times \left(x_{teacher,i}^{t+1} - x_{teacher,j}^{t+1}\right) + g \times \left(x_{teacher,i}^{t+1} - x_i^t\right) \end{gathered} \quad (9)$$

Where are:
e and *g* - random numbers in the range [0,1],
$x_{student,i}^{t+1}$ - the knowledge of student *i* at time t by learning from the student phase,
$x_{teacher,j}^{t+1}$ - the knowledge of student *j* at time *t* by learning from the teacher.
As for the student *j (j ∈ {1, 2, …, i − 1, i + 1, …, N}),* student is randomly selected. In Eq. (9), the second item and the third item on the right mean learning from the other student and self-learning, respectively. In addition, one student may not gain knowledge by the student phase, which can be addressed by (take the minimum problem as an example)

$$x_i^{t+1} = \begin{cases} x_{teacher,i}^{t+1}, f\left(x_{teacher,i}^{t+1}\right) < f\left(x_{student,i}^{t+1}\right) \\ x_{student,i}^{t+1},\ f\left(x_{teacher,i}^{t+1}\right) \geq f\left(x_{student,i}^{t+1}\right) \end{cases} \quad (10)$$

Where are:
x_i^{t+1} - the knowledge of student *i* at time *t+1* after a learning cycle.

4.4. Teacher allocation phase

It is difficult task to improve the knowledge of students. Also, it is important to make a good teacher allocation. The teacher allocation in proposed method can be expressed as

$$T^t = \begin{cases} x_{teacher,i}^{t+1},\ f\left(x_{first}^t\right) \leq f\left(\frac{x_{first}^t + x_{second}^t + x_{third}^t}{3}\right) \\ \frac{x_{first}^t + x_{second}^t + x_{third}^t}{3},\ f\left(x_{first}^t\right) > f\left(\frac{x_{first}^t + x_{second}^t + x_{third}^t}{3}\right) \end{cases} \quad (11)$$

Where are:
$x_{first}^t, x_{second}^t, x_{third}^t$ - the first, second and third best students, respectively.
In order to accelerate the convergence of the proposed GTOA, outstanding group and average group share the same teacher.

4.5. Implementation of GTOA for optimization

In the following, the step-wise procedure for the implementation of GTOA is given and GTOA is explained with the aid of the flowchart in Fig. 3. [6].

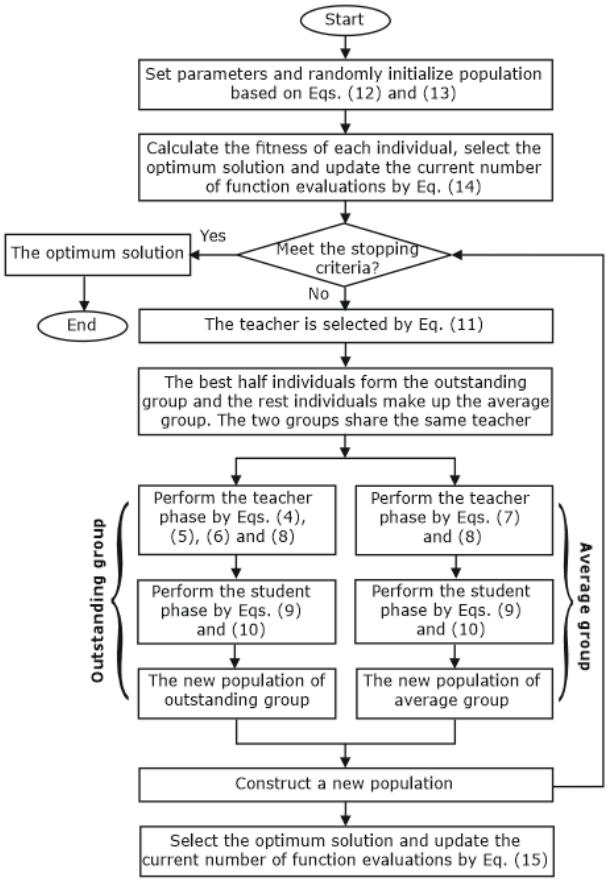

Figure 3. *Flowchart of GTO algorithm*

Step 1: Initialization parameters and population. These parameters include:
T_{max} - the maximum number of function evaluations,
$T_{current}$ ($T_{current}=0$) - the current number of function evaluations,
N -population size,
l - the lower bounds of design variables,
u - the upper bounds of design variables,
D - dimension of problem and
f(•) - fitness function.
A random population $\boldsymbol{X}^t$ is generated on the basis of the initialization parameters, which can be described as

$$X^t = [x_1^t, x_2^t, \dots, x_N^t]^T = \begin{bmatrix} x_{1,1}^t & x_{1,2}^t & \dots & x_{1,D}^t \\ x_{2,1}^t & x_{2,2}^t & \dots & x_{2,D}^t \\ \dots & \dots & & \dots \\ x_{N,1}^t & x_{N,2}^t & \dots & x_{N,D}^t \end{bmatrix} \quad (12)$$

$$x_{i,j}^t = l_i + (u_i - l_i) \times k \quad (13)$$

where *κ* is a random number in the range [0, 1].
Step 2: Population evaluation.
The optimal solution $\boldsymbol{G}^t$ is selected and the fitness values of individuals are calculated. The current number of function evaluations $T_{current}$ is updated by

$$T_{current} = T_{current} + N \quad (14)$$

Step 3: Termination criteria.

If the current number of function evaluations $T_{current}$ is greater than the maximum number of function evaluations T_{max}, the algorithm stops and the optimal solution $\boldsymbol{G}^t$ is outputted. Otherwise, go to Step 4.

Step 4: Teacher allocation phase.

The first three best individuals are selected. Then the teacher T^t is calculated by Eq. (11).

Step 5: Ability grouping phase.

The student population is distributed into two groups based on the fitness values. The best half of individuals form the outstanding group and the rest individuals become the average group. These two groups share the same teacher. The outstanding group and the average group are marked as $\boldsymbol{x}_{good}^t$ and $\boldsymbol{x}_{bad}^t$, respectively.

Step 6: Teacher phase and student phase.

For the group $\boldsymbol{X}_{good}^t$, the teacher phase is implemented based on Eqs. (4), (5), (6) and (7). Then the student phase is conducted according to Eqs. (9) and (10). Finally, the new population $\boldsymbol{X}_{good}^{t+1}$ is obtained. For the group $\boldsymbol{X}_{bad}^t$, the teacher phase is implemented based on Eqs. (7) and (8). Then the student phase is conducted according to Eqs. (9) and (10). Finally, the new population $\boldsymbol{X}_{bad}^{t+1}$ is obtained.

Step 7: Construct population. The population $\boldsymbol{X}_{good}^{t+1}$ and the population $\boldsymbol{X}_{bad}^{t+1}$ compose a new population $\boldsymbol{X}^{t+1}$.

Step 8: Population evaluation. The fitness values of individuals are calculated and the optimal individual Gt is selected. The current number of function evaluations Tcurrent is updated by

$$T_{current} = T_{current} + 2N + 1 \quad (15)$$

Then Step 3 is executed.

5. COMPARISON OF TLBO AND GTO ALGORITHMS

Like GTOA, TLBO is also inspired from the teaching phenomenon in the classroom. A fundamental difference between TLBO and GTOA is that TLBO and GTOA imitate traditional teaching and group teaching, respectively. More specifically, their differences can be summarized as follows [6]:

1. In the teacher phase, GTOA considers the differences of accepting knowledge among students to make two different teaching methods as shown in Eqs. (2) and (5). However, TLBO uses the same teaching method for all students, which neglects the differences of accepting knowledge among students.
2. In the student phase, GTOA uses self-learning and interaction with other students to gain knowledge while TLBO only concerns the interaction with other students.
3. The ability grouping phase is introduced to GTOA, which is the distinct feature of the proposed GTOA. However, TLBO has not this phase.
4. The best student is regarded as teacher in TLBO while GTOA defines a teacher allocation mechanism related to the first three best students.

6. REVIEW OF GTO AND TLBO ALGORITHMS IMPLEMENTATION

The application of algorithms inspired by learning and teaching is diverse from the application in solving complex robot movements, scheduling processes in various types of systems, production systems, etc. The main goal of the implementation of these algorithms is to optimize a complex problem in order to reduce cost, time of production, procurement of spare parts, etc.

The implementation of TLBO and GTO algorithm is presented in Table 2 [10-15].

Although the GTO algorithm was developed in 2020, it has found applications in various fields of optimization in industry and technology.

Table 2. *The implementation of TLBO and GTO algorithm*

Application & Reference	Discussion
Mechanical design problems [1]	The method is tested on five different benchmark test functions with different characteristics, four different benchmark mechanical design problems and six mechanical design optimization problems which have real world applications. The effectiveness of the TLBO method is compared with the other population based optimization algorithms based on the best solution, average solution, convergence rate and computational effort. Results show that TLBO is more effective and efficient than the other optimization methods for the mechanical design optimization problems considered.
Engineering application [10]	The book offers a valuable resource for the development and usage of advanced optimization algorithms. TLBO algorithm can be used to solve continuous and discrete optimization problems in the fields of computer engineering, electrical engineering, manufacturing engineering, civil engineering, structural engineering, electronics engineering, mechanical design, thermal engineering, physics and biotechnology.
Balancing multi-objective two-sided assembly line [11]	Two-sided assembly line is designed to produce high-volume products such as trucks, cars, and engineering machinery. In this paper is considered minimization of the total relevant costs per product unit, maximization of the line efficiency, and minimization of the smoothness index. The proposed algorithm is tested on the benchmark instances and a practical case. Experimental results, compared with the ones computed by other algorithm and in current literature, validate the effectiveness of the proposed algorithm.

Power generated in ships using renewable sources [12]	In this paper is described minimization of total harmonic distortion in multilevel inverter (MLI) has been taken as an optimization problem and is solved using TLBO. MLI is a popular power electronic converter producing the desired output voltage from several DC input voltage sources like solar panels, batteries, and supercapacitors. The TLBO algorithm is applied to compute the optimum switching angles for MLI to produce the required fundamental output voltage with less harmonic distortion. This research outcome bears testimony to TLBO optimization's efficiency in improving the quality of the power generated in ships using renewable sources.
Resource-constrained project scheduling problem [13]	The main objective is the minimization of the makespan or total project duration. The TLBO algorithm has been used as additional features to enhance its exploration and exploitation capabilities. An activity list-based encoding scheme has been modified to include the resource assignment information because of the multi-skill nature of the algorithm. In addition, a genetic algorithm (GA) is also developed in this work for the purpose of comparisons. The computational experiments are performed on 216 test instances with varying complexity and characteristics generated for the purpose.
Unmanned aerial vehicle route planning [14]	This paper is considered constructs a 3-D flight environment model with multiple obstacles, and designs a novel diversified GTO algorithm for the generation of flight routes of unmanned aerial vehicles. In the environment model, a variety of obstacles are taken into consideration to make the flying scenarios more realistic. In the proposed algorithm, three novel teaching methods are introduced to balance the exploitation and exploration phases. The constraints are incrementally added to the fitness function to avoid the premature phenomenon in the initial iteration stage of algorithm. The experimental results show that the proposed algorithm is significantly superior and can always generate the optimal flight route in complicated environments.
Multi-product disassembly line balancing problems [15]	Remanufacturing systems play significant roles in end-of-life product recovery, environment protection and resource conservation. Disassembly is treated as a critical step in remanufacturing systems. Designing and applying highly efficient intelligent optimization algorithms to handle a many complex problems in the disassembly process. Here is presented a stochastic multi-product disassembly line balancing problem with maximal disassembly profit with disassembly time requirements. An enhanced GTO algorithm incorporating a stochastic simulation method is developed by considering developed model's features. Via performing simulation experiments on real-life cases is verify the excellent performance of the designed method in solving the real problem.

7. CONCLUSION

The implementation of optimization algorithms has a widespread application in various fields of science. Algorithms inspired by learning and teaching have emerged relatively recently, but their application is reflected in various aspects [16], from application in robot motion control, selection of optimal vehicle routing problems, to application in manufacturing systems, civil engineering [17], software development system, scheduling problem [18], logistics [19] and other important systems for the science development. These algorithms can be further improved to help solve various problems that require reduced production time, cost or human resources in performing various tasks.

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Mathematical Modeling in Digital Environment and its Implications on Teaching and Learning Extreme Values and Functions' Monotonicity

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Abstract: *In this paper, we present a way of introducing teaching and learning method based on the principles of mathematical modeling empowered by digital technologies. The role of mathematical modeling in educational practice is discussed as also the implications of the realization of mathematical modeling in a computer environment. In the example of teaching Extreme values and functions' monotonicity, step by step procedure of making a mathematical model is explained – from starting preparation, to implementing GeoGebra as the software tool. The experiences of students and teachers during and after learning and teaching using mathematical modeling in the GeoGebra environment were supportive concerning further implications of this method.*

Keywords: *Mathematical modeling, GeoGebra, Extreme values, Functions*' monotonicity

1. INTRODUCTION

Computer technologies are present in education for quite some time. However, recently emerged new conditions and restrictions concerning pandemics, which imposed new demands on teachers, students, and the educational process itself.

The teaching methods had to be adaptable not only to the classroom but also to the online and hybrid teaching and learning process. The teaching materials had to be adapted in order to, in some way, simulate the real conditions and to have visual and dynamical elements with which could be manipulated and experimented.

For that purpose, we decided to use mathematical modeling, especially realized in a computer environment, mostly because of our previously good experiences with it [1].

On the example of teaching Extreme values and functions' monotonicity, we described the application of mathematical modeling realized in GeoGebra environment. The modeling process and the use of GeoGebra options are described in detail, as also the reactions of students.

2. MATHEMATICAL MODELING

Mathematical modeling is a mapping between reality and mathematics. The purpose of the mathematical model is reflected in drawing conclusions about reality based on the model. The most important for a mathematical model is that it represents a basis for drawing conclusions about reality which can then be tested experimentally.

2.1. Mathematical modeling in education

The role of mathematical modeling is very significant, viewed from the standpoint of education. The need for the application of mathematical modeling in the educational process is mostly reflected in the fact that students leave schools and colleges with a relatively high level of theoretical knowledge, but are not adequately prepared for the application of that same knowledge in practice. The modern business and economic interests of employers require students to be prepared and trained to solve problems from real practice, which means that they must be ready at all times to adapt to new situations and the tasks they entail. This means that those from schools and colleges must leave as better-trained experts.

Taking into account that mathematical modeling is a technique of teaching based on connecting real-life problems with their mathematical representation, it can be considered a tool for illustrating mathematical content and for motivating students for learning and application of gained knowledge.

2.2. Mathematical modeling process

Establishing a relationship between mathematics and the real world is actually a process of mathematical modeling. The modeling process is not rather complicated and there are

different approaches and points of view concerning the modeling phases, i.e. modeling cycle [2].

The most common mathematical modeling cycle consists of several phases, which are: selection of a real-world situation that will be modeled, based on the selected real situation the real-world problem is observed, a mathematical model based on the real-world problem is made and a mathematical solution is derived from the mathematical model. If the solution is accepted, a report about it is made. If not, we can do a revision of the modeling process, and the mathematical model itself.

The modeling processes used for educational purposes are constantly improved, especially good results are achieved by combining mathematical modeling with computer technologies.

3. DIGITAL ENVIRONMENT AND MATHEMATICAL MODELING

Due to the complexity of the mathematical modeling process, there is a general opinion that it should be realized with the application of computer technologies [3]. It is considered that the best results are obtained when mathematical modeling is combined with the application of computer technologies because computers add a visual dimension. The contribution of computer technologies is reflected in the ability to quickly generate a large number of examples that students can explore and examine the relationships that exist between them. Working with dynamic displays with the use of interactive tools is even more effective because it gives students the opportunity to manipulate mathematical objects, which greatly facilitates the process of mathematical modeling.

3.1. GeoGebra as a digital tool for mathematical modeling

In this paper, we presented the use of GeoGebra software as the support for the modeling process. GeoGebra is dynamical mathematical software that can be used for implementing various mathematical theories. The main characteristic of GeoGebra, when considering its application for educational purposes, is its simplicity of use, and low teacher training demands. But nevertheless, this is very powerful software, with the possibility to respond to all requests of the user, especially when used in the mathematical modeling process. The dynamical nature of GeoGebra is one of the main reasons for being the most used software in the modeling process because GeoGebra can describe real-life problems through animations and simulations, and at the same time build a mathematical representation of the considered problem.

Also, we used GeoGebra because it enables a direct connection between the visual/dynamical contents and its mathematical representation. In that way, students are becoming familiar with formal mathematics' language and at the same time, they can see how it is connected with the meaning of the real-life problem and how it represents mathematically.

Today, GeoGebra represents software that is constantly present at all levels and in many areas of education, especially in the teaching of mathematics and natural sciences [4]. The positive results of using GeoGebra have been confirmed in the teaching and learning of mathematics at all levels of education which is one of the main reasons why this software was chosen to implement the modeling process [1], [5].

4. LEARNING EXTREME VALUES AND FUNCTIONS' MONOTONICITY USING MATHEMATICAL MODELING AND GEOGEBRA

The application of mathematical modeling using computer technologies and GeoGebra will be demonstrated on the example of teaching and learning extreme values and functions' monotonicity.

4.1. The modeling process

To describe the real-world situation that was used for modeling, a part of a popular cartoon was used in which its main character moves up and down and during that movement passes through positions corresponding to his highest/lowest achieved height. The story that was used for the real-world situation is based on a famous cartoon (more precisely one of its parts from 1 min 40 s to 2 min 20 s) where the main character Coyote the Genius (wolf) tries to catch the Road Runner Bird (Wile E. Coyote and The Road Runner–Beep Beep, 1952).

First, the teacher showed the cartoon to the students on YouTube:

(https://www.youtube.com/watch?v=132XmBjsOiE).

The wolf in the cartoon is trying to cross a wire strung between two hills, while holding an anvil in his hands. Due to the weight of the anvil, the wire stretches, lowering the wolf to the ground. The moment the wolf touches the ground, it drops the anvil and, since it is on a wire, is launched into the air. For a certain period of time, it flies up through the air, slows down, reaches a maximum, and then begins to fall down. In the end, because he fails to open the parachute, the wolf falls to the ground, (Fig. 1).

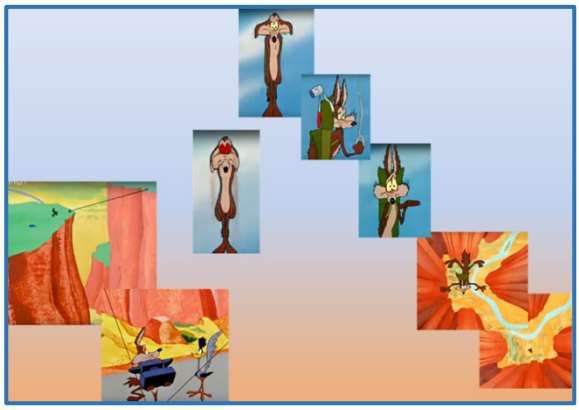

Figure 1. *Cartoon story*

After the students saw the cartoon, the teacher posed the real problem that corresponds to the situation being modeled.

The real problem: Model the movement of a character from a cartoon, that is, mathematically represent and describe his movement.

The students concluded that they should first find a function that corresponds to the two-dimensional representation of the wolf's trajectory. However, many students commented that the cartoon did not provide them with any information that could help them obtain the required function. The teacher then, in order to help the students, said that they could observe the function on the interval $[0,10]$ and assume the following: that the wolf at the beginning of its movement was at the position corresponding to the coordinates $(0,8)$, after for a few moments it was at the position with coordinates $(2,0)$, and then passed through the point $(5,9)$. It completed its movement when it fell to the ground, at the point $(10,0)$. The students used GeoGebra, they imported points A, B, C and D into GeoGebra and applied the GeoGebra option *Polynomial*. In this way, they came up with a mathematical model of the wolf's path (Fig. 2).

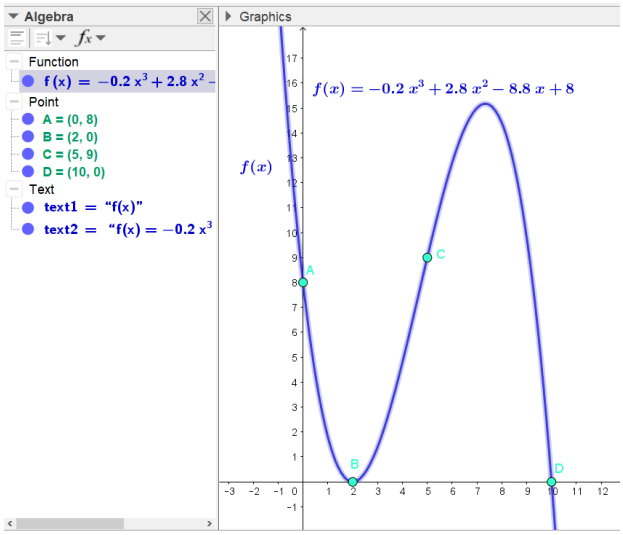

Figure 2. *The mathematical model of the path*

Continuing the modeling process, the students added images of individual frames from the cartoon to the GeoGebra material they had created up to that point, in order to additionally illustrate the movement of the character, (Fig. 3).

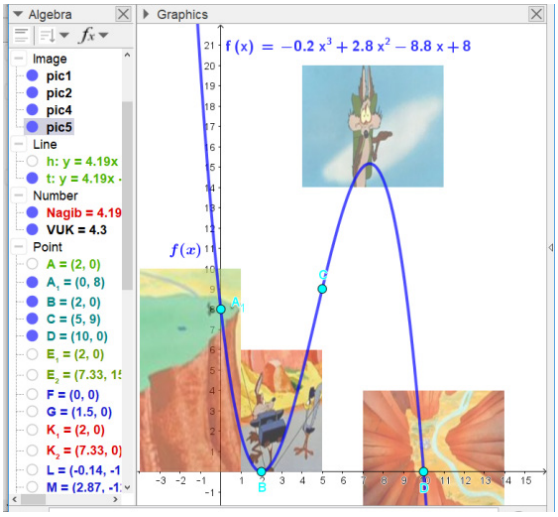

Figure 3. *Illustrated path*

In order to further model and experiment with the movement of the wolf, the students continued the development of the GeoGebra material by using the opportunity to add another window, activating the GeoGebra options *View→Graphics 2*. In the second window, they extracted the path function f and limited its display to the observed interval $[0,10]$ because they wanted to observe only the movement of the wolf from the starting point $A(0,8)$ to the point $T(10,0)$ when they considered that it finally fell to the ground and completed its movement, (Fig. 4). The point $T(10,0)$ was obtained by the students using the GeoGebra option *Intersect* (intersection of the function f and the Ox axis).

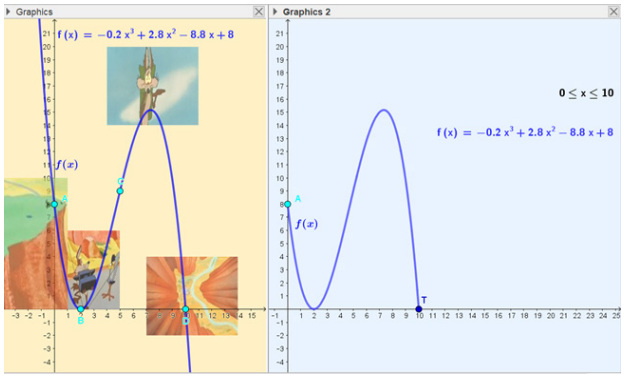

Figure 4. *Dual window representation of the path function*

The students then observed what happens to the slope when the wolf moves along the function f. For this purpose, they added a GeoGebra option *Slider* (marked with VUK) on the second graphic,

the purpose of which was to move the point that would represent the wolf according to the function f. Also, they tied the tangent t on the function f to the slider at the point representing the wolf and turned on the *Slope* option for the slope of the tangent, and displayed everything within the first and second graphs, (Fig. 5).

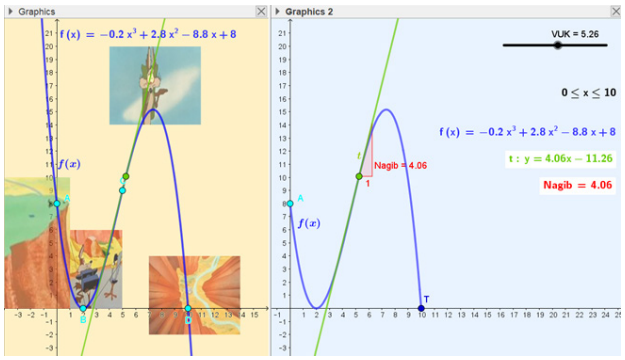

Figure 5. *The movement of the wolf according to the function f, the tangent t, and its slope at the points of its positions*

By moving the slider, the students could observe the movement of the cartoon character and the slope values. In that way, they noticed that the slope of the tangent to the function f is positive when the wolf is moving up, and when it is moving down, the slope has a negative value.

Next, they used GeoGebra's Derivative option to draw the derivative function from the function f and *then* observed how *the* changing sign of the slope affects the derivative function f', (Fig. 6).

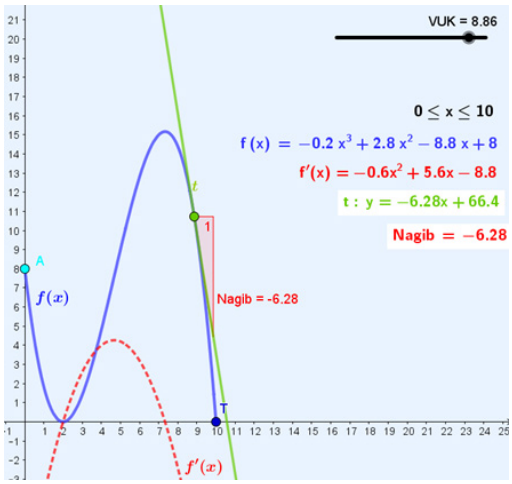

Figure 6. *The derivative function f' and the sign of the slope of the tangent t*

By comparing the sign of the slope of the tangent t to the function f and the sign of the derived function f', after a short experiment with the GeoGebra material they created, the students concluded that the positive sign of the slope of the tangent t appears when the wolf moves up, i.e. when the sign of the derived function is f' is positive and vice versa (negative slope – the wolf moves down – the sign of the derivative function is negative).

Further, the students used GeoGebra again and the *Intersect* option, which they now applied to the derived function f' and the Ox axis. From GeoGebra, the students read the coordinates of the intersection points of the derivative function f' and the Ox axis: K_1 (2,0) and K_2(22/3,0), (Fig. 7).

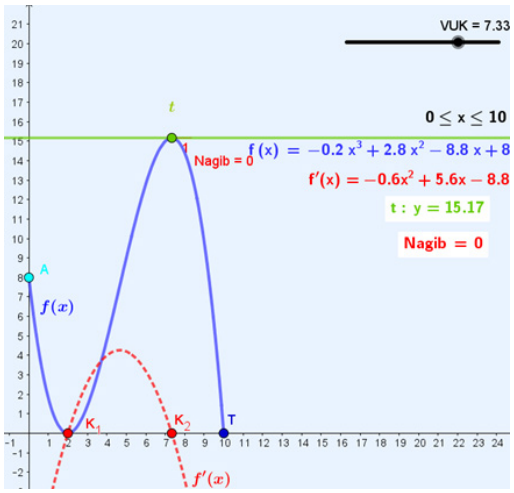

Figure 7. *Zeroes of the derivative function f' (intersection of the derivative function f' and the Ox axis)*

Observing the points K_1 and K_2 and the subintervals they determine on the interval $[0,10]$ and analyzing the sign of the derived function, the students came to a part of the mathematical solution to the real problem, that is, they could determine the intervals in which the wolf moves up/ down.

Furthermore, the students observed the function f and the slope of its tangents near the points $(2, f(2))$ and $(22/3, f(22/3))$. They noticed that the slope of the tangent of the function f changes its sign near the observed points (that is, the wolf goes up to each of the observed points and then down, or vice versa). Then they entered the mentioned points into the GeoGebra material, and by analyzing the graphic representation of the function f concluded that these points correspond to its extreme values: the minimum (point E_1) and the maximum (point E_2) on the observed interval $[0,10]$, (Fig. 8).

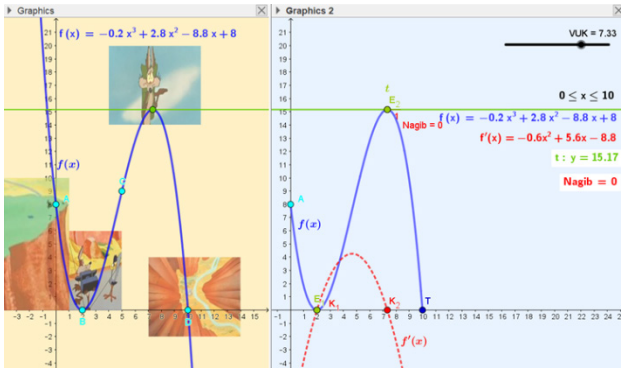

Figure 8. *Extreme values of function f and slope of the tangent at point* E_2

Connecting all the conclusions reached during the previous modeling process related to the up/down movement of the wolf, the sign of the derived function f' and its zeroes, as well as the tangents to the function f at its points, the students came to the mathematical solution of the situation from the real world they have modeled. The mathematical solution to the posed real problem is presented in Table 1.

Table 1. *The mathematical solution of the real problem*

Interval	$[0,2)$	$(2,\frac{22}{3})$	$(\frac{22}{3},10]$
The sign of the function f'	-	+	-
Functions monotonicity	↘	↗	↘
Extreme value	$E_1(2,0)$ min		$E_2(\frac{22}{3},f(\frac{22}{3}))$ max

The mathematical model and mathematical solution were accepted after being previously validated in GeoGebra.

5. REMARKS AND DISCUSSION

The presented process of mathematical modeling in the GeoGebra environment illustrates the work with students in the processing of the topic: Extreme values and functions' monotonicity. The impressions of the students during and after the modeling process were positive, emphasizing that this type of teaching and learning suits them much more than the classical one, in the sense that connecting the teaching content with real situations enables better learning and understanding, which actually achieved the goal of the application of the mathematical modeling.

The students marked one detail as very useful and interesting, the possibility to use the material in their own time and to access it multiple times. In their words, they could practice and experiment with different functions and by it, learn the application of the functions' monotonicity and the nature of extreme values.

The teachers also had very positive experiences with this material, and it was used for teaching in a few high schools by different teachers who all agreed that this material was of great help in realizing the teaching process. The teachers also commented that the results of students' achievements were at a satisfactory level during the online teaching process and connect these good results with the application of mathematical modeling and GeoGebra.

These kinds of materials, based on both, mathematical modeling and realized in GeoGebra, are to be even more present in the teaching and learning process, online and in the classroom, because of the good experiences of teachers who used them and on demand of our students.

6. CONCLUSION

Finding the most appropriate way of teaching which will lead to optimal learning results can be very challenging, especially if one of the goals is to transfer functional knowledge to our students.

Also, the recent conditions concerning pandemics have greatly influenced to change and adaptation of educational methods.

Mathematical modeling proved to be a highly efficient method for teaching mathematics and sciences precisely because of its feature to connect real-world situations with its mathematical representations. The digital environment has intensified the modeling capabilities as it enabled faster and simpler manipulation of objects and added a dynamic effect through simulations and animations.

The students accepted mathematical modeling as a teaching and learning method and their impressions are more than positive. The teachers also confirmed the benefits of modeling, concerning both, the easier realization of the teaching process and the better achievements of students.

Future plans include the further adaptation of the curriculums to the application of mathematical modeling and sharing good practice with our colleagues.

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Teaching Quadratic Functions in Classroom and Online Using Mathematical Software Tools

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Abstract: *In this paper, we present our experience and the materials used for teaching quadratic functions in the classroom and online. For the purpose of the research, we developed dynamical teaching materials prepared using mathematical software GeoGebra. The GeoGebra material for the quadratic function is discussed and described in detail. The experiences of the students and teachers concerning the used GeoGebra material are also presented in the paper. The results and impressions during the application of this material, in the classroom and online, were positive with the implications for further improvement and future applications.*

Keywords: *quadratic function; GeoGebra; dynamical materials*

1. INTRODUCTION

Digital technologies have a significant impact on education, educational content, methods, and techniques, curricula, and programs, as well as on the entire organization of teaching and learning. In modern education, the question is no longer whether digital technologies should be applied, but the main task is to find optimal solutions for how and in what way to apply new technologies in teaching practice, in order to improve the quality of teaching and make learning more efficient.

Taking into account the new situation related to the pandemics, new conditions and restrictions have been imposed regarding the realization of the teaching process. Digital technologies have gained even more importance and their application has significantly contributed to the quality of teaching and learning in the conditions of hybrid and online education [1].

Teaching materials should be adapted to new conditions and types of teaching. On the example of the realization of the theme: Quadratic function, we have shown one way of integrating digital technologies into teaching. For the needs of teaching and learning, we have developed dynamical teaching material using GeoGebra mathematical software and described how it can be applied in different teaching conditions.

The impressions and reactions of students and teachers to the proposed GeoGebra material were discussed and further guidelines were given for the improvement and application of this type of material in teaching and learning.

2. GEOGEBRA SOFTWARE

GeoGebra is a dynamical mathematical software that combines elements of geometry, algebra, analysis, statistics, probability, and spreadsheets, so it can be applied to study a wide range of different mathematical topics. GeoGebra has exceptional educational potential and can be implemented at all levels of education, from preschool to university.

The following features of this software are especially important for teaching and learning mathematics: the use of multiple representations, visualization, dynamics, and interactivity. In the GeoGebra environment, mathematical objects are created using appropriate tools and are displayed in multiple representations: graphical, algebraic, and numerical. All representations of an object are dynamically linked and automatically change when any one of them changes. In addition, objects can be animated into a moving image - a dynamical visual representation. GeoGebra is a powerful tool for dynamical visualization and working with multiple representations and has the potential to actualize visual thinking and facilitate the connection of visual knowledge with the formal-symbolic language of mathematics [2].

The visual-dynamical and interactive functionality of GeoGebra software enables teachers to create a stimulating environment for studying functions [3]. GeoGebra is a cognitive tool that can take over the execution of procedural activities in less time, thus leaving students more time to make connections between different functions' representations, think critically, and build a better understanding of

concepts and ideas. This educational software has the potential to encourage active student participation through visual-manipulative activities, experimentation, interactive exploration, discussions, and collaborative learning

3. TEACHING QUADRATIC FUNCTIONS

The quadratic function is one of the required subjects studied in high school. It is of great importance for students to fully master the quadratic function, which means understanding its features and possible applications.

In our high schools, the teaching practice is to explain to the students the definition of quadratic function, give different examples, and show its different forms. The most common form used is:

$$y = ax^2 + bx + c \qquad a \neq 0. \qquad (1)$$

Then, we explain its features like its roots, the basic shape (parabola), vertex (minimum, maximum value), sign, monotonicity, and the shape concerning the cases when the parabola opens upward or downward.

To illustrate all these features to students we usually draw all the cases together, like it is shown in Fig. 1.

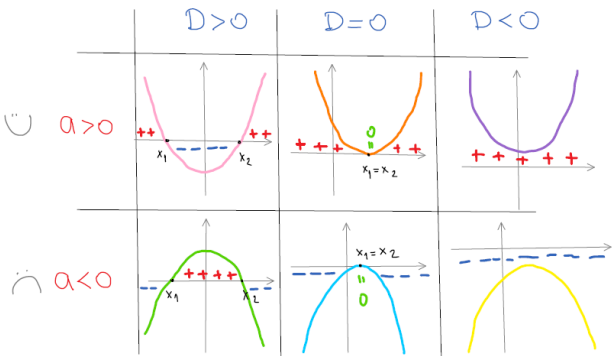

Figure 1. *Different cases of the quadratic function*

One of the most important requirements we put before students is that they properly understand the connection and dependency of coefficients $a, b,$ and c from the standard form (1). For that purpose, we encourage our students to practice by exploring various cases of quadratic functions and sketching their graphs.

Mostly, they were given tasks to sketch two different cases of a quadratic function on one paper, usually with the same roots but with different shapes (Fig. 2).

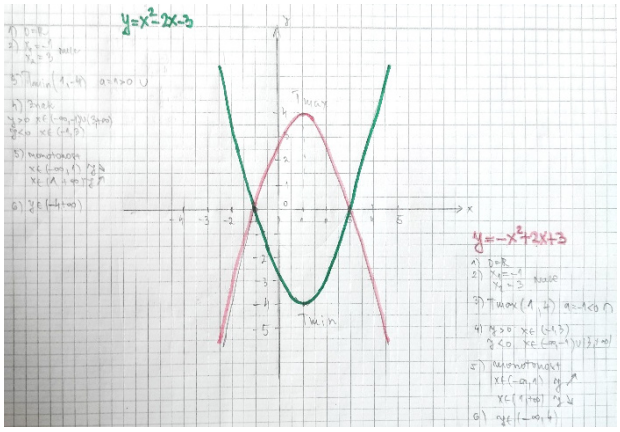

Figure 2. *Students' sketch of the quadratic functions*

In this way, the students can observe how changing the value of the coefficients $a, b,$ and c affects the change in the shape of the graph and the properties of the quadratic function.

The students are happy to solve tasks of this type, and when they practice examining and sketching function graphs in this way, they can later easily apply the acquired knowledge.

However, we always looked for more efficient methods concerning teaching and learning quadratic functions where the students could be more actively involved in the process of learning and where they could explore quadratic functions by manipulating the coefficients $a, b,$ and c, and observe the changes on the function graph at the same time.

Lately, especially considering teaching and learning in pandemic conditions, the search for more efficient methods became even more emphasized because we had to take into account not only learning in the classroom but also teaching and learning in online conditions.

4. METHOD

In order to improve the teaching of mathematics in high school, and taking into account the possible and available ways of teaching in the conditions of the pandemic, we tried to integrate mathematical software into the teaching to create additional learning materials.

4.1. GeoGebra-assisted quadratic function learning

The idea was to design dynamic materials using GeoGebra software because such materials give the possibility of changing parameters and manipulating them, and all of that can be displayed and experimented with in different cases. We already had positive experiences with GeoGebra dynamical materials in teaching mathematics and sciences online and in the classroom [1], [4], [5].

For the purpose of teaching and learning quadratic functions, we used the GeoGebra official website, where we have placed the dynamic quadratic function study material that we have created. Geogebra material is available for everyone to use and can be found at the following link:

https://www.geogebra.org/m/zjsg8tes

On the GeoGebra official site, our material for learning quadratic function is marked as the "*activity*", as shown in Fig. 3.

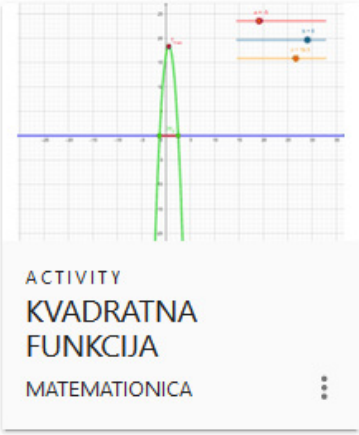

Figure 3. *Activity for learning quadratic function on the official GeoGebra website*

By clicking on the link for the activity, opens the dynamical material, shown in Fig. 4.

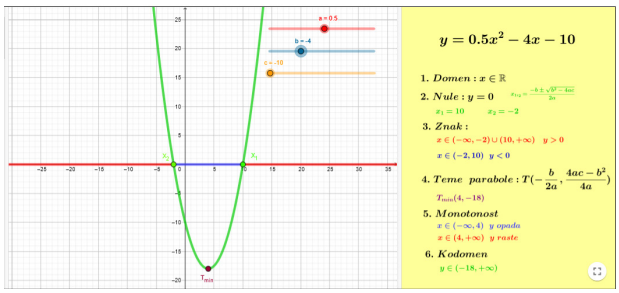

Figure 4. *Dynamical material for learning quadratic function*

It can be observed that this material consists of two windows. In the window on the left, there is a graph of the quadratic function, and in the upper right corner three sliders.

The sliders are the special feature of GeoGebra, constructed in order to enable the change of parameters values and by that gives the possibility to create dynamical materials.

In the case of the quadratic function material, we inserted three sliders, each one for the three coefficients $a, b,$ and c. By dragging the point on the slider, the value of the coefficient connected with this slider is changing (Fig. 5).

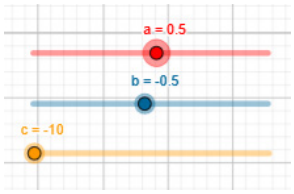

Figure 5. *Sliders for the quadratic function coefficients*

The window on the right contains all the features which correspond to the function from the left window like the expression of the quadratic function, roots, signs, vertex, monotonicity, etc. Fig. 6 shows the right window:

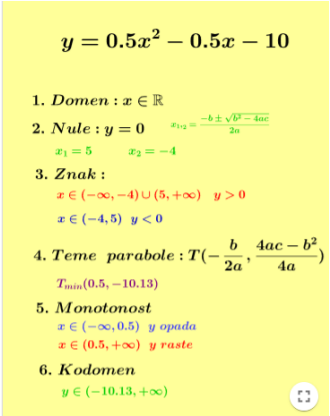

Figure 6. *The right window appearance*

It is important to emphasize that both windows are connected, meaning, that the change of parameters' values in the left window changes the functions' graph in the same left window, and simultaneously all the features of the function in the right window are changed.

In that way, many different cases of the quadratic function can be easily obtained and represented.

Case 1 ($a > 0, b > 0, c < 0$)

Case 1 is the standard example of the quadratic function. This is the case that illustrates the quadratic function with the two roots, vertex in minimum, its signs, and parabola opened upward. The students can also observe the values of the coefficients (Fig. 7).

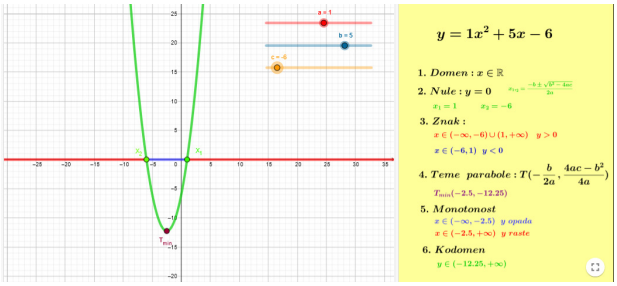

Figure 7. *Case 1 ($a > 0,\ b > 0,\ c < 0$)*

Case 2 ($a > 0$, $b < 0$, $c < 0$)

In Case 2 only one coefficient changed its value. The coefficients $a > 0$ and $c < 0$ did not change their signs, but the coefficient by x power one is now negative, $b < 0$ and the students can observe how the functions' graph and its features changed compared to Case 1 (Fig. 8).

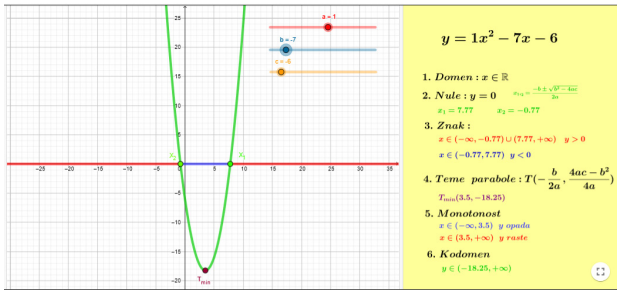

Figure 8. *Case 2 ($a > 0$, $b < 0$, $c < 0$)*

Case 3 ($a < 0$, $b < 0$, $c < 0$)

Case 3 illustrates what happens with the quadratic functions' graph when all the coefficients are negative (Fig. 9).

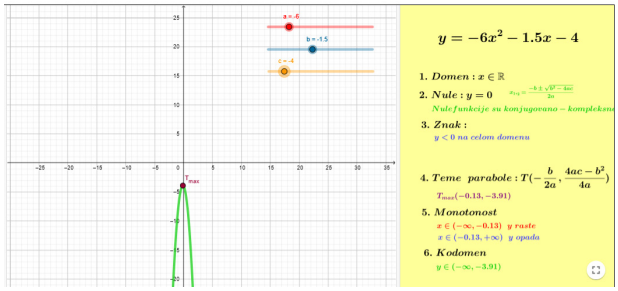

Figure 9. *Case 3 ($a < 0, b < 0, c < 0$)*

Case 4 ($a > 0$, $b < 0$, $c = 0$)

Case 4 illustrates the special type of quadratic function (whose roots are solutions of incomplete quadratic equations) where $c = 0$ (Fig. 10).

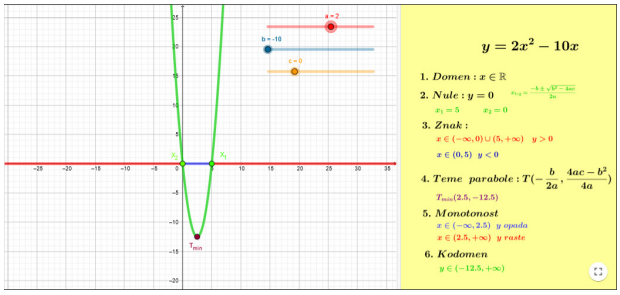

Figure 10. *Case 4 ($a > 0$, $b < 0$, $c = 0$)*

Case 5 ($a > 0$, $b = 0$, $c > 0$)

Case 5 illustrates the other special type of quadratic function (whose roots are solutions of incomplete quadratic equations) where $b = 0$ (Fig. 11).

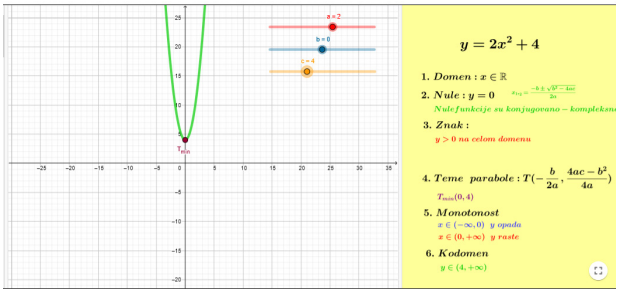

Figure 11. *Case 5 ($a > 0$, $b = 0$, $c > 0$)*

Of course, in addition to these cases, there are many others that can be generated in our GeoGebra material. The point is, that the material that we proposed can help students to experiment with the graph of a quadratic function in a simple way, only by moving the sliders for coefficients from the function. In that manner, the students can obtain the solutions and conclusions related to the quadratic function.

5. FINDINGS AND DISCUSSION

The presented GeoGebra material was primarily used for the purpose of online teaching, during pandemics. The material was developed for the personal use of the teacher, as additional material for the high school online mathematics course. At first, the material was sent to students only by email, but concerning teachers' positive impressions of using this material, it was decided to make it accessible to all teachers and students, and consequently, it was placed on the official GeoGebra site. It was noticed, that the material was used by many other mathematics teachers who also said that the material significantly helped them in the teaching process, online and in the classroom.

The students also had very positive impressions of this material. They especially emphasize the possibility of experimenting with the different values of coefficients and the instant sketching of the function graph and display of functions' features. They also commented that the possibility to access the material at any time helped them a lot in the organizing and planning of the learning process.

The observations of teachers were also in favor of using this material. First, they commented that the teaching process was more effective and the students were very active and more interested in the topic they learned when using GeoGebra material. Also, the teachers detected that the attitudes of the students toward homework and other learning responsibilities were better compared to the ones before. Also, the teachers noticed that the grades of the students remained at the same level, meaning that the GeoGebra dynamical material helped them to overcome the

obstacles that may have appeared during the online teaching and learning process.

Although this material is used in online teaching and learning during the pandemic, when we returned to the classrooms we also continued to use the same material as support for the regular teaching process as a response to our students' requests and to our positive experiences.

6. CONCLUSION

Finding the most appropriate way for teaching mathematics in high school can be very challenging, especially when the conditions are more than unusual, as we witnessed during the last two years of the pandemic.

It was of great importance to find the appropriate way, for the teaching process and for learning, so that the achievements of the students remain at a satisfactory level.

Contemporary software tools have proven to be of great help to teachers and students also. In teaching mathematics, specialized mathematical software, such as GeoGebra are particularly useful for teaching and learning mathematics because of its dynamic nature and the possibility for multiple representations.

We have presented and described the GeoGebra material that we have created and used for teaching quadratic function in high school. The experiences using GeoGebra materials were positive, concerning both, teachers and students. The students said that the GeoGebra material we have made for quadratic function helped them to better understand it, but most important of all, they emphasized that the opportunity to experiment on their own using this dynamical material helped them the most.

The students' and our positive experiences from the teaching and learning process using GeoGebra materials as support in the classroom and online, lead us to the conclusion that the implementation of mathematical software and dynamical materials can contribute in many ways to teaching and learning process.

In the future, we will continue with the implementation, improvement, and development of the digital materials and the software we use. Also, we will share our good practice with colleagues thru the exchange of experiences and materials we are yet to develop.

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Mathematica software graphical simulation of Iodine isotopes nuclear decay for teaching purposes

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Abstract: *The aim of this work is to show the simulation of the nuclear decay of Iodine isotopes using the Mathematica software package. The nuclear decay of Iodine occurs most often during nuclear accidents in various types of nuclear facilities, during which radioactive isotopes are produced. Radioactive Iodine isotopes lead to the manifestation of harmful side effects, but with the development of science, it has been established that some of them can be used for diagnostic purposes and to detect certain types of carcinoma. The software package itself makes it possible to actively change the parameters in real time that are characteristic for the nuclear decay of Iodine. Graphically by displaying the exponential curves for decayed and non-decayed nuclei, the ratio of the number of undecayed nuclei as a function of the elapsed time can be directly calculated. The model can be implemented in classes and enables students to better understand nuclear decay in the undergraduate courses of Physics, Physics 2 and Computer simulation of physical phenomena.*

Keywords: *Mathematica software; graphical simulation; nuclear decay; Iodine; isotopes*

1. INTRODUCTION

Radioactive isotopes of Iodine, which are produced as a result of nuclear decay, represent one of the main pollutants during nuclear processes and nuclear incidents. Nuclear incidents are occurrences of sudden and uncontrolled release and effects of ionizing radiation isotopes along with other accompanying phenomena. They are very often unintentional and arise as a result of the human factor (ignorance, carelessness, technical failures, outdated technology, non-observance of safety measures at work and others) [1]. Damages and breakdowns on nuclear reactors in nuclear power plant as well as other objects such as artificial satellites, containers with nuclear fuel and radioactive material lead to many ecological and biological unfathomable consequences [2-4].

Radioactive isotopes of Iodine are interesting from the aspect of our research, because they represent a potential source of pollutants during the nuclear process. Given properties such as high volatility, and therefore potentially high speed of spreading into the surrounding environment, radioactive isotopes of Iodine represent the primary danger of exposure to a radioactive cloud in the first stages of a nuclear accident. For example, in the first days immediately after the nuclear accident in Chernobyl, the dominant influence on the total measured radiation in the air was given by Iodine isotopes I-127 and I-131 [5].

There are 37 known isotopes of Iodine ($_{53}$I) from I-108 to I-144. All undergo radioactive decay except I-127, which makes Iodine a monoisotopic element [6].

The longest-lived radioactive isotope of Iodine is I-129, which has a Half-life ($T_{1/2}$) of 15.7 million years, which is too short to exist as a primordial nuclide. Most of the I-129 present on earth, made by man are an unwanted long-lived byproduct of early nuclear tests and accidents caused by uncontrolled nuclear fission [6,7].

It is important to note that in addition to side effects, some of the Iodine isotopes show great applicability in therapeutic practice and treatment. Decades of experience indicate that due to its beneficial properties due to its biophysical characteristics, I-131 compared to other isotopes has been used in the treatment of, above all, some kind of cancer, although it has been established that there may be certain harmful effects in addition to beneficial ones, which occur as a result of radiation damage to other tissues and organs [8]. Iodine isotope I-131 was used in the diagnosis and for the first time for the treatment of thyroid gland diseases in 1942 by Hertz and Roberts [9].

This radionuclide was introduced into clinical practice as a drug for the treatment of hyperthyroidism and some forms of cancer and it has an important role in detection of diseases [10-11].

Based on all of the above, the numerous negative but also positive properties of Iodine isotopes, and their application, various programs of simulative nuclear decay of Iodine are used. This program predicts the ratio of the number of decayed and

undecayed nuclei when different parameters are changed, such as the elapsed time, that is, the number of Half-lifes. It is also useful for students to better understand nuclear decay and can be applied in the undergraduate courses of Physics, Physics 2 and Computer simulation of physical phenomena.

2. SELECTION THE TYPE OF GRAPHICS PRESENTATION

For the simulation of the nuclear decay of the Iodine isotope, the *Mathematica* software package was selected, which is actively used in various undergraduate courses. *Mathematica* can also be used as a standalone programming language that supports procedural, functional and object-oriented constructions, because it has great connections to other program packages (C, JAVA, SQL, OpenOffice, Acrobat, etc). Also, a large number of simulations related to different physical phenomena were written in it [12].

Mathematica software package has various functions that we used to actively change the parameters of decay. It is particularly convenient to use a *Manipulate* function that allows students to actively change different parameters, such as:

- *Graphics* - there are *Plot* and *BarChart* graphical options;
- *Isotopes* - where the radioactive elements of iodine isotope are selected;
- *Starting number of nuclei N_0* - the initial number of nuclei;
- *Time (days)* – the elapsed time since the beginning of the measurement;
- *Half-life ($T_{1/2}$)* – which represents the time of semi-decay, i.e. the time it takes to decay half of the radioactive nuclei of the selected radioactive element;
- *Number of $T_{1/2}$* – number of Half-life at *BarChart* presentation graphics.

2.1. Choosing the type of Iodine isotope

At the beginning of the simulation, students have options to choose from *Plot* and *BarChart* graphical presentation (Fig. 1). *Plot* graphical presentation by function *Plot*, offers graphical display in the form of curves view of the number of remaining and decayed nuclei, while *BarChart* graphical presentation offers a so-called bar chart for graphical display of the remaining nuclei.

The next option offered to students is a selection of radioactive Iodine isotopes. The selection of isotopes that is performed on the drop-down list isotopes and brings with it a selection of different types of isotopes of radioactive Iodine $_{53}$I: I-124, I-125. I-126, I-130, I-131 and I-133 (Fig. 2). Each of these radioactive elements has different characteristics reflected in different $T_{1/2}$. They range from 0,515 days for I-130 to 59.4 days for I-125.

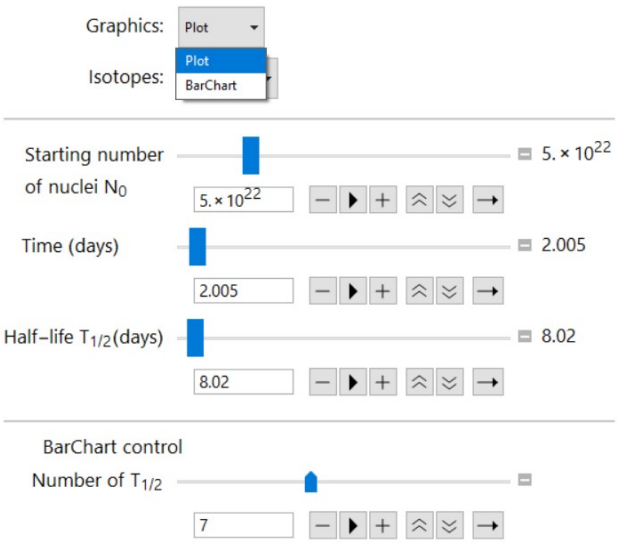

Figure 1. *Option for selection Plot or BarChart graphical display type, along with options for changing different parameters: Starting number of nuclei, Time, Half-life $T_{1/2}$, and Number of $T_{1/2}$*

In fact, option *Isotopes* only provides the option for choosing isotopes which Half-life are expressed in days (Table 1).

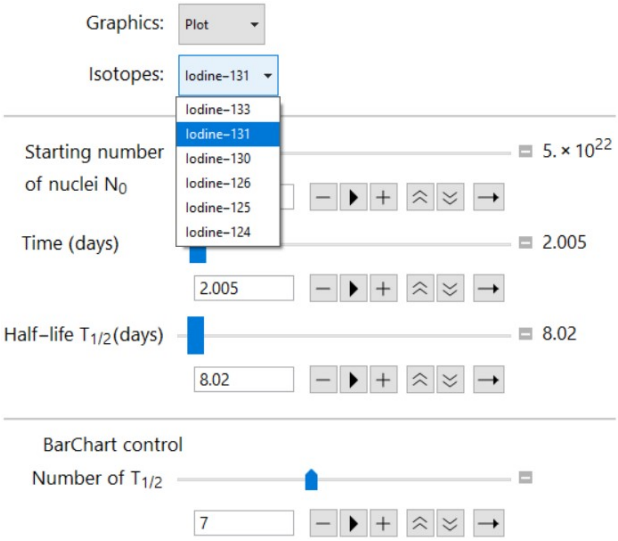

Figure 2. *Option to select type of radioactive Iodine isotope*

Other radioactive Iodine isotopes have small times of Half-life and are not in the long-term health-environmentally significant.

Table 1. *Radioactive isotopes of Iodine $_{53}$I which are used in simulation*

symbol	Mass number	Half-life $T_{1/2}$ (days)
$_{53}I^{124}$	124	4.18
$_{53}I^{125}$	125	59.4
$_{53}I^{126}$	126	12.93
$_{53}I^{130}$	130	0.515
$_{53}I^{131}$	131	8.02
$_{53}I^{133}$	133	0.867

3. CURVE GRAPHICS PRESENTATION AND NUCLEI CALCULATION

After choosing type of graphical display (*Curve* or *BarChart*) and the type of radioactive Iodine isotope, students are offered to set the number of nuclei with *Starting number of nuclei* N_0 slider. This number ranges from some starting value of 10^{22} nuclei to the end value of $20 \cdot 10^{22}$ nuclei, but the initial number of nuclei is a set to be $5 \cdot 10^{22}$, unless a student selects the otherwise.

This choice is made possible by using the *Manipulate* function, where the interval of the number of nuclei is set to be comparable to the number of radioactive isotope samples corresponding to the real situations of removing samples from soil, food and water. That is, since one moll contains $6{,}022 \cdot 10^{23}$ nuclei, the selection of the number of nuclei is indirectly and the initial number of molls ranges from approximately 0.0166 to 0.332 molls.

By using the *Manipulate* function in software package *Mathematica*, students are also given the ability to animate or linearly change the value of parameters over time. Below each slider is a minus sign, a right arrow, a plus sign, an acceleration of changing the value of a given parameter, option to reduce it value, and ultimately choosing it direction of change - right to increase or left to decrease (Fig. 2). Pressing a minus or plus character changes the value of the selected parameter with a step defined by the user in the code itself. Pressing the arrow between the minus sign and plus starts the animation, which can be further accelerated or slowed down. At the end of a row is an arrow that indicates the direction of the change of a given parameter: from the minimum value to the maximum - direction to the right, or vice versa from maximum to minimum value - direction to the left. The next option is to select the time given in days - *Time (days)* that represents elapsed time since the beginning of measuring the number of decayed and undecayed (remaining) nuclei. And here there is the possibility of moving the slider from the initial moment to the maximum of the time parameter, which is 6 times the Half-life of the selected isotope. Also, by moving the slider that changes the value of time, a shaded blue area appears on the graphic, indicating the elapsed time (Fig. 3).

In Fig. 3, two curves can be observed: one that indicates an exponential decline in the number of nuclei as a function of time; and another that indicates an exponential increase in the number of decayed nuclei as a function of time. The equation for calculating the number of remaining nuclei is

$$N_n(t) = N_0 \cdot e^{-\lambda \cdot t} \tag{1}$$

and it represents the so-called Radioactive Decay Law, while the equation for calculating the number of decayed nuclei is

$$N_r(t) = N_0 \cdot \left(1 - e^{-\lambda \cdot t}\right) \tag{2}$$

Parameter λ is a constant of radioactive decay and is closely linked to the isotope Half-life over the equation

$$\lambda = \frac{\ln 2}{T_{1/2}} \tag{3}$$

The top part of the graphics in Fig. 3 also shows the number of remaining and decayed nuclei over time that are displayed in percentage.

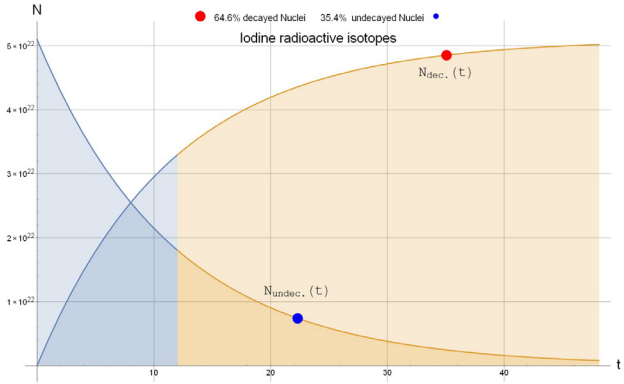

Figure 3. *Curve graphics with curves that represents undecayed (remaining) and decayed nuclei as a function of the elapsed time*

By introducing *DynamicModul*e and *LocatorPan*e functions, it is possible to use the mouse to move the locator and select individual dots on the graphics whose values we want to read. In Fig. 3, they're marked with blue dot for remaining nuclei, and with red dot for decayed nuclei. Graphical presentation of these values and volume ratio of remaining and decayed nuclei is shown on Fig. 3 which displays curve graphic type. In Fig. 4, which represent the right side of the Fig. 3, in addition to the elapsed time, the number of remaining and decayed nuclei is also being display.

This graphics presentation is closely linked to *DynamicModule* and *LocatorPane* functions in the simulation and is not associated with a *Time* slider. The slider, which is related to the time of nuclear decay, displays volume ratio of remaining and decayed nuclei, as shown in Fig. 4.

In addition to the two previous parameters given by *Manipulate* function, there is a third parameter in the *Curve* graphics option that can also be selected. It's a time that is represented in Half-life's (*Half-life* $T_{1/2}$) with unites represented in days. It is a characteristic of the radioactive isotope itself and represent time required to decay half of the total number of radioactive nuclei. The program automatically selects a certain Half-time that corresponds to the selected radioactive isotope, but students have option to move slider in order to change this parameter and observe changes to the graphics that occur as a consequence of that.

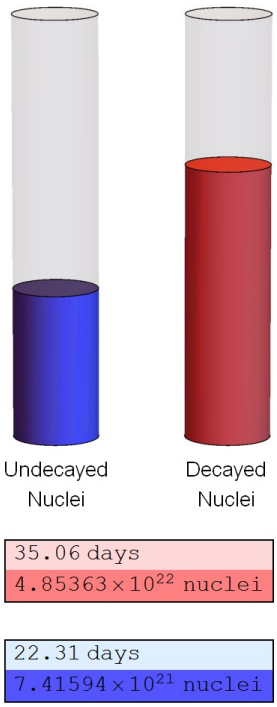

Figure 4. *Representation of the volume ratio of remaining (blue color) and decayed (red color) nuclei; elapsed time and number of nuclei*

4. BARCHART GRAPHICS PRESENTATION

At the beginning of the simulation in the *Graphics* option, beside the possibility of selecting the curve representation of the graphic, there is also a possibility to select graphic view using bars - *BarChart* option. With this option, using the *Manipulate* function, the slider is set to change the number of bar columns - *Barchart control* which is connected to parameter *Number of* $T_{1/2}$ (Fig. 2). The set value is number 7, but if necessary, it can be changed from 1 to 16 (Fig. 5).

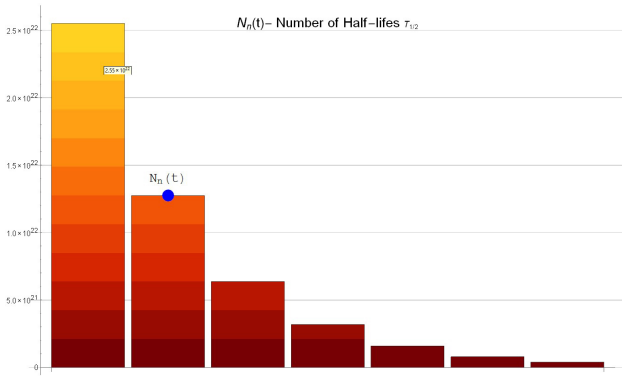

Figure 5. *BarChart graphic for time period of 7* $T_{1/2}$ *for radioactive isotope I-131 and starting number of nuclei* $N_0 = 5{,}2 \cdot 10^{22}$

Each column of bars represents one Half-life, that is, 16 columns of bars will represent a time equal to 16 $T_{1/2}$, while the number of remaining undecayed nuclei is related to the height of the bars (Fig. 6).

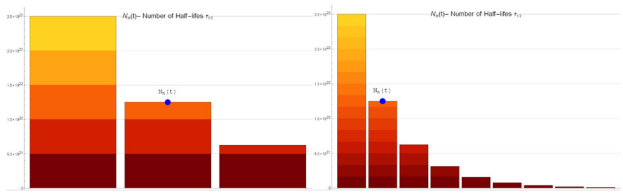

Figure 6. *Example BarChart graphics presentation for* $T_{1/2}$ *(left) and 9* $T_{1/2}$ *(right)*

As with drawing a curve graph in the *Curve* option, with the *BarChart* graph there is the possibility of moving the locator on which the elapsed time and the number of nuclei are read. As for the previous graphics, this was achieved by introducing the *DynamicModule* and *LocatorPane* functions into the simulation. The elapsed time (in $T_{1/2}$) and the number of undecayed nuclei are printed on the right side next to the graph (Fig. 7).

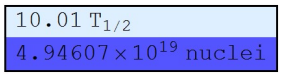

Figure 7. *Displaying of the elapsed time in* $T_{1/2}$ *units and the number of undecayed nuclei on the BarChart graphic*

Moving the locator and reading the data for each individual *BarChart* allows students to gain a better insight into the change in the number of undecayed nuclei values that can be represented by the equation

$$N_n(t) = N_0 \cdot 2^{-\frac{t}{T_{1/2}}} \tag{4}$$

, which is obtained from expression (1) as follows

$$\left.\begin{aligned} N_n(t) &= N_0 \cdot e^{-\lambda \cdot t} \\ \lambda &= \frac{\ln 2}{T_{1/2}} \end{aligned}\right\} \Rightarrow N_n(t) = N_0 \cdot 2^{-\frac{t}{T_{1/2}}} \tag{5}$$

5. MATHEMATICA SOFTWARE SIMULATION CODE

The code for this graphical simulation, which was done in the *Mathematica* software package, is as follows:

```
ClearAll["Global`*"]
Manipulate[If[uslov==1,
DynamicModule[
{pt={2.2, 1.4*10^22},pt1={2.0, 3.8*10^22}},
  Row[{LocatorPane[Dynamic[{pt, pt1}],
    Plot[Evaluate[{
If[c<t,{N0-N0*e^(-Log[2]/tpol c),N0*e^(-Log[2]/tpol c)}],
If[c>t,{N0-N0*e^(-Log[2]/tpol c),N0*e^(-Log[2]/tpol c)}]}],
{c, 0, 6tpol}, Filling->Axis,
AxesLabel->{"t (days)","N"},
PlotLabel->PaddedForm[Row
```

```
[{Graphics[{Red,Disk[{0, 0},1-e^(-Log[2]/tpol c)]},
PlotRange->1.4, ImageSize->30,
BaselinePosition->(Center->Center)],
100N[1-e^(-Log[2]/tpol c)],"% decayed Nuclei     ",
100N[e^(-Log[2]/tpol c)],"%  undecayed Nuclei",
Graphics[{Blue,Disk[{0, 0},e^(-Log[2]/tpol c)]},
PlotRange->1.4, ImageSize->30,
BaselinePosition->(Center->Center)],"
        Iodine radioactive isotopes
        "},{3, 1}],
     LabelStyle->Darker[Black],
GridLines->Automatic, ImageSize->{850, 600},
Epilog->{PointSize[0.018], Point[{
Dynamic[
{First[pt],(N0-N0*Exp[-(Log[2]/tpol)*First[pt]])}],
Dynamic[
{First[pt1],(N0*Exp[-(Log[2]/tpol)*First[pt1]])}]
        },
VertexColors->{Red, Blue}]}],
Appearance->{"Ndec.(t)","Nundec.(t)"}],
Column[{Graphics3D[{Opacity[.10], Gray,
Cylinder[{{-8, 0, 0}, {-8, 0, 10}}, 1],
Opacity[1], Lighter[Blue],
Cylinder[{{ -8, 0, 10*Exp[-(Log[2]/tpol)*t]},
{-8, 0, 0}}, 1],
{Black,
        Text[Style["Undecayed
             Nuclei", 12],{-8, 0, -1.2}],
        Text[Style["Decayed
            Nuclei", 12],{-4, 0, -1.2}]
},
       Opacity[.10], Gray,
Cylinder[{{-4, 0, 0},{-4 ,0, 10}}, 1],
Opacity[1], Lighter[Red],
Cylinder[{{-4, 0, 0},{-4, 0, Piecewise[
{{(10-(10*Exp[
(-(Log[2]/tpol)*t)])),t<=100000}}]}},1],
Opacity[1]},ViewPoint->{0, -10, 2},
Boxed->False,ImageSize->{160, 320}],
     Dynamic[Column[{First[pt]"days  ",
(N0-N0*Exp[-(Log[2]/tpol)*First[pt] ])"nucleus"},
Background->{{LightRed, Pink}},
Frame->True]],"   ",
Dynamic[Column[
{First[pt1]"days  ",
N0*Exp[-(Log[2]/tpol)*First[pt1] ]"nucleus"},
Background->{{LightBlue,Lighter[Blue]}},
Frame->True]]
      }]
    }]],
  DynamicModule[{pt2={2, 1.4*10^22}},
   Row[{LocatorPane[Dynamic[pt2],
     k=Table[2^i,{i, 1, n}];
     BarChart[N0/k,
ChartElementFunction-
>ChartElementDataFunction["SegmentScaleRecta
ngle","Segments"->1.75n,
"ColorScheme"->"SolarColors"],
ImageSize->{850, 600},
PlotLabel->"
       Nn(t)- Number of Half-lifes T1/2
       ",
LabelStyle->Darker[Black],GridLines->Automatic,
Epilog->{PointSize[0.02],
        Point[
Dynamic[
{First[pt2],(N0*Exp[-(Log[2]/1)*First[pt2] ])}],
VertexColors->Blue]},
Background->None],
Appearance->"Nn(t)"],
Dynamic[
Column[{First[pt2]"T1/2",
N0*Exp[-(Log[2]/1)*First[pt2] ]"nucleus"},
Background->{{LightBlue,Lighter[Blue]}},
Frame->True]]
    }]]
  ],
 {
{uslov,1,"Graphics:"},
   {1->"Plot",
   2-> "BarChart"},ControlType->PopupMenu},
 {
{tpol,8.02,"Isotopes:"},
   {0.8667->"Iodine-133",
   8.02-> "Iodine-131",
   0.515 -> "Iodine-130",
   12.93->"Iodine-126",
   59.4-> "Iodine-125",
   4.18 -> "Iodine-124"},
ControlType->PopupMenu},
Delimiter,
 {{N0, 5*10^22,"Starting number
   of nucleus N0"}, 1*10^22, 20*10^22, 0.1*10^22,
Appearance->"Labeled"},
```

```
 {
{t, tpol/4, "Time (days)        "}, 0, 6tpol,
Appearance->"Labeled"},
 {
{tpol, tpol, "Half-life T1/2(days)"}, .1, 250,
Appearance->"Labeled"},
Delimiter, Item["       BarChart control",
Alignment->Left],
 {
{n, 7, "Number of T1/2"}, 1, 16, 1,
Appearance->"UpArrow"}
]
```

6. CONCLUSION

The presented simulation in the *Mathematica* software package enables students to better understand nuclear decays, which are studied in the undergraduate courses Physics, Physics 2 and Computer simulation of Physical phenomena. In this simulation, students are given the opportunity to change certain parameters that are characteristic of nuclear decay in real time. The graphic representation is given in two forms - *Curve* and *BarChart* graphics presentation, each of which in its own way contributes to the understanding of nuclear physics and the dynamics of nuclear decay.

Curve graphic presentation with exponential curves for undecayed and decayed nuclei, and a *BarChart* graphic presentation that directly gives the relationship of the number of undecayed nuclei with the elapsed time represented by the number of Half-lives. In this way, students can understand much better the mechanism and pace of the nuclear decay process. Also, they can draw conclusions about the number of undecayed and decayed nuclei as a function of the elapsed time and Half-life time, for which they could previously draw conclusions only by performing calculations using the appropriate equations.

ACKNOWLEDGEMENTS

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E-invoicing – Case Study in Serbia

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Abstract: *The paper analyzes the application of e-invoices on a sample of public and private sector entities. The purpose of this paper is to point out the advantages and disadvantages of e-invoices in the first phase of their implementation. routing within offices and automatic synchronization of data upon receipt. E-invoices facilitate international trade operations due to instant and automatic data processing. Also, the application of e-invoices contributes to getting rid of huge amounts of unnecessary paper and thus contributes to the ecological balance. E-invoices provide great savings in printing, postage, and archiving, eliminate manual review and approval of received invoices, and input the invoice data into accounting systems. The research indicates the advantages and disadvantages of applying e-invoices in real working conditions. The goal of this paper is to point out the problems that e-invoice users have recorded in the first months of work in the application.*

Keywords: *invoice*; *e-invoicing; e-business; process automation; digitalization.;*

1. INTRODUCTION

E-business is an integral component of business operations and as such is an integral part of all business activities in the company. For the integration of electronic business in the company, it is necessary to be ready for changes. Changing the concept of business, new technologies integrate a set of changes in the environment, but at the same time within the organization itself. Implementation of this type of business moves the limits of previous activities.

With the electronic exchange of standardized documents, the company acquires competitive advantages:

- considerably a shorter time required for individual processes,
- possibility of significant improvement in process planning and optimization,
- greater security and reliability of the business,
- exclusion of the performance of errors when entering documents in business applications,
- greater visibility over documents, and thus better control over business processes,
- raising the effectiveness of the company's resources,
- release of human resources that can be arranged and in other tasks and thus increasing their effectiveness,
- reduction of operating costs.

The benefits of e-business are:

- savings in business costs
- an increase in the reputation of companies
- the placement market becomes global
- negotiation channels are shortened - customer direct connection and manufacturer
- customers are easier and directly, from manufacturers, inform about products
- new logistics concept of support

E-business deficiencies can be viewed through technological and non-technological restrictions.

Technological restrictions are:

- lack of generally accepted standards
- lack of telecommunications capacities
- set access

Non-technological restrictions are:

- feeling insecurity in e-commerce
- unresolved legal issues
- lack of critical mass of sellers and customers
- abuse of Internet technologies
- legal regulations

The Republic of Serbia dated 1 May 2022 introduces the obligation to take the public sector entity to receive and preserve electronic invoices and to issue electronic invoices to another public sector entity. Also, the obligation of the private sector entity is performed to issue an electronic invoice to the public sector entity.

The obligation of the private sector entity to accommodate and preserves electronic invoice

issued by the public sector entity will be applied from July 1, 2022.

Structural reform, which belongs to the Law on Electronic Invoicing, implies two measures - introducing a new model of fiscalization and transitioning to electronic invoicing. In this way, business with the state becomes more economical and safer, and the law prescribed the manner of sending, receiving, and storing electronic invoices will gradually adopt economic entities in mutual transactions.[7]

2. INVOICE IN PAPER FORM

The invoice is a business document issued by the seller to the customer. It lists the names, quantities, and prices agreed for products or services provided by the seller to the customer. The invoice obliges the customer that the amount that is in the invoice is indicated to the seller, by the terms of the payment. The customer was determined the maximum number of days pay for this merchandise, and sometimes the discount was offered if paid before the deadline.

From the seller's point of view, the invoice is an exit invoice. From the customer's point of view, the invoice is an input invoice. In a speech, the term invoice is usually used to clarify its meaning, as "we sent them the invoice) or" We got the invoice from them "(we owe the money).

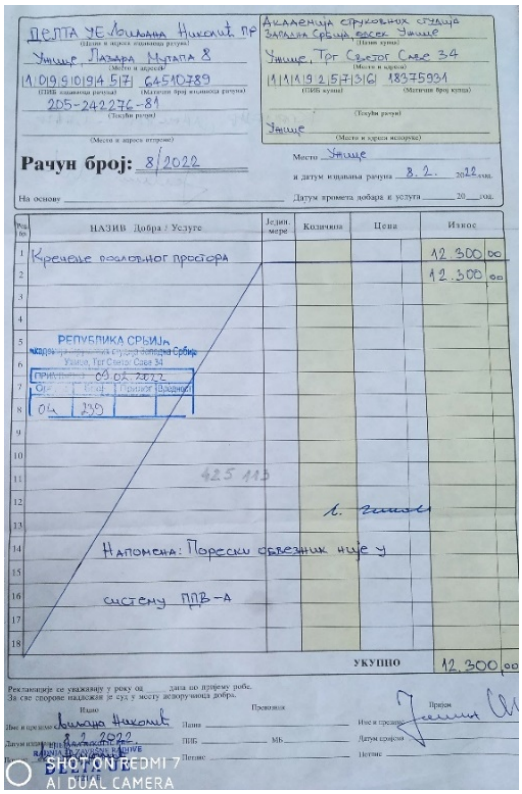

Figure 1. *The appearance of a former account/invoice in paper form*

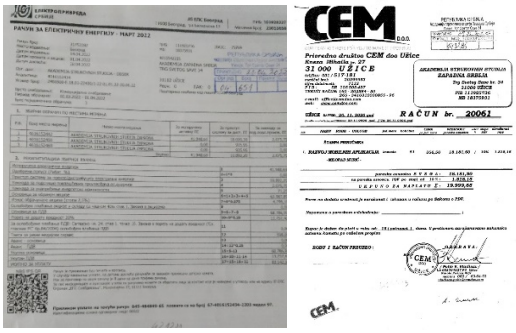

Figure 2. *Examples of invoices*

Invoices are different from receipts. Invoices and receipts are ways of tracking the procurement or sale of goods and services. In principle, the content of the invoice may be similar to that on the receipt. Invoices differ from receipts in that invoices serve to notify customers of debt, while a receipt serves as proof of payment has been completed.

In addition to the concept of the invoice, it is important to know the concept of proforma invoice or pro forma invoice as a very commonly used document in business relations.

Namely, the pro invoice does not have binding significance as an invoice and represents a document that one legal entity gives a price offer for a particular service or product to another person.

Proinvoicing is useful for many reasons, primarily because it does not oblige the issuer to pay VAT, unlike the invoice when the obligation to pay VAT exists whether the invoice is paid or not. Also, a pro invoice often represents an offer for delivery of goods or services to a potential customer who is also a call for payment.

When someone makes a payment based on a pro invoice, it is necessary to issue an invoice/account. Pro invoicing is not the basis for posting.

An account or invoice is a basic document issued by the seller, wider, it is the account that the supplier of goods or the executor provides the provider of the provider or service.

Taxpayers, all legal and natural persons in the VAT system are legally obliged to issue an appropriate invoice with all obligatory elements for each supply of goods or services.

This is prescribed by Article 42 of the Value Added Tax Act, which reads in full, that the taxpayer is obliged to issue an account for each turnover of goods and services. In case of providing time-limited or unlimited services, the duration of more than a year, a periodic account is required, with the period for which this account is not subject to be longer than one year ".

Each invoice should contain these basic elements according to the provisions of Article 42 of the Value Added Tax Act [10]:

1) name, address, and PIB of the taxpayer-account issuer;

2) place and date of issue and ordinal number of accounts;
3) name, address, and PIB of the taxpayer - the recipient of the account;
4) type and amount of goods delivered or type and scope of services;
5) date of turnover of goods and services and the amount of advance payment;
6) the amount of the basis;
7) the tax rate applied;
8) the amount of VAT, which is calculated on the basis;
9) noted on the provision of this Law based on which it is not calculated VAT;
10) note that the sale of the collection is applied to the turnover of goods and services.

The account is issued in at least two copies, one retains an account issuer, and the others are given to the recipient of goods and services.

Invoice and pro invoice are documents that are often identified. It's not strange, because they contain the same elements, so they look like it. However, the pro invoice is not the same as an invoice and for proper business is important to know the difference.

The invoice is the same as the bill, while a proforma invoice is a pro forma invoice.

We look more proforma as a vision of business offer, which is not binding on the customer. It will be expressed in the price of goods or services, along with the payment instructions. As the customer does not have to pay, the pro invoice is not credited and does not withdraw any obligations with it.

The invoice on the other hand shows that there has been a turnover of goods or services, binding on both sides (the buyer should be paid, and you should be recorded, and according to issued invoices, income is monitored according to the issued invoices. The required elements of the invoice are prescribed by the VAT law (Article 42).

Based on the proforma invoice, the buyer can make a payment and thus accept your offer, and you are obliged to issue an invoice, ie you must issue an invoice for the service you provide or the goods you sell.

Invoice and proforma invoices can be in paper and electronic form. The invoice does not have to contain a signature, nor is the use of a stamp obligatory (Law on Companies), but it is necessary to contain an identification mark (Law on Accounting), which confirms its authenticity.

What is an advance invoice?

In certain situations (eg it can be determined by the contract) payment is made before the service or delivery of goods, or in advance.

If the payment is not delivered within the same tax period (month or quarter), VAT payers are required to issue an advance account. Based on the advance account, VAT calculation according to the advance payment will be performed.

After services or goods are delivered, an invoice is issued to be stated in advance payments and calculated VAT.

Invoice advances are credited and they are important and mandatory for persons in the VAT system.

As lumpers cannot be in the VAT system, they do not calculate VAT, so they are not obliged to issue advance accounts.[1][2][4][10][12][13]

3. E-INVOICE

There are several different definitions of e-invoices, but if we try to define them in one sentence, then these invoices/accounts are issued, received, and processed exclusively electronically. In other words, they are the exchange of accounts (invoices) and accompanying information from companies to their clients, using electronic infrastructure, mainly the internet.

The standard used for e-invoices is ISO 20022 standard. With this standard, you can send any document, whether in question book approvals, delivery hours, brochures, or catalogs ... Send attachments can be in any format.

Every year, millions of invoices are exchanged between the recipient and the issuer of the invoice, where most of them are in paper form. This situation leads to inefficiencies, which can be solved today using information solutions such as e-invoices. In this way, efficiency is raised in work, both on the party's side and the invoice recipient's side.

In this model, the invoices are created in the so-called XML format on the issuer's side, which is directly sent to the Information System of the Invoice, through the existing e-banking channel, which guarantees security ("if safe for money is certain for e-invoices ").

```
<cbc:ID>Broj avansnog računa</cbc:ID>
<cbc:IssueDate>2022-02-28</cbc:IssueDate>
<cbc:DueDate>2022-03-07</cbc:DueDate>
<cbc:InvoiceTypeCode>386</cbc:InvoiceTypeCode>
<cbc:Note/>
<cbc:DocumentCurrencyCode>RSD</cbc:DocumentCurrencyCode>
<cac:InvoicePeriod>
<cbc:DescriptionCode>432</cbc:DescriptionCode>
</cac:InvoicePeriod>
<cac:ContractDocumentReference>
```

Figure 3. *Example of XML files in advance e-invoice*

Using this channel, we satisfy two basic properties of e-invoices, and these are the presentation of the invoice ("Bill Presentment") and the possibility of payment ("Bill Payment ").

When classic sending of invoices is used, we see that we have a greater number of steps in the entire procedure, and costs are increased due to paper, envelop and, mailing, all of which are paid for.

Figure 4. *The difference between classic and e-invoices (retrieved with eRačun - PANTHEON - Datalab)*

When classic sending of invoices is used, we see that we have a greater number of steps in the entire procedure, and costs are increased due to paper, envelop and, mailing, all of which are paid for. Depending on the size of the company, a larger number of people may be needed to open mail, sort, and register, which again increases the costs and time it takes to do the whole process properly. In this way, the automation and digitization process will be significantly accelerated and the overall costs of the business will be directly reduced.

With e-invoices, the number of steps in the process is twice as small, the costs and time required for implementation are drastically reduced, and the biggest advantage is that we have insight into the desired invoice at any time.

The electronic invoice system processes an electronic invoice, which is:
1) final invoice,
2) advance invoice,
3) a document on the increase in compensation,
4) or a document on the reduction of compensation.
The electronic invoice must contain:

1) name, address, and tax identification number of the issuer if any of the issuers is a legal entity, i.e. the taxpayer income from self-employment in the sense of the law governing the personal income tax, by the current data from the appropriate register;

2) unique number of users of public funds (hereinafter: JBKJS)of the issuer if the issuer is a user of public funds that is on the list of users of public funds from Article 8, paragraph 1 of the Law on the Budget System ("Official courier RS", no. 54/09, 73/10, 101/10, 101/11, 93/12, 62/13, 63/13 - correction, 108/13,142/14, 68/15 - dr. law, 103/15, 99/16, 113/17, 95/18, 31/19, 72/19 and 149/20);[32-33]

3) business account of the issuer;

4) name, address, and tax identification number of the recipient, if any the recipient is a legal entity, that is, a taxpayer on income from self-employment in the sense of the law governing the personal income tax, by the current one data from the appropriate register;
5) JBKJS of the recipient if the recipient is a user of public funds that are on the list of users of public funds from Article 8, paragraph 1 of the Budget Law system;
6) serial number and date of the e-invoice;
7) date of advance payment, if it is an invoice for advance payment,
that is, the date of the transfer of goods, that is, of the provision of services, if it is not an invoice for advance payment;
8) the code and/or name of the good or service for each electronic item invoices and the quantity and unit of measure for the delivered goods, that is, the scope of the services provided service for each item from the electronic invoice;
9) value for each item from the electronic invoice;
10) the total amount of the electronic invoice;
11) the number of advance payments if any advance payments were made related to one or more items from the electronic invoice [24].

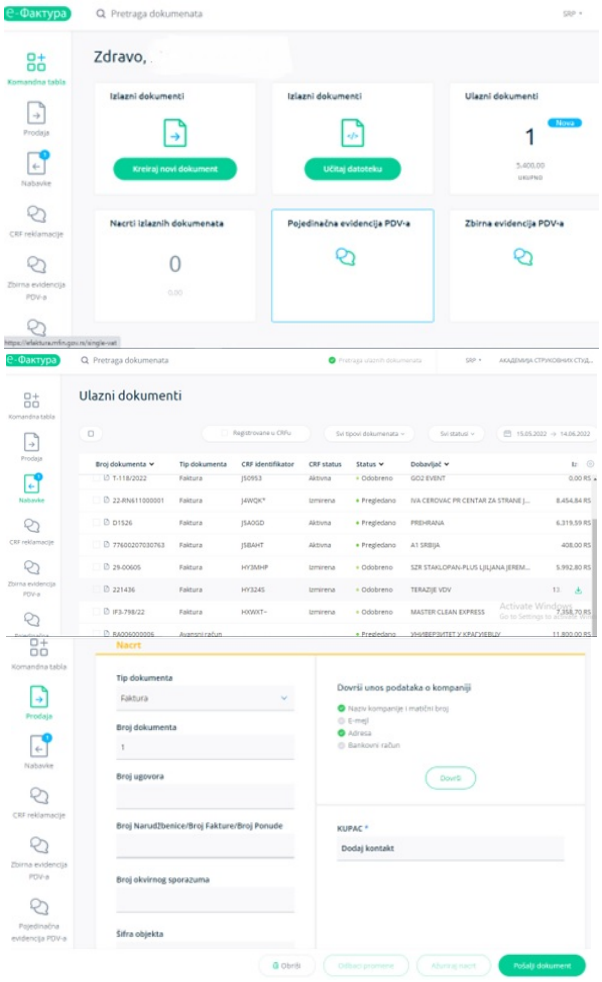

Figure 5. *Examples of the e-invoices on Western Serbia Academy of Applied Studies*

Figure 5 shows an example of the use of e-invoices at the Western Serbia Academy of Applied Studies. The same application is used by most public institutions, and the next research would aim to determine which applications are used in the e-invoice system.

Electronic invoices as provided for in regulations will be applied phased. And if the official start of application of electronic invoices from 01. 01. 2022, this date does not apply to everything.

The phase application is beneficial to prepare businessmen for new business conditions, in addition to the issuer of the account, it is necessary to prepare information intermediaries for a new type of service and service providers.

The obligation of a private sector entity	Start of application
Issuance of an electronic invoice to a public sector entity (budgetary and public enterprises)	May 1, 2022
Receipt and storage of electronic invoices (issued by public and private sector entities)	July 1, 2022
Issuance of an electronic invoice to a private sector entity	January 1, 2023
Registration of VAT calculations except for transactions in which one of the parties is a public sector entity	January 1, 2023
The obligation of a public sector entity	Start of application
Issuance of an electronic invoice to a public sector entity	May 1, 2022
Receipt and storage of electronic invoices (issued by public and private sector entities)	May 1, 2022
Registration of VAT calculations	May 1, 2022
Issuance of an electronic invoice to a private sector entity	July 1, 2022
According to Article 24 of the Law on Electronic Invoicing, starting from July 1, 2022, the private sector entity must receive electronic invoices issued by public and private sector entities, which were sent through the System of Electronic Invoices (SEF).	

Figure 6. *Dynamics of e-invoice applications (available on* https://www.paragraf.rs/kancelarko/obaveza-izdavanje-e-fakture-cesto-postavljana-pitanja.html)

Electronic invoices are not required in the following cases:

1) Retail and received an advance for retail turnover by the law governing fiscalization;
2) Contractual obligation directed according to the beneficiaries of funds from international framework agreements;
3) Procurement, modernization, and overhaul of weapons and military equipment, procurement of security sensitive equipment, as well as related procurements of goods and services.

The new way of exhibiting electronic accounts will benefit:

- The state, as they will have an absolute insight and the possibility of paying VAT;
- businessmen who will more efficiently charge for their claims and
- Information system service providers.

The benefits of e-invoice are:

- Simple and fast business,
- Reducing material costs (no more use of paper, envelopes, and printing),
- Discount of postal services costs (no more postage),
- Lowering Manual Work Costs (Process Improvement and Reducing Error Opportunity Options),
- Cheaper issuance and distribution,
- Lighter control and fewer mistakes,
- Automated delivery (there may be more addresses, in any format and different media),
- Environmentally friendly business.

The Law on Electronic Invoicing the prescribed the content of electronic invoices as well as all the elements that electronic invoices must contain

A system of information intermediaries within which electronic invoices are stored. The service provider must provide a high level of protection against data losses, violating the integrity of these data, and unauthorized access to these data.

Exhibitions of electronic invoices are exempt from entrepreneurs who lead business books by a system of space, as well as entrepreneurs' lumpers.

Some alternative solutions make it easy to work with e-invoices and allow for work in the cloud. The advantage of this way is that e-invoices are managed by technically trained staff with appropriate infrastructure and experience, but it is possible to use such services for such services on a monthly or annual basis which can be a problem for small and medium enterprises.[5-33]

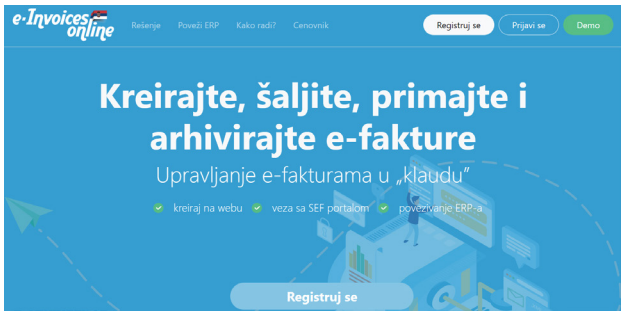

Figure 7. *E-invoice in the cloud*

3. BACKGROUND RESEARCH

The goal of the research was to determine what opinion on e-invoices have subjects in the public and private sectors after the obligation to apply electronic invoicing. The survey was conducted in the period May-June 2022 in the territory of the City of Uzice and included 15 subjects from the public and private sectors.

For research purposes, a survey was created available on e-invoice - Google Questions.

The survey contains 12 questions where the subjects covered by the survey could give their observations.

For questions from 1 to 10, respondents chose one of the 5 answers offered, where it was possible to choose only one answer. On questions 11 and 12, respondents gave their observations in the form of a text answer.

The items in the survey are:

1) E-invoice makes business easier.
2) E-invoice has all the required data entry requirements.
3) Working in the app is easy and simple.
4) It requires an internet intermediary to work in the application.
5) Registration on the e-invoice system is simple
6) Sending the necessary documents is clear and simple.
7) The instructions for using the application are clear.
8) All necessary documents and instructions can be found on the official site.
9) Webinars are a great help to use application
10) Lecturers gave answers to all questions asked.
11) Indicate what are the benefits of e-invoice.
12) Specify e-invoice shortcomings.

The following options were offered to questions from 1 to 5 with the possibility of choosing only one:

- Not
- Unsatisfactory
- Partially
- Satisfactory
- Completely

The survey results are shown in the following figure.

Results of survey					
Question	Answer				
	Not	Unsatisfactory	Partially	Satisfactory	Completely
E-invoice makes business easier	16,7%	/	16,7%	33,3%	33,3%
E-invoice has all the required data entry requirements	/	/	33,3%	50%	16,7%
Working in the app is easy and simple	/	16,7%	33,3%	16,7%	33,3%
It requires an internet intermediary to work in the application	66,7%	/	33,3%	/	/
Registration on the e-invoice system is simple	/	/	16,7%	50%	33,3%
Sending the necessary documents is clear and simple	16,7%	/	33,3%	16,7%	33,3%
The instructions for using the application are clear	16,7%	/	33,3%	16,7%	33,3%
All necessary documents and instructions can be found on the official site	/	/	50%	33,3%	16,7%
Webinars are a great help to use application	/	16,7%	50%	/	33,3%
Lecturers gave answers to all questions asked	16,7%	/	66,7%	/	16,7%

Figure 8. Survey results (https://docs.google.com/forms/d/1xw1jpP9DnO-RiH6uTlwm7idxdqRDQSWT43mcAAzdYzY/edit#responses)

What can be concluded based on survey results?

In the first question, e-invoices facilitate the operations of respondents the greatest percentage gave an affirmative answer.

The second question E-invoice has all the necessary fields for data entry in the largest percentage of respondents answered in the affirmative.

On the third issue, Work in the application is easy and simple to give different answers indicating insufficient technical and informative literacy.

In the fourth question For work in the application needs an internet mediator, the largest number of respondents replied waived.

The fifth question Registration on the e-invoice system is simple, the majority of respondents answered in the affirmative.

The sixth question Sending the necessary documents is clear and simple, but the respondents gave different answers. It should be noted that the instructions for working with e-invoices clearly state that XML files cannot be created based on existing PDF files, and also the Instructions for using XML files[28] explain how to create an XML .file correctly and that the invoice sender works. Users can also solve this problem with Microsoft Dynamics or with the use of various converters that they can find on the Internet.[29-31]

In the seventh question, the Instruction for using the application is clear, the respondents also gave different answers, which suggests that they have .not studied the instruction enough or that they lack computer literacy.

For the eighth question, All the necessary documents and instructions can be found on the site, and the respondents mostly gave an affirmative answer.

To the ninth question, webinars are a great help for using the application, the largest number of respondents answered partially.

In the tenth question, the lecturers gave answers to all the questions asked, the respondents gave the largest percentage of answers that can be treated as negative.

In the eleventh question, state that in your opinions of e-invoice we can set aside the following answers:

- No postal services are required,
- Lower costs,
- Efficiency,
- Better overview of overdue receivables and liabilities,
- Availability of information,
- Everything related to bookkeeping,
- Stepping into easier and more secure payments,
- Control of due invoices,
- Faster receipt of invoices.

Users' experiences in working with e-invoices coincide with the expected and projected advantages of their use. This is just an indicator and encouraging fact that e-invoices and what help for er, safer and faster business.

For the twelfth question List the shortcomings of the e-invoice we can single out the following answers:

- Additional waste of time;
- Mismatch with real business;
- Create additional cost because documents are stored in both electronic and paper format;
- Problem with pro forma invoices and closing of advance accounts;
- The need for more staff to comply with all legal procedures regarding the receipt, liquidation, control, and approval of invoices;

- The need for the accompanying accounting documents from the invoice.

It is realistic to expect a certain user resistance to each new application, because we need to consider the age structure of users, their IT literacy, as well as most important, and it is willingness to learn and readiness to change. The research was conducted in a relatively short period in the initial phase of using e-invoices and on a relatively small sample. We assume that even the users themselves did not gain sufficient insight into the way the e-invoice system functions, and it is possible that a repeated survey in the future period would give completely different results. In any case, we believe that this research can be a starting point for the evaluation of the e-invoice system and its way of functioning, as well as that it can indicate possible problems and shortcomings. We are sure that all the shortcomings of e-invoices will be eliminated in soon as possible to the satisfaction of all participants in this process.

4. CONCLUSION

The paper presents a comparison between classic and e-invoices, as well as their advantages and disadvantages.

Classic invoices have been present for a long time, but their application has shown many shortcomings:

- Manual data entry,
- Possibility of errors,
- Inability to adequately monitor implementation,
- Excessive paper wear.

E-invoices bring a completely new approach to business with several advantages and expected disadvantages in the initial phase of their implementation.

In a conclusion, it can be reported that e-invoices are indisputably progressed in business that will enable all entities to raise their business to a higher level, with the possibility of continuous control and up-to-dateness at all levels of business.

Some questions remain open:

- How to create an XML file as easily as possible and whether it is profitable for smaller companies due to the need for trained staff or developers?
- Can the electronic invoicing system work safely in conditions when a large number of users log in to the system (for example 300,000)?
- How secure are the data contained in the system and whether there is a possibility of their misuse?
- Whether and in what way the export of data from the system is enabled and in which formats?
- Is it possible to recognize all certificates?
- To what extent is training needed to work with the application and what types of training are necessary?
- Is it possible to check whether the goods or services were purchased?
- Is it possible to misuse the data from the ID card or certificate?

The fact is that many problems will arise in the early stages of using e-invoices. The reason for this may be resistance to new technologies, insufficient computer literacy, and insufficient knowledge of laws, regulations, and rules. Thanks to the fact that the entire process of introducing e-invoices takes place in stages, we are sure that the outcome will be successful and that all problems will be solved. All this will also contribute to process automation and digitalization.

The purpose of the work is to show the impressions of users in the first month of using e-invoices and does not provide ready-made solutions or guidelines for solving problems. The goal of the paper is to point out the problems that users face in their daily work, which can help all participants in the e-invoicing process to find an adequate solution faster.

For a more complete picture of the effects of the implementation of the e-invoice system, the research should be repeated in the following period and on a much larger sample than was the case now. Also, it would be desirable to gain insight into which applications users use for e-invoicing, and whether and how much they use cloud applications or other solutions. The research itself would then have a different form because it is expected that the users will have a much better insight into how the e-invoice system works and what problems have arisen in the implementation of the e-invoice system.

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The Course E-business in the Secondary Education Curricula – regional study

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Abstract: *The subject of research in this paper is the representation of the subject E-business in the curricula of secondary schools in the region. The development of information technologies has resulted in the emergence of new types of business. A growing number of organizations are recognizing the need for doing business through the Internet. As a promising field, subject to constant development, it finds a place in the plans and programs of universities, both technical and technological, and social and humanistic sciences. Apart from higher education, e-business, as a field, is increasingly being studied in secondary schools, i.e. it is part of secondary school curricula. The paper presents the results of the research, which included 96 educational profiles, in 14 secondary schools, in 4 municipalities of the Moravica district.*

Keywords: *electronic business; secondary school; education.*

1. INTRODUCTION

Computer literacy is part of the perception of a new type of literacy that is caused by the use of computers and the application of technology in all aspects of society [1]. Technology changes by leaps and bounds, existing skills become antiquated, and there is no migration path to new skills...to adapt to changes in the new technologies [2], [3]. In recent years, children are exposed to mobile devices and computers, as well as their use, from an early age [4], [5], [6].

Until 2020, in primary schools, in lower grades, as an elective, there was a subject called *From toy to computer* [7]. The subject *From toy to computer* was proposed for preschool teaching as well, and from 2020, students of lower grades of primary schools had the opportunity to attend the subject Informatics. From the 2017/2018 school year the subject of Informatics and Computing became a compulsory subject for fifth-grade primary school students [8].

In accordance with the development of techniques and technology, the labor market is increasingly demanding experts in this field. Informatics as a subject has been part of the secondary school curriculum for some time. However, this is not where the study of this area ends. Since 2017, specialized IT departments have been established in many high schools in Serbia. The classes are intended for students with special abilities for computing and informatics [9].

The variety of educational profiles offered in secondary schools in the territory of Serbia is defined in accordance with the needs of the market, and the aim is to profile young people for the job market. The development of information technologies and their application in various spheres of life, in addition to educational profiles, provided the opportunity for the development of a new group of subjects, which are studied in secondary schools. One of the subjects that has been introduced in the curriculum of secondary schools in Serbia in recent years is the subject Electronic Business.

Regardless of whether it is viewed as modern business management via the Internet or the application of information technologies in business processes, the subject is mostly represented within the educational profiles of economic orientations.

2. METHODOLOGY

For the purposes of this paper, a survey was conducted that included 14 secondary schools in 4 municipalities of the Moravica district, namely [10], [11]:

- General secondary schools (3),
- Vocational secondary schools (8),
- Mixed secondary schools (1),
- Art schools (1),
- Special education secondary schools (1).

The research methodology is based on internet searches, i.e. internet presentations, both secondary schools, as well as presentations of the Ministry of Education, Science and Technological Development of the Republic of Serbia, the Institute for the Improvement of Education and Training of the Republic of Serbia, as well as the Legal Information System of the Republic of Serbia.

3. RESULTS

Based on the results of the conducted research, it was concluded that 14 secondary schools of the Moravica district offer the possibility of education in 96 educational profiles.

We analyzed the curriculum of each educational profile, in order to obtain data on the representation of the E-Business subject (Table 1).

Table 1. *Overview of the representation of the subject E-business in the curricula of secondary schools in the Moravica district*

Municipality	School	Educational profile	I	II	III	IV
Čačak	High school	Natural sciences and mathematics	CI	CI	CI	CI
		Social and linguistic	CI	CI	CI	CI
		Students with special abilities for computing and informatics	CA	CA	CA	
	Economic school	Economic technician	CI	BI	BI	EB
		Financial administrator	CI	BI	EB	
		Commercialist	CI		BI	EB
		Financial and accounting technician	CI	BI	EB	
		Trader	CI		BI	/
	Technical school	IT electrical technician	CI			EB
	Food and catering school	Tourism technician	CI	CI		
		Culinary technician	CI	CI		
		Catering technician	CI	CI		
		Cook	CI	BITH		/
		Pastry chef	CI	BI		/
		Waiter	CI	BITH		/
Gornji Milanovac	High school	General	CI	CI	CI	CI
		Social and linguistic	CI	CI	CI	CI
		General - English	CI	CI	CI	CI
	Economic and commercial school	Economic technician	CI	BI	BI	EB
		Financial and accounting technician	CI	BI	EB	
		Commercialist	CI		BI	EB
		Tourist and hotel technician	CI	BIT	BIT	
		Trader	CI		BI	
		Cook	CI	BITH		
		Waiter	CI	BITH		
Ivanjica	High school	General	CI	CI	CI	CI
		Informatics	CA	CA	CA	
		Students with special abilities for sports	CI	CI	CI	CI
	Technical school	Economic technician	CI	BI	BI	EB
		Tourist technician	CI	BIT	BIT	
		Cook - Waiter	CI	BITH		/
Guča	Secondary school	General	CI	CI	CI	CI
		Economic technician	CI	BI	BI	EB
		Financial administrator	CI	BI	EB	
		Trader	CI		BI	/

EB – Electronic Business; CI – Computing and Informatics; CA – Computer Application; BI – Business informatics; BIT – Business Informatics in Tourism; BITH – Business Informatics in Tourism and Hospitality

By analysing curricula, we concluded that the subject E-business is represented in 11 out of 96 teaching plans of educational profiles, in only 5 out of 14 secondary schools. It is interesting that the subject E-business is represented in higher years, as an elective within the educational profiles of economic orientations, as a professional subject.

By analyzing course programs, it was concluded that electronic business, as a field, is studied in

segments and through subjects with different names.

One of those subjects is Computing and Informatics. The subject is part of a group of general education subjects, which are compulsory in the curriculum in all secondary schools in the first year of schooling, except within the educational profiles of IT-oriented high schools and secondary schools for special education. It is important to note that the Computing and Informatics subject contains a low percentage of E-Business.

Within the educational profiles of high schools for students with special abilities for computing and informatics, the subject Computer application is studied. The aim of the subject Computer application is identical to the aim of the subject Computing and Informatics [9], [12].

When it comes to professional subjects, which in the curriculum include more significant elements of the field of e-business, they are the subjects Business Informatics, Business Informatics in Tourism and Business Informatics in Tourism and Hospitality.

Table 1 shows the educational profiles, in which the subject of Computing and Informatics is represented in another, except in the first year of schooling, as well as educational profiles whose curriculum includes the subjects E-Business, Business Informatics, Business Informatics in Tourism and Business Informatics in Tourism and Hospitality, as well as Computer Application [10], [13], [14], [15].

4. CONCLUSION

E-business, as a new form of business, is an inevitability of modern life. Although some countries have been quicker to accept the changes in the way of doing business, neighboring countries are still working on it. In Serbia, this type of business is more and more prevalent.

In order for companies to survive on the market, it is necessary to follow the dynamics of market development and business trends. The question is no longer whether a company will expand its business to the Internet, but the question is at what point will it realize that doing business via the Internet is a necessity.

In Serbia, the awareness of electronic business has not reached the level, so that electronic business is seen as one of the priorities for introduction and understanding, at all levels of organizing society.

There are a large number of factors that directly or indirectly affect the effectiveness of the introduction and implementation of electronic business, and some of them are insufficiently developed legal regulations, infrastructure, insufficient staff expertise, insufficient IT skills of the population, level of awareness, etc.

Educational institutions take on the role of educating future generations, who will be trained to work in the new environment. Introducing the subject of e-business in secondary schools can significantly increase awareness of the very concept of doing business via the Internet and reduce economic losses caused by insufficient staff expertise.

The results obtained from the research are indicators of the fact that, in recent years, the need to introduce the subject of e-business in high schools has been recognized, both through the introduction of the subject of e-business and through the introduction of other subjects, which include elements of e-business in the curriculum. Educational profiles that lead in this are economic educational profiles.

Although the representation of the subject of electronic business in the curricula of secondary schools is insufficient, there is a noticeable and praiseworthy tendency of growth.

Since it is a business that is significantly different from the traditional way of doing business, it is necessary to work on raising the level of awareness of e-business and its concepts.

In addition to what has already been presented, the above is also necessary for the purpose of raising awareness of the levels and measures of security, awareness of an area that is becoming inevitable and that is more and more a part of our lives every day. The importance of the application of electronic business needs to be recognized, both for the individual and the company as well as the entire country.

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Vocational Teacher Training in Online Course Design and Tutoring: Motivating Teachers to Participate in the E-training

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Abstract: *The professional development of teachers is carried out for the sake of continuous progress in the level of their professional, pedagogical and technological competencies. In contemporary conditions, it is considered that technological competencies of teachers are their capability to prepare and realize teaching in an online environment, which can be an addition to or an option of teaching in the classroom. The School of electrical and computer engineering in the Academy of technical and art applied studies in Belgrade is one of the partner institutions of the Erasmus+ program "Professional Development of Vocational Education Teachers in Russia and Serbia with European Practices Pro-VET" (2018-2022) with the goal to develop the training program "Online course design and tutoring". In this paper is a short overview of the above mentioned training program, which was developed (2018-2019), redesigned based on results of alfa and beta testing (2020-2021) and realized twice (2022). In the paper is a brief presentation of the following: an overview of the training program, methods used to motivate teachers to enter the program, work on it and successfully complete it, teachers' achieved success in the program and their grades for the quality of the training program.*

Keywords: *teacher training; vocational teacher; online course; course design; course tutoring;*

1. INTRODUCTION

The professional development of teachers in today's conditions is considered to be a development of the level of their competencies for designing and tutoring online courses [1]. It is considered that teachers today should be familiar with contemporary program environments and tools, the possibilities of developing online teaching material and activities and all segments of preparing and realizing online courses. In the area of higher education, online teaching is present in many forms: from online learning activities that are assigned and realized before lessons in the classroom over the ones in the actual lessons in the classroom, to online learning activities that are assigned after lessons. No matter the area of teaching and learning and the form of online teaching, it has become a regular occurence to prepare an online course, which can be an addition, an option or possibly in some cases also a replacement for the traditional course in the classroom, depending on the conditions for realizing teaching. In order for the teachers to understand their online course attendants as well as possible and have as much success in developing these kinds of courses as possible, they need to finish at least one online program in the role of a beginner [2], [3], [4], take into account recieved suggestions and experience and adjust them to the conditions of realizing their online program. The teachers' training program for designing and tutoring online courses should firstly motivate teachers to access the program and work on it and only after that to prepare them for working on all segments of developing online courses. Vocational teacher training "Online Course Design and Tutoring" was developed in the period between 2018 and 2019 at the Academy of Technical and Art Applied Studies in Belgrade, in the department of The School of Electrical and Computer Engineering, Belgrade (ATUSS-VISER), Serbia, as a part of the Erasmus+ Pro-VET program. This program has the goal to train vocational teachers in Serbia to design and tutor online courses by applying current methods and technologies. The program is realized exclusively online and is 6 working weeks long. It requires individual and team work from the teachers and does not ask for their previous experience in designing or tutoring online courses. The program offers teachers a theoretical base in the form of interactive lessons, video tutorials for working with recommended program environments and tools, tutor instructions and administrator and media designer support. Practical work in the

training program is based on developing online courses in the teachers' specific areas of work.

In the period from 2020 to 2021, alfa and beta program testing levels were prepared and realized in order to check their quality before putting them to work. Testing on every level consisted of its own teacher team. The alfa testing level was carried out in October/November 2020 for 15 vocational teachers, vocational associates who are employed at ATUSS-VISER. Remarks and suggestions were received from teachers on this level of testing, which mostly referred to rearranging the tasks within the working weeks, were used to redesign the training program and prepare beta testing. The beta testing level of the same training program was realized in April/May 2021 for 21 vocational teachers. In addition to the vocational associates, vocational professors also employed at ATUSS-VISER were included as attendants on the beta testing level. Results of the beta testing level showed that the developed training program was ready for realization.

Applications for the online training program "Online Course Design and Tutoring" for vocational teachers were published on the ATUSS-VISER website in January 2022. After completing the teachers' applications, the program was realized twice in 2022, in February/March (for 23 teachers) and April/May (for 21 teachers). The teachers of this program were vocational high school teachers and vocational college professors, who are not employees at ATUSS-VISER. Considering that, the attendants needed to be informed about the beginning of the program on time, much in advance and to get detailed information about the program. Providing necessary assistance as well as regularly updating the table with a track of acquired points for completed tasks was necessary during the program.

Further in the paper is a short presentation of the following: an overview of the training program, methods used to motivate teachers to access the online course regularly as attendants, to work on learning materials, activities and tasks. Analyzed teachers' results from the programs realized up to now as well as their feedback are also presented.

2. ONLINE TEACHER TRAINING OVERVIEW

Vocational teacher training "Online course design and tutoring" consists of a course on the LMS Moodle platform [5], it lasts 6 working weeks and is realized exclusively online. The program provides teachers with a theoretical base in the form of interactive online lessons, which cover the following topics:

- Modern teaching strategies;
- LMS learning environment;
- Video teaching materials;
- Instructional design;
- Online course tutoring;
- Online course evaluation.

In addition to the lessons, the program offers teacherss a developed e-laboratory which is equipped with recorded video tutorials for working with recommended program environments and tools on the following topics:

- The use of e-learning platform;
- Adjusment of LMS environment for online courses;
- The use of Screencast tools for creating video teaching materials;
- The use of Google tools for team and individual work on online course materials;
- The use of LMS and Conference tools for the work on online course tutoring scenario;
- The use of LMS tools for work on online course assignment.

An important segment of every online program is managing the process of its realization. Therefore, it is very important to question which environment to choose for the program [6], [7]. The training program "Online Course Design and Tutoring" was prepared and realized on the platform of the LMS Moodle system, which is widely accepted in the area of high education, considering its free installation, large number of services, simple administration and use. After configuring the training program course on the LMS platform completed by the program administrator after applications by the participants with the role of tutors and media designers, the structure of the training program was defined along with all the predicted topics and the teaching resources and activities for each topic were defined. An interactive unit was prepared for each topic earlier mentioned. Each of these lessons simply leads you through its contents, explains terms with easily understandable text segments with illustrations and also, after each of these segments a test is given to review the covered curriculum. It is necessary to correctly complete this test to continue covering the unit. For each training program topic, a compilation of video instructions for using current program platforms and tools provided for working on designing and tutoring online courses [8], [9] is prepared. This is uploaded to a reserved Google Drive folder and is accessible to the teachers via links on the LMS Moodle course program.

During the entire course of the training program, the teachers are provided with assistance via forums and video conference meetings by the:

- Tutor – defines the teachers' goals, the program contents and acitivities, leads them through individual and team work, provides information about tasks and monitors the teachers' improvements in completing tasks;

- Administrator – provides teachers with instructions and help on how to access and use the resources and activities in the LMS;
- Media designer – provides teachers with instructions and help with using the recommended program environments and tools for working on the program.

Evaluation of the training program, which is prepared during its development, is also realized during the entire course of the program. Team and individual tasks for teachers, as well as getting feedback about the quality of the program material and activities and the quality of cooperation with the tutor, by conducting a final anonymous survey are provided as part of the evaluation.

Traning evaluation team activities include:

- At the beginning of the course: creating teams for practical work;
- In the first part of the course, starting online team course design: a syllabus, learning guide, course topics and video material for one of the course topics;
- In the second part of the course, defining online team course tutoring scenario: a calendar of teaching activities, a calendar of assessment and evaluation and knowledge test for one of the course topics.

Training evaluation individual activities include:

- Two discussions via LMS Moodle forums, one in the first part and another in the second part of the training;
- Working on the video learning diary at the end of the training.

Training evaluation also includes getting feedback from attendants, creation and distribution of attendants acquired points, through:

- Final questionaire and final report.

3. ACHIEVING TEACHER MOTIVATION FOR ONLINE COURSE DESIGN AND TUTORING

Considering that teaching prepared in an online environment is becoming imperative in every area of teaching and learning, it is necessary to motivate as many teachers as possible to get involved in developing and realizing online courses. In order for them to gain competencies for this, what is necessary, among other things, is for them to successfully complete at least one online course as an attendant. Further in this chapter of the paper suggestions for motivating the teachers before and during the training program are presented based on experience with teachers who are attendants of the alfa and beta testing, as well as the teachers who are attendants of the two realized training programs.

In order for the teachers to get interested in the online training course in the first place and accept it what is necessary is:

- To explain the importance of working on developing online courses for improving teachers' careers;
- To explain the importance of using the training program in practice in the process of designing and tutoring online courses;
- To provide necessary information about the online training program on time: the beginning of and duration of the program, which program platform is being used and how to access this platform for work, which type of certificate/confirmation is achieved for successfully completing the program.

In order for the program to be ready for teachers' work from the very beginning of the program, it is necessary to complete the following much before the start of it:

- Materials and program activities need to be prepared so that they are available via mobile devices (for more program attendants' access) if possible;
- The materials and program activities need to be prepared so that they are summarized and understandable and the program tasks need to be clearly defined (to avoid unclarity when working on them);
- The course should be made to be flexible and always available, that the teachers can work on the materials and tasks whenever they have time, considering their obligations at work.

In order for the teachers who apply as attendants to be interested in working on the program the following learning activities are recommended:

- Sending a message for the beginning of the program on the forum, announcing and holding the first video conference meeting for the program attendants to meet each other and understand the working methods;
- Welcoming the attendants to the program at the very beginning and explaining the rules of working on the program to them (so that there are no doubts about the beginning of working on the program);
- Opening a "Training overview", "Training calendar", "Acquiring points" and "Initial Questionnaire" to get to know the attendants at the beginning of the program;
- Informing attendants on time about posted material, activities and tasks (they should be familiar with what is being done in the program at every moment);
- Providing forums and a video conference room (plan regular asynchronous and occasional synchronous communication) for communication between participants;
- Providing continuous support by tutors, administrators and media designers (answering questions about the program, LMS platform and program tools regularly);

- Continuously providing teachers with feedback about their work on the program (update the table with points which contains team work and individual work results regularly);
- Announcing and holding a final video conference meeting for comments and suggestions as well as for reporting to the teachers about their work on the program;
- Opening an anonymous "Final Questionnaire" to get feedback from teachers: remarks by teachers about training program, at the end of the program.

4. TRAINING EVALUATION RESULTS

The first training program for a group of 23 teachers, vocational high school teachers and vocational college professors, was realized in February/March 2022. Out of the mentioned number of teachers, 17 teachers actively participated in working on the program and successfully completed the training. From the initial survey information about the teachers' previous experience with online teaching was received and what was received in the final survey was feedback from them about the quality of interactive lessons and video tutorials as well as the quality of cooperation with the tutor, administrator and media designer, as well as teachers' preparedness to apply the experience from the training program in practice.

The second training program for a group of 21 teachers (before the beginning of the program 30 teachers were signed up but 9 of them backed down because of obligations at work), vocational high school teachers and vocational college professors, was realized in April/May 2022. Out of the mentioned number of teachers, 16 of them actively participated in working on the program and successfully completed the training. This time around feedback was received from the teachers in the final survey as well. Fig. 1 shows the data received from the teachers at the beginning of every realized program.

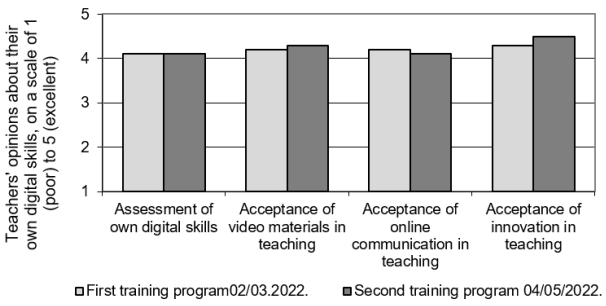

Figure 1. *Teachers' opinions about their own digital skills, at the start training*

Fig. 2 shows teachers' participance in certain team and individual activities, as well as their success in the realized training programs.

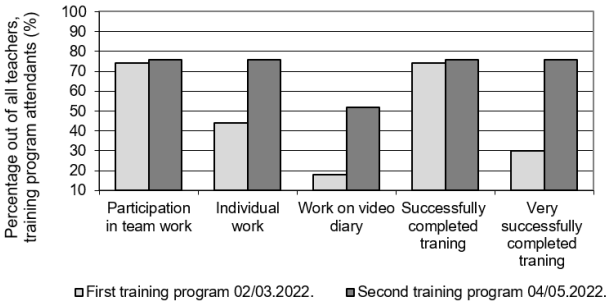

Figure 2. *Teachers' work and pass rate in two realized training programs*

In the previous figure we can see that in each of the realized training programs, the largest percentage of attendants was involved in working on team tasks, a somewhat lower percentage in discussions (both types of activities were assigned continuously during the course of the program) while the lowest percentage of program attendants worked on a video diary of the program (this diary was a task in the final working week).

Fig. 3 shows the evaluation of the program quality by the teachers of the realized training programs.

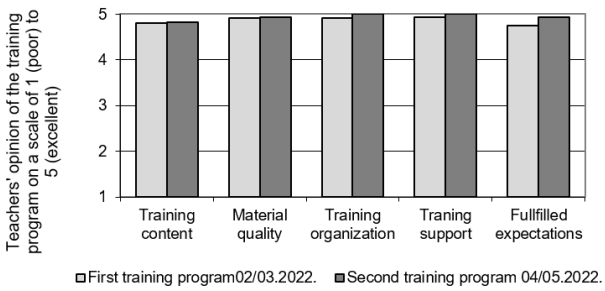

Figure 3. *Teachers' feedback about two realized training programs*

From the previous figure we can conclude that the teachers, attendants of each realized program evaluated the content, material quality, program organization support as excellent and also that the teachers' expectations of the training program were fulfilled.

In the final survey the same teachers' comments about the first realized program were received. According to the words of the teachers:

- The training program topics are clearly defined;
- Concrete examples were shown with posted videos in the program and they were excellent;
- Lectures and video instructions were very clear;
- Program support was very effective;
- The tutor, administrator and media designer supported the attendants in every step of the course.

The teachers' comments about the second realized program from the final survey were the following:

- The course is available 24h and the tempo of the program is adequate, in accordance with work obligations;
- By creating your own online course, the current program tools were tried out;
- The program atmosphere was pleasant and the deadlines for the tasks flexible;
- All praise for complete support which was available non-stop during the program.

What we can see from the results of the programs realized until now, which have been briefly demonstrated and commented in this paper, is that the program received excellent evaluations from the teachers, attendants of the program. The majority of teachers who evaluated their acceptance of online teaching with mostly very good evaluations in the beginning, managed to successfully complete this program and accept their role as designer and tutor in their online courses.

5. CONCLUSION

The development of online courses has become common, no matter the area of teaching and methods of realizing it. Taking this into consideration, programs for teachers' professional development also consist of training programs for designing and tutoring online courses. Every training program of this kind should introduce the teachers to the basic principles of online teaching, the principles of choosing and methods of using program platforms and tools for developing teaching materials and activities. The training program "Online course design and tutoring" was developed as a part of the Erasmus+ program Pro-VET as an exclusively online program with the goal to enable the professional development of the biggest number of vocational teachers in Serbia in the area of preparing, realizing and evaluating online courses as possible.

Testing the mentioned training program was carried out in two stages, and after that the program was realized twice. The training program is realized in the LMS Moodle program platform and provides continuous support to the teachers from the tutor who leads the teachers through the training program, from the administrator who helps with using LMS resources and activities as well as the media designer who helps with choosing and using recommended program tools.

At the training program beginning, after the program guide and program calendar, the initial program survey was realized. The paper presents the results of this survey, the questions and answers of teachers regarding their opinion to what extent they accept the methods and technologies of online teaching. From the responses of the teachers, it can be seen that at the beginning of each program, there was a very good basis for the teacher-attendants to accept the tools used for video teaching materials, for the development of these materials, for working on methods of online communication about the material with students, as well as for accepting other digital skills needed in the modern teaching process. It can be concluded that, regardless of previous experiences, the motivation to prepare and implement online courses is present among today's teachers, considering that online courses are becoming an inevitable addition to the traditional courses.

The six-week program consists of teachers going through six topics, six interactive units and the same number of video tutorial compilations for recommended program platforms and tools. They complete the required team and individual tasks and start with developing a concrete online course in the area of their work. The paper shows the extent to which teachers participated in certain activities of the training program. In team tasks, they could distribute parts of the tasks among themselves, and therefore it is not surprising that their participation in these tasks was generally higher than in individual tasks. It should also be noted that a significantly smaller number of teachers worked on the video diary task in the last week than on the tasks in the previous weeks of the program. The mentioned results lead to the conclusion that programs of this type need team tasks, as well as larger tasks as early as possible in the program, rather than at the end of the program, in order to have the opportunity and time for their realization. In the paper, it is shown that greater participation of teachers was achieved in the second realized training program. This is expected, considering that after the completion of the first training program, the received feedback was analyzed and presented to the teachers, attendants of the second implemented program, in order to make a better organization of their work on the program in time. Based on this, it can be concluded that the analysis of feedback from the attendants is very important for the redesign of the training program.

In the final week of the program the final survey is realized when teachers evaluate the completed training and give their comments, suggestions and remarks regarding the realized program. From the final survey of the program, the results of which are also presented in the paper, it can be seen that the attendants of the implemented training programs are very satisfied with the clearly defined tasks of the program, support from tutor and administrator, as well as communication with them during the entire program. These results lead to the conclusion, which was expected, that in order to realize the most efficient training program of this kind, it is necessary to prepare each of its segments on time, well before the start of the program.

Based on this paper results, it can be concluded that the timely teacher training program preparation, regular support and communication during the entire course of the program, are very important for working on motivation of teachers to

access the online training program, to work on the program and completing it as successfully, as well as to be trained to use in practice what they learned and to improve their teaching.

ACKNOWLEDGEMENTS

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Undergraduate Students Perception of Improvement of Teachers Competencies Based on using Information System

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Abstract: *The paper presents the analysis of the Information System (IS) impact on the improvement of the teachers' skills and competences. This research is based only on students' perceptions and survey methodology. According to the data of the research described in the paper, it is possible to investigate the correlation between students' perception of teachers' IT competencies and assessment of their effects on students' achievement or teaching effectiveness. Besides, we are particularly interested in investigating the degree to which IS impacts the undergraduate students' motivation and satisfaction in the teaching process. The impact of e-communication on gaining knowledge, monitoring, evaluation and reporting on the undergraduate students' improvement is analysed. The paper also presents the analysis of the research results on the application of IS and its impact on gaining knowledge as well as the undergraduate students' motivation and satisfaction increase. The model of the IS impact on the improvement of the teaching process has been presented as an important factor for directing learners towards IS application.*

Key words: *Information System (IS); knowledge; competences; skills; teaching process.*

1. INTRODUCTION

In order to become the members of the Information Technology community, both experts in different fields and undergraduate students should develop necessary knowledge and skills in this domain. The research analysis of the degree of knowledge innovativeness in different fields proves that there have been a number of activities for finding solutions for the problems that have evolved and affected by contemporary technical inventions [1].

This research is based only on students' perceptions and survey methodology. According to the data of the research described in the paper, it is possible to investigate the correlation between students' perception of teachers' IT competencies and assessment of their effects on students' achievement or teaching effectiveness [2].

When the teaching process is concerned, a teacher can implement IS in lectures, exercises, project tasks and seminar papers. The teachers' competences in the teaching process include the ability:

- to define the modes and forms of gaining knowledge (to choose and develop the tools for knowledge transfer);
- to collect and evaluate the results and assess undergraduate students' knowledge according to the previously defined assessment criteria;
- to consider the necessary IS application in teaching clearly and precisely thus enabling the undergraduate students to improve their competences and performances and
- to analyse undergraduate students' improvement.

A curriculum comprises a range of teaching activities. Before the beginning of the term a teacher needs to prepare for the activities that follow. A teacher needs to prepare the necessary documents for the teaching process according the established rules and to enroll the students in the corresponding e-courses. These activities imply preparing lesson plans, lesson timetables, schedules, mid-term exams, finals, etc.

The lesson plan contains a set of teaching activities for each teacher individually. If a group contains a large number of students, the course is realized through several groups. A student can also be taught individually if the group contains only one member. If necessary, the plan is changed in accordance with the obligations of other teachers.

Within the teaching process, professors are in charge of the specific/assigned e-course of the subject they teach. The duties of the teacher in the teaching process at the faculty consist of holding lectures, consultations, pre-examination duties, mid-term exams, final exams, etc. In order to improve the teaching process, a teacher tends to apply new methods, as well as to choose and develop tools for transfering knowledge. The previous activities lead towards establishing a modern educational system which tends to suit the contemporary society.

The most important implications of the paper concern the use of IS in the teaching process which promotes its improvement in academic and vocational studies. The process of finding a solution within IT implementation in the educational process which is based on IS concept is the most influential element.

1.1 Standardized sources of knowledge in the field of information technology

If an organization's information technology (IT) processes are not properly implemented, managed and supported, business will suffer a loss depending on the impact of the unexecuted IT service in business. Nowadays, the teaching process in most higher education institutions also relies on innovative technologies. Regardless of the field in which IT is applied, the use of IT standards is necessary.

Standardization is necessary at both levels, global (International Standards, ISO-International Organization for Standardization) and local (National Standards- SRPS). Standardization refers to the connection of knowledge that would lead to the identification of potential differences and the establishment of the measures for IT improvement [3]. Figure 1 shows 40 hierarchically organized areas of standardization covered by the International Classification for Standards (ICS). ICS is a hierarchical classification consisting of three levels [4].

The first level (ICS1) covers 40 areas of activity in standardization. The field of Information Technology (IT, ICS1=35) has 15 sub-areas of ICS2, one of them is Software Development (35.080). The analysis includes monitoring the frequency of innovativeness in the fields of knowledge and its sources, trends, knowledge of each expert as well as knowledge bases updating [1].

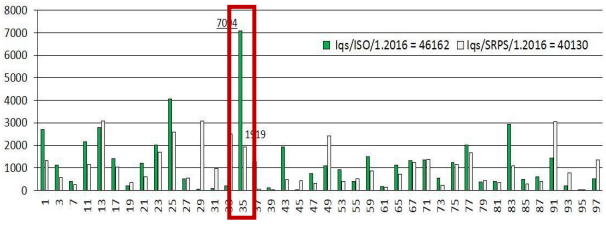

Figure 1. *Comparative overview (ISO-SRPS) of the total amount of knowledge sources on ICS platform, January 2016*

According to the International Classification of Standards (ICS), Information Systems belong to the field of 35 Information Technology which is a very innovative area. Figure 1 shows the results of the access to knowledge sources in ICS1=35 and a comparison with the standardized knowledge sources at the local (national) and international level in all other areas (ICS1=01 to 99). The significance of the model for improving the basic knowledge system is grounded on the defined degree of innovativeness and the elements in the PDCA (Plan-Do-Check-Act) concept. The time dimension of the quality improvement loop determines the degree of innovativeness of the target fields and subfields and the application of the information system [5].

IS development and application in the teaching process aim at achieving:

- digital educational contents development;
- teacher training for IS use;
- raising the level of knowledge and skills for IT use;
- developing the ability for IS application at work in the manner that helps to raise efficiency, improve working process quality and obtain better jobs;
- implementation of e-learning and distance learning;
- integration of IS into educational programs and
- adjusting educational programmes and teaching processes to suit the needs of the society that uses IT and educating teachers to apply new teaching methods.

1.2 Research Objectives

The main objectives of the research include:

- investigating basic knowledge of the IS application in the teaching process among students in academic and vocational studies at the Faculty of Technical Sciences (FTS) in Čačak, University of Kragujevac;
- identifying the respondents' interest in IS if they do not recognize the IS application;
- recognizing the possibilities of applying IS in the teaching process and their impact on the improvement of teachers' skills and competneces, i.e. on education and improvement of the teaching process and
- activating social groups with specific educational needs, which includes gaining knowledge and the development of lifelong learning and education.

2. METHODOLOGY

The questionnaire is used to collect the data necessary for the research. It was organized to identify the level of knowledge about the application of IS when teaching students of the Information Technology study programme at the academic and vocational studies at FTS in Čačak, the University of Kragujevac.

The research was realised within IT subjects with first-year and second-year students of FTS in Čačak. It was conducted during the summer term of the 2021/2022 school year (May-June 2022) and 72 students participated as the respondents.

The research tends to investigate whether the IS implementation in the teaching process has a positive impact on gaining knowledge and motivation increase.

The results show the teachers' influence on their students' motivation and satisfaction as well as the effects of the IS implementation on the teaching process by the teachers.

The research was conducted from May to June 2022 with 72 academic and vocational undergraduate FTS students as participants. The survey was used as the research instrument. It consisted of 9 questions with close-ended yes/no/maybe answers. The approximate completion time was 7 minutes.

3. INFORMATION SYSTEM IN THE TEACHING PROCESS

Data flow diagrams are used to describe the main processes as well as the data that are made and used. Some specific units are further modelled by BPMN (*Business Process Modelling Notation*) diagrams. During the creation of part of the documentation in the teaching process, some diagrams of the unified modeling language UML (*Unified Modeling Language*) were created:

- case use diagram;
- activities diagram;
- sequence diagram;
- class diagram;
- condition diagram;
- components diagram.

Figure 2 shows the case use diagram (lesson plan preparation) which represents the interaction between all actors in the teaching process.

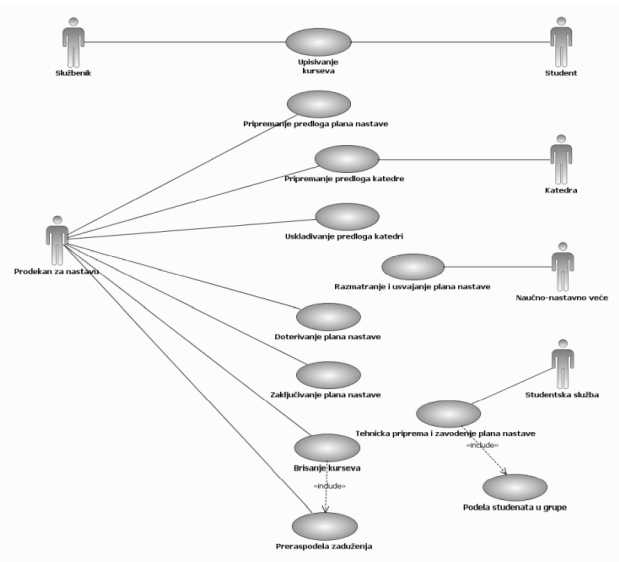

Figure 2. *Case use diagram - Lesson Plan Preparation*

Traditional classrooms are the predominant form of knowledge transfer. Even today, approximately 80% of the teaching process takes place in the classrooms. Printed books are the last universal learning technology. However, new learning technologies are constantly appearing. The experience in using these technologies has revealed the possibilities for improvements of learning quality and efficiency. It is only now that learning through practice is understood to be incorporated into the use of 'blended' combinations of traditional and technology-based methods. Technological development has gathered pace in almost all areas of human life, with a direct impact the education system improvement [6, 7].

The contemporary vision of higher education system with a student as the most important figure in the teaching process implies that teaching and learning methods enable more efficient teacher-student communication, assessment, feedback and the overal interection either among the students themselves or among the stuedents and the teachers. The main principles of such a system are: publicity, avalilability, free flow of information, reciprocity and interaction [8].

3.1 IS Impact on Teachers' skills and competences

For the purpose of the research, the questions were formed in order to obtain the best possible indicators for competences, motivation and the ability to apply IS. Some of the questions were asked as follows:

- The students' motivation, understanding and acquisition are affected by the teachers' motivation to apply the innovative IS in the process of knowledge transfer;
- The capability of the teachers to use IS affects students' understanding and satisfaction;
- Teachers' skills and competences affect students' satisfaction and motivation;
- Teachers' skills and competences affect students' understanding and knowledge acquisition;
- Clearly and accurately presented topics and teachers' requirements affect students' satisfaction and motivation;
- Availability of a teacher for additional help and explanations promotes students' satisfaction and motivation;
- Electronic communication with a teacher (e-mail, text messages, Viber, Forum, Facebook chats, etc.) is more efficient than the traditional one (face to face).

4. RESULTS AND DISCUSSION

The results are presented in Table 1 in Figure 3.

The research shows that the IS application promotes the following:

- more efficient knowledge transfer and acquisition;

- students' satisfaction and motivation in the teaching process;
- improvement of the teachers' competences and motivation as well as the teaching process improvement.

Besides, the majority of students agree that the teachers' skills and competences positively affect:

- students' understanding and knowledge acquisition and
- students' acquisition, gaining knowledge and satisfaction.

Table 1. *Results of the conducted research*

Questions	Answers (%)		
	Yes	No	I don't know
1. Do you think that the motivation of the teachers to apply the innovative information system (IS) in order to enable more efficient knowledge transfer and its adoption by the students affects their motivation and satisfaction?	79.17	9.72	11.11
2. Does the teacher's ability to apply IS affect the understanding of the material and the students' satisfaction?	83.33	8.33	8.33
3. Do the teachers' skills and competences affect students' motivation and satisfaction towards the teaching process?	86.11	2.78	11.11
4. Teachers' skills and competences affect students' understanding and knowledge acquisition.	93.06	1.39	1.39
5. Using IS for clear and precise presentation of the topics and requirements by the teacher affect students' motivation and satisfaction.	81.94	4.17	13.89
6. IS application intended for additional explanations and help for students promote their motivation and satisfaction.	83.33	11.11	5.56
7. Electronic communication (e-mails, text messages, Viber, forum, Facebook chats, etc.) is more efficient than the traditional one (face to face).	30.56	54.17	15.28
8. Clearly presented topics and requirements by the teacher affect students' motivation and satisfaction.	86.11	9.72	4.17
9. IS application affects the promotion of the teachers' skills and competences as well as the teaching process.	77.78	5.56	16.67

The inferences based on the results in Table 1 show that the greatest majority of students (93.06%) consider that teachers' skills and competences affect students' understanding and knowledge acquisition.

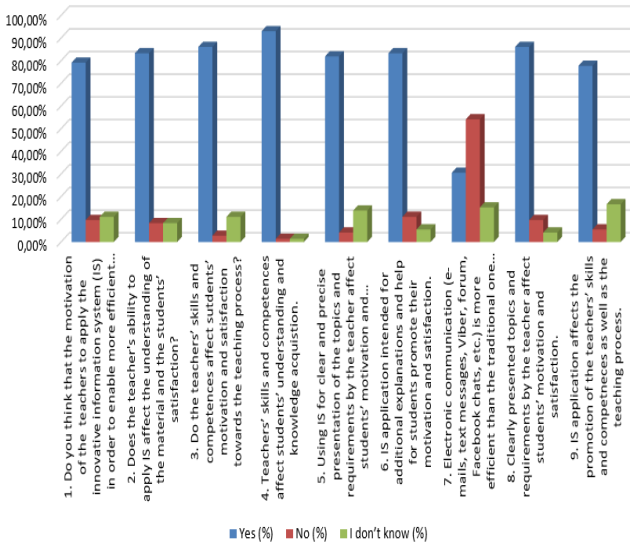

Figure 3. *Graphic presentation of research results - application of IS in the teaching process*

However, the results also show that although the students widely use different forms of electronic communication, more than half of the respondents (54.17%) consider the traditional communication more efficient than the electronic one (Figure 4).

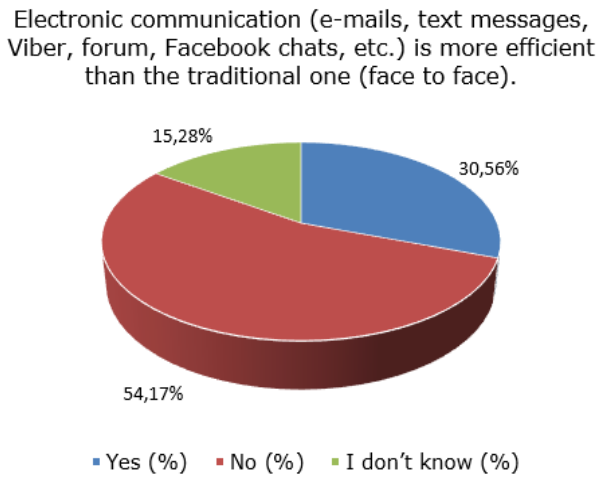

Figure 4. *Graphic presentation of t research results – electronic communication with teachers*

The results point out that 83.33% of the respondents agree that the IS application for providing additional help and explanations can promote their motivation and satisfaction.

The research results prove that there is a clear need for the IS application within the teaching process since it positively affects teachers' skills and competences as well as the studnets' knowledge acquisition and their performance.

5. CONCLUSION

The results of the conducted research show that the IS application substantially promotes teachers' skills and competences. It also supports students' understanding and knowledge acquisition. The application of IS enables the improvement of teachers' skills and competences concerning all the segments of the teaching process (lectures, exercises, seminar papers, mid-term exams, homework, etc.) Students' involvement in the IS application is considered to be the most important element of the teaching process improvement. Precautionary measures are the most important part of the whole process and it takes a lot of time to realize them. The period of realization is different depending on the person who is in charge of realization as well as the means for their implementation. These measures can affect students in great measure and if they are conducted appropriately, they will enable the best possible results.

The environment, which implies the necessary IS application in the teaching process, had a strong impact on new generations of students. Traditional models of education are less motivating. Today, students prefer the application of multimedia content that will capture their attention and provide them with the opportunity to make contact with their teachers using modern communication methods. Practical application of the acquired knowledge is very important for students. Therefore, the teacher is expected to satisfy all their needs and to adapt to the modern environment and generations by continuous improvement of competences and skills, which has been confirmed by the research.

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Developing Teaching Competencies for Implementing Blended Learning in Higher Education: Experiences of Faculty of Science, University of Kragujevac

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Abstract: *One of the invariants for the education through the time is the effort for improvement and changes caused by different cultural, economic, and overall civilization circumstances. Nowadays, the huge impact of digital technology on educational systems and everyday practice is evident. The didactic theory still seeks guidelines for adequate use of new information communication technology. Higher education in Serbia also is a part of this process, as activities of ERASMUS+ project TeComp (Strengthening Teaching Competencies in Higher Education in Natural and Mathematical Sciences, 598434-EPP-1-2018-1-RS-EPPKA2-CBHE-JP) testified. In this paper, we present some outcomes and experiences collected during the project with an aim to disseminate results and to contribute broad discussion in the HE community. We give a quick overview of teachers' attitudes about ICT in their teaching practice as well as some important information and conclusions conducted from evaluations of trainings the most visited by teachers from the Faculty of Science, Kragujevac, concerning aspects of incorporating blended learning in HE in fields of natural sciences, mathematics, computer science, and informatics as a way for strengthening teacher competences.*

Keywords: *teaching competencies; blended learning; higher education*

1. INTRODUCTION

The educational theory and practice have been constantly evolving since the establishment of the first school. Those transformations have been rapidly accelerated in the last several decades, becoming more demanding in the process. This has primarily been caused by the changes in the living conditions of entire societies, in fact, the whole of humanity, setting new educational goals and outcomes. Furthermore, dramatic circumstances connected with the COVID 19 pandemic have shown how important the flexibility of one of the vital systems in any society is, the system which determines the very fate of the society's future – the educational system. All this has additionally motivated but also forced, teachers around the world to integrate technology in their instruction regardless of how willing they were to take such a turn, or how prepared they were to implement new strategies (1).

One of the dominant features of the modern age is the omnipresent influx of technology into our lives (both on the individual level and the level of the entire society), as well as the exponential increase of the available information. This also affects the change in instruction and teaching methods, so that the education results in what could in brief be called the key competencies of a 21st-century individual.

Some of these are for instance problem-solving competence, "learning to learn" competence, and social competence. A question arises about how to accomplish this. One of the answers which the contemporary pedagogic and didactic theory states is the use of teaching strategies that will support active learning, which will put the student into a position of the key participant in the process and the key agent in activities, while the teacher is more likely to play the role of the organizer and coordinator of the learning process. At the same time, it is recommended that the instruction suits the current moment, the environment in which students live today, and their habits, so it is recommended that there is a purposeful and adequate introduction of the technology into education. Actually, what is intended is to find a way to maximize the use of the good sides of face-to-face traditional teaching combined with the new potentials of providing information and cooperation by using modern technologies, or more precisely to form a synergy between traditional and online classes. Briefly put, it is an idea from which a new model of education has emerged, a new strategy of

teaching and learning, the so-called *blended learning*.

Following modern trends and the increasing influence of technology in everyday life, especially in the last decade, higher education in Serbia introduced and planned the accelerated development of appropriate models of mixed learning, which primarily related to the introduction of information and communication technologies in the educational process. Thus, one of the main goals of the ERASMUS+ project TeComp (Strengthening Teaching Competencies in Higher Education in Natural and Mathematical Sciences, 598434-EPP-1-2018-1-RS-EPPKA2-CBHE-JP) is the improvement of teacher competencies by introducing innovations in teaching supported by modern digital resources and ICT tools. This goal was imposed primarily because the general observation was that there is a great potential for ICT in education, even in higher education, but there is a lack of clear guidelines and a systematic approach in the application, which in the previous period was more often the exception than the rule. However, something that was planned as a gradual introduction, due to the pandemic, has become a necessity in the past two years. This dramatic turn certainly required a quick adjustment and from the initial coping, it is now taking on formal outlines. The work on the TeComp project, which began in 2019 with an analysis of the current state and good practices of universities from the EU, faster than planned, during the pandemic focused on the application of what was seen and the design of training for the improvement of teaching practice, while learning was immediately put into practice and tested.

In this paper, we will present the experiences of the Faculty of Science in introducing and fostering blended learning technology implementation, which resulted from the TeComp project activities. Major conclusions derived from results and evaluations of conducted activities will be presented along with the direction of future activities.

2. BLENDED LEARNING

Blended learning is a teaching model that relies on the strategies and systematic approach of combining time and types of learning, so that the best aspects of traditional face-to-face teaching, i.e., the teaching in a real classroom, and online interactive teaching, using suitable digital and communication technologies, are combined (1).

The genealogy of blended learning can be found in distance learning through correspondence courses. For example, the children of lighthouse keepers in Canada were educated in this way as early as 1919 (2). The objective of overcoming the spatial distance remains one of the major motives for the use of blended learning. An additional incentive for the development of such a type of teaching happened at the end of the previous century when the availability of personal computers and the emergence of the Internet and social networks made the development of new teaching models and learning at the various educational levels possible. The new technology had the potential not only to cross the space but also to cross the time (by recording) and to individualize learning (students have the control to choose their path through the curriculum and to choose their learning pace).

Most broadly understood, and most probably the most profound and useful interpretation of blended learning is the one where it needs to include a combination of various teaching theories in educational practice in a way that most adequately suits the given situation. Essentially, this approach involves the blending (combining) of:

- face-to-face learning activities with online activities and formats,
- traditional teaching schedule with some other types, such as working at weekends, intensive work, supplementary work,
- conventional technologies, such as note-taking, combined with social networks and modern technologies,
- simulations, group activities, learning by using sites, practical exercises.

What needs to be kept in mind is that learning theories are not like a religion, one does not exclude the other, and the aim is to have a proper theory for a proper situation (3). The choice in a specific situation depends on the characteristics of the students, educational field, and concrete teaching content, as well as the nature of the knowledge and skills that the students need to acquire and the context in which these are meant to be applied.

Five key factors can be distinguished as the important elements of the contemporary implementation of blended learning (4):

1. live events, which are synchronous learning events headed by the teacher, where the students participate synchronously in a real or virtual classroom;
2. self-paced learning, i.e., learning where the student is autonomous, learning at his or her own pace at the time which is the most suitable for him or her;
3. cooperation, students communicate among themselves in an appropriate format and environment, e.g. by email, as a part of a forum or on social networks;
4. grading/assessment, the evaluation of students' knowledge, which can precede the live events and self-paced learning, so in these instances they aim at reinforcing the previous knowledge on which the new knowledge builds, while subsequent instances of testing the knowledge are obligatory in order to determine

the accomplished level of knowledge and measure the achieved knowledge transfer;

5. performance support materials, which can be diverse: printed, electronic, linear, non-linear, interactive, or not.

In [5] authors performed thorough analyses of different designs of blended learning applied to higher education courses. Here we will give final conclusions in brief. Authors emphasized that there is no generally accepted definition of the model, so different course designs, resulting from various blended learning concept interpretations, were developed by the teachers.

The main challenge for numerous teachers who have only started to adopt the idea of blended learning is the appropriate choice of the course designing approach. Investigating different processes of designing blended learning courses, the authors distinguished three different design approaches (5):

1) low-impact of blended learning, which includes adding supplementary activities to the existing course,

2) medium-impact of blended learning, which includes substituting activities in the existing course,

3) high-impact of blended learning, which assumes building the course from scratch based on the strategy which relies on the blended learning model.

The classification of these approaches has been made in accordance with the potential changes in the existing curriculums and students' learning experiences.

The authors summarized factors influencing the choice of approach in the course design in the following way (5):

1. Low-impact blend
   - Teacher has no experience in designing and developing for blended learning.
   - Teacher has no prior experience in teaching the traditional course.
   - Teacher has some knowledge in integrating technology.
   - Teacher has no confidence in integrating technology.
   - No institutional support is provided.
2. Medium-impact blend
   - Teacher has designed and developed a blended learning course.
   - Teacher has thought the traditional course.
   - Teacher has good knowledge in integrating technology.
   - Teacher has some confidence in integrating technology.
   - Institutional support is provided.
3. High-impact blend
   - Teacher has several years of experience in designing and developing for blended learning.
   - Teacher has made several iterations of teaching the traditional course.
   - Teacher has strong knowledge in integrating technology.
   - Teacher has high confidence in integrating technology.
   - High institutional support is provided.

It can be concluded that implementing blended learning demands multiple competencies and experienced teachers, where ICT competencies play a very important role.

3. BUILDING COMPETENCIES FOR SUCCESSFUL BLENDED LEARNING IMPLEMENTATION

Due to constant technological, scientific, and social development, knowledge and skills that should be acquainted through institutional and informal education, as well as the technology of their delivery are constantly adapting and changing. Consequently, universities must follow trends and demands and must support the continuous development of teaching competencies of their staff. Support for continuous education and development of teaching skills should be well planned and efficient. If an institution plan to promote and implement, or broaden the implementation of some educational technology, such as blended learning methodology, to teaching practice in a systematic way, it must be aware of the current teaching practices of its staff, their attitudes, skills, capabilities, and their preparedness for new practices. Preparing supporting materials, training, workshops, and similar, for educating educators must be planned accordingly. Delivery methods must be suitable and effective. One of the key factors influencing the success rate of blended learning implementation are teaching and educational technology competencies of teachers. Teacher training courses are indispensable and very important part of such support. Such courses must be designed to help teachers reach the necessary skill level in an efficient way and be conducted in a way that they can fit into tight university teacher schedules, also. Fulfilling those demands is not a trivial task, so finding, studying, and applying good practices from referent institutions with rich experience in the field can reduce development and experimentation during training design.

In this section we will present experiences of the Faculty of Science in introducing and fostering blended learning technology implementation, which resulted from the TeComp project activities. In the first phase of the project, in early 2019., an analysis of current teaching practices and teacher competencies was conducted. Results and

conclusions were used for defining plans for collecting good practices in teachers' training courses. During the period from late 2019 until early 2022, the Faculty of Science project team members, along with colleges from other partner universities, attended 11 trainings related to contemporary pedagogical approaches, methodologies, and educational technologies. Nine of them were conducted by teachers from European universities (University of Gent, University of Oviedo, University of Granada, University of Ostrava, University of Metej Bel in Banska Bistrica), experienced in teaching methodologies and contemporary teaching practices.

To present the successful concept of training aiming at leveraging teaching skills in the usage of educational technologies, we will describe, in brief, a professional development course in "Educational interaction and communication" held by the University of Gent, highly rated for its usefulness and organization by all participants.

Due to Covid pandemics, the course in "Educational interaction and communication" was held in an online form. The course was designed as a hands-on course where participants were challenged to implement contemporary information and communication technologies to create various teaching materials. The themes covered during the course (Knowledge clips, Video feedback, Posters, Discussion and collaboration in higher education, Animations as an interaction and communication strategy, and Asking questions) were based on approaches commonly found in higher education and applicable in all knowledge domains. The course run in six cycles of two weeks. One cycle per theme and one task for each theme. Participants received materials and information about theories and research that supported design guidelines for completing each task.

Participants were working in small groups (usually three members). Each task elaboration of each participant was the subject of peer review of group members on the base of a feedback cycle, meaning that the participant gives feedback on the feedback received. Upon course completion, participants evaluated course organization, and usefulness and gave their own impressions, by filling out a survey.

Experiences collected from described and all other trainings resulted in developing training material (1,6) and conducting the professional seminar "University Teaching - Can It Be More Efficient?", designed for a broader audience of teachers and young teaching associates employed at the Faculty of Science. The aim of the seminar was to present practices in blended learning implementation on higher education courses, along with supporting software tools, to raise teachers' awareness of blended learning possibilities and to motivate them to familiarize themselves with the available tools.

The seminar was conducted over a period of four weeks, where each week assumed one term for a meeting. The first meeting was dedicated to presenting and informing participants on methods and tools of interest. Since participants had expertise in different knowledge domains (physics, mathematics, biology, chemistry, computer science) and different teaching and learning context to fit in accordingly, presentations were divided into two parts:

1. Common themes session covering the following themes: Blended learning - potential for applications in higher education, Flipped classroom - how and why?, Visualization in teaching and its effects - presentation of empirical data, Tools for creating educational video content, Interactive video - a way to increase students' motivation and attention.
2. Parallel sessions dedicated to teaching methods and educational technologies practices in different scientific fields of education. Each section covered several themes. Section for biology and ecology covered: Application of selected IT tools and web resources in teaching biology, The use of an EPSON camera as a tool for improving the teaching of botany. Section for physics and chemistry covered: Remote - online laboratories in teaching, Application of virtual laboratories in the teaching of chemistry, Vision of the use of experiments in physics teaching in 2050. Section for mathematics and informatics covered: Possibilities of applying the dynamic software GeoGebra in teaching in higher education, Improving teaching using Wolfram Mathematica software.

Since it was the first seminar concerning new educational technologies from the period before Covid pandemics and teaching practice during pandemics changed point of view and tackled teachers' awareness of ICT usage and distant learning practices, one section of the seminar was dedicated to discussion about the benefits and issues of distant education during pandemics. Its aim was to enable the exchange of experiences and attitudes, estimation of willingness for adapting teaching practices to new contexts, and demands, recognition of limitations and possibilities for the adoption.

At the end of the first term of the seminar, participants were encouraged to transfer some of the presented practices to their actual course setting. Support for this task was provided within two terms for discussion meetings. The fourth and final term was dedicated to presentations and discussion on materials participants delivered as final. All meetings were held online. Upon completion, participants were asked to give feedback on seminar content, organization, and usefulness and to consider their interest in further activities aimed toward building their own teaching competencies and improvement of teaching practice.

4. RESULTS AND ANALYSIS OF ACTIVITIES

Before any concrete activity aiming at building teaching competencies, we have conducted screening of teaching practices and self-evaluation of teaching competencies among the Faculty of Science teaching staff, including teachers and teaching associates (7). 47 lecturers have participated. Lecturers from five areas were present in the sample in the following way: mathematics - 8, computer science - 4, physics - 10, chemistry - 13, and biology - 11. The average number of years of teaching experience is 15.69 years (the standard deviation is 11.33 years). 42,55% were younger lecturers (up to 12 years of experience) and 57,45% were older lecturers (more than 12 years of teaching experience). The shortest teaching experience in the sample is 1 year, while the longest teaching experience is 40 years.

Previous education on courses concerning teaching methodologies and educational tools differed between younger and older lecturers. 31,82% of younger lecturers and 8% of older lecturers did have some courses concerning electronic educational technologies, while 59,09% of younger and 68% of older lecturers attended teaching methodology courses during their education.

Work at the university allows for a significant individual distribution of time. For these reasons, teachers/associates filled out how many hours of work were active during the week and how it was arranged. Average respondents said they spend 43.72 hours of work on different activities (with a standard deviation of 17.45). Participants estimated time spent on teaching activities, preparations, and communication with students against the total working hours participants, which resulted in a relative average of 35%.

Participants did a self-estimation of the quality of teaching and gave opinions on the importance of using modern educational technologies by answering a series of questions. Here, we will only the most interesting findings. Teachers' responses indicated that they have a positive attitude towards the use of ICT in teaching. They are open for improving their ICT skills (the average for p4 is the highest, 3.844), and at the same time, they consider ICT to be very important for the quality of teaching (the average for question p1 is 3.787). The same stands both for younger and older teachers. Among all available software packages usable in the context of teaching and creating teaching materials, teachers have the lowest confidence in their skills related to web conference, video editing, and LMS systems (the average mark was below 3 on a scale from 1 to 5), which indicated that there is a significant space for improvement. More than 90% of teachers noticed the benefits of using ICT in teaching and learning while increasing student interest in the subject matter was considered the most important advantage (70.21%). As the most important barrier to applying modern teaching technologies 46.81% of teachers stated a lack of teacher competencies, while 34.04% stated a lack of time, which highly relates to competencies and inability to improve skills in a short time.

The course held by the University of Gent was attended and finished by 14 staff members from the Faculty of Science (3 professors and 11 assistants), 1 biologist, 2 physicists, 2 computer science researchers, and 9 mathematicians. 13 of them participated in a survey on course quality and their own previous competences. 84,6% of participants stated that they did not previously attend any training on the improvement of teacher competencies. The course was highly rated with an average mark of 4,85, on a scale from 1 to 5. 69,2% stated declared as very satisfied with the training organization and structure. 30,8% said that they plan to participate in similar training in the future, while 69,2% stated that they will probably participate. Participants' attitudes on fulfilling expectations, the usability of course, and quality of communication during the course are summarized in Figure 1.

Figure 1. *Attitudes on University of Gent course quality and applicability*

Overall impressions were highly affirmative. Participants were willing to write a comment, such as "The impressions are phenomenal, the tasks were creative and purposeful. I will try to include as many learned things as possible in my future pedagogical work" and "I think that the training is extremely useful having in mind the current situation of teaching because it provides an opportunity to immediately adopt the acquired knowledge and skills in the teaching process".

A professional seminar held for the Faculty of Science staff was promoted and offered to all staff members included in teaching as an elective activity. Among 121 teachers and associates who did not attend courses held by foreign universities within TeComp activities, 23 participated in all seminar activities and gave their feedback. This means that 20,66% of all staff members were interested and willing to participate actively. 60,9% of participants did not previously attend any training on methods of teaching university courses. The course was rated with an average mark of

4,47, on a scale from 1 to 5. 73,9% said that they plan to participate in similar training in the future, while 21,7% stated that they will probably participate. Overall impressions were positive. Some of them gave suggestions for future seminars concerning its structure, like "to organize more seminars with a smaller number of topics (lecturers), to show/try some ICT tools in more detail", frequency, like "I would like the realization of such training to be more frequent, perhaps to organize a similar meeting every two or three years" or significance of new teaching methods acceptance by a broader audience, like "I think that the entire training is very useful and that as many teachers as possible should join". Additionally, some of the participants have implemented some of the presented practices and used demonstrated tools in their courses immediately after training completion, which presents real proof of training concept value.

5. CONCLUSION

In this paper we presented experiences in planning and conducting activities aiming to strengthen university teachers' competencies for implementing blended learning methodology in their teaching practice. The aim of the conducted trainings was to achieve compatible compositions of traditional and ICT-supported teaching technics to gain an efficient and effective learning process. Presented activities were organized within TeComp project. Analysis of training results and surveys shows that there is a positive attitude and willingness of teachers to introduce new methods and teaching practices, which is a prerequisite for anything further. The first trainings were successfully implemented, but surveys and discussions revealed a need for more systematic support for teachers through organizing activities and trainings on a more regular basis. Therefore, a further step would be defining a strategy for continuous development of teaching competencies that will ensure constant improvement and sustainability of achieved results.

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Entrepreneurial education in emerging countries: how to keep abreast with global competitive needs

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Abstract: *Entrepreneurship is considered to be the driving force and generator of economic and social development worldwide. Entrepreneurship is a kind of expression of creativity and innovation while Entrepreneurs are the lifeblood of any economy. So entrepreneurial skills are moving the world today, creating new jobs, more humane social progress and economic growth. But what the entrepreneurial developed world has been analyzing, promoting and applying for more than 300 years, the emerging countries have been developing and institutionalizing for barely 30 years. To overcome such a time and institutional gap, universities must keep abreast of business and entrepreneurial needs and be forced to use their entire intellectual and academic "arsenal" of instruments to help young people with innovative knowledge and practice to "instill" the entrepreneurial mindset. Otherwise, a mass exodus of highly skilled individuals arguably will weaken local knowledge networks and will reduce social welfare (hence, brain drain or white plague). This paper aims to explore the real possibilities and practices in reformed entrepreneurship education in emerging countries to meet the global competitive needs.*

Keywords: *emerging countries, entrepreneurial skill, academic program, brain drain.*

1. INTRODUCTION

Education within a national economy is the main thread on which the future directions of the country depend. On the other hand, entrepreneurship is a link without which modern society cannot survive. The cohesion between these two fields is very important, ie., it is necessary to support and supplement them. To be able to talk about a quality entrepreneur, his education must be at a high level - a person who is professionally trained and can respond to the challenges of globalization. Education in which professional and practical examples are not largely included does not allow the person to learn much and prepare for their future.

Education, knowledge and practical skills are a key factor for the development of any economy. Promoting and stimulating the entrepreneurial mind for starting and developing a business is a generator of all positive changes in a country. Therefore, education and the acquisition of practical knowledge should be high on the scale of priorities in each country and cannot be excluded from the marginal excuses of education policy makers in a country. Therefore, in line with EU recommendations, a coordinated policy response is needed to ensure that the energy and incentives of young people are best used to meet the needs of the 21st century economy. Rising youth unemployment threatens economic and political stability. Countries with high youth demographics are even more at risk. Furthermore, negative growth means a reduction in job opportunities and the need for alternative means of job creation. Youth entrepreneurship can be part of the solution [1].

Entrepreneurship is one of the eight defined life competencies that the European Union declares, and that every individual needs to succeed in life. Defined sense of innovation - initiating an idea and entrepreneurship refers to the opportunities for the individual to turn the idea into action. It includes creativity, innovation and risk-taking, as well as the ability of the individual to plan and implement projects to achieve certain goals. This concept supports everything from activities in everyday life, digital solutions in homes, in society; makes employees more aware of the organization of their work and more able to take advantage of digital technology.

2. ENTREPRENEURIAL EDUCATION – DEFINITION AND IMPORTANCE

The term enterprise education is primarily used in United Kingdom and has been defined as focusing more broadly on personal development, mindset, skills and abilities, whereas the term entrepreneurship education has been defined to focus more on the specific context of setting up a

venture and becoming self-employed. Entrepreneurship education helps the entrepreneur to upgrade and build into a true entrepreneur [2].

Entrepreneurial education is defined as a whole education and training activity that try to develop participants' entrepreneurial intention or some factors that affect the intention, such as knowledge, desirability, and feasibility of the entrepreneurial activity. Entrepreneurial education is related to career choice and personal skills, also entrepreneurship is an important factor for the development of an economy. The economic growth and development of a country depends on the entrepreneurs in that country, hence the need to create courses and programs that are entrepreneurial at the Universities themselves [3].

Developing the entrepreneurial potential of young people, citizens and organizations is one of the key goals for the European Union and its members. The view that "investing in entrepreneurship education is one of the highest return investments that 'Europe can do' is stated in the Entrepreneurship Action Plan 2020" [4].

In this regard, the European Framework of Reference for Key Lifelong Learning Competencies defines entrepreneurship as "A sense of initiative and entrepreneurship is the ability to turn ideas into action. It includes creativity, innovation and risk-taking, as well as the ability to plan and manage projects in order to achieve goals. The individual is aware of the context of his work and can take advantage of the opportunities that arise. It is the basis for acquiring more specific skills and knowledge needed by those who establish or contribute to social or commercial activity. "This should include awareness of ethical values and the promotion of good governance."

The "Entrepreneurship Education" study seeks to cover all educational activities "that would prepare people to be responsible, entrepreneurial individuals who have the skills, knowledge and attitudes needed to prepare to achieve the goals they have set for living a full life [5]. Hence, it covers a wide range of activities across all levels of education - from creativity classes in primary education to business master's degrees.

The most important thing is the impact that entrepreneurial education leaves on students, ie., how through this education they will develop as individuals. Entrepreneurial education greatly helps students develop a perception of innovation. Innovative awareness and innovative ability are the core process of students' innovation activities, which are also influenced by innovation personality. The educational system of universities has to provide an academic environment that may serve as a catalyst for high-technology start-ups. Entrepreneurs are made by imparting the knowledge and skills needed for a new business venture. The process of shaping the ability of student entrepreneurs is a social interaction process in which information resources are acquired and transformed in the form of observation or direct participation in entrepreneurship education. Entrepreneurship education may change a student's attitudes toward entrepreneurship. Students' perception and attitudes toward entrepreneurship education can determine whether students' creativity will be expressed and constitutes a self-judgment of one's perceived competence in generating novel ideas. [6] This education helps students to enter the markets much more prepared, which in today's conditions of globalization is a very important criterion. In recent years, technological breakthroughs have particularly emphasized the need for innovation, creativity and ingenuity in young people to penetrate and stay in the market. The young generations and their technical-technological readiness need to be upgraded and combined with entrepreneurial education to build a good entrepreneur [7].

The need for entrepreneurial education is eminent and important for every economy, but the opportunities for development of this type of education vary from country to country. There are countries that are highly economically developed, technologically advanced and the beginnings of the development of entrepreneurship education have been observed for a long time. In emerging countries, opportunities for development have emerged later, so the beginning of entrepreneurship education is in recent decades.

3. NEED OF ENTREPRENEURIAL EDUCATION IN EMERGING COUNTIRES

The need for entrepreneurial education applies to every country, regardless of the level of development. However, in order for emerging countries to move closer to highly developed countries, it is necessary to introduce this education as officially at universities [8]. Entrepreneurship education will help accelerate development in many ways in these countries. First, it will be possible to create professional and capable staff, then new entrepreneurs will be created in the markets who will see the ideas as a challenge. Another important component for the economic development of these countries is that it will enable the retention of some young people. [9] That is, the opportunity to learn entrepreneurial skills and hear about different experiences will encourage them and some of them will decide to complete their education in their countries, and then contribute with their knowledge. In these countries the processes of digitalization and automation are at a much lower level, which is another additional reason to introduce this type of education [10]. That is, today's innovative ideas could not be realized and give results if they do not

include digital solutions. From that aspect, the inclusion of entrepreneurial education will cause interest for greater digitalization in work and of course everyday life. The trend of digitalized activities in these countries has gained momentum in the last two years with the emergence of the pandemic caused by Covid 19. That is, the need for digital living has emerged, which is especially noticeable among the young population that is more educated. Within these countries there are young people who have an entrepreneurial spirit and can come up with ingenious ideas in the future, but the fear of failure, poor preparation by the education system and of course the lack of sufficient technical and technological support affects young people not to approach in realization of their ideas and even worse to leave their country and get involved in the work process in another highly developed country [11].

An example of emerging countries is the Western Balkans - they are located in Europe.

3.1. Emerging countries in Western Balkans

In European politicians often mention the idea that the periphery of Europe is reduced to a single region called "Western Balkans" (a term that encompasses the countries of former Yugoslavia minus Slovenia but Albania) is a kind of experiment from which depends on the future of Europe. Balkans should be western to not balkanized Europe.

The member states of the Western Balkans can be mentioned as a category of emerging countries, and it consists of six countries: Albania, Kosovo*, Montenegro, North Macedonia, Serbia, Bosnia and Herzegovina. About 20 million people live in this territory, which although small yet a potential market for the emergence and development of entrepreneurs.

In addition, at table 1, the GDP growth by country is shown, as well as the total of the 6 countries.

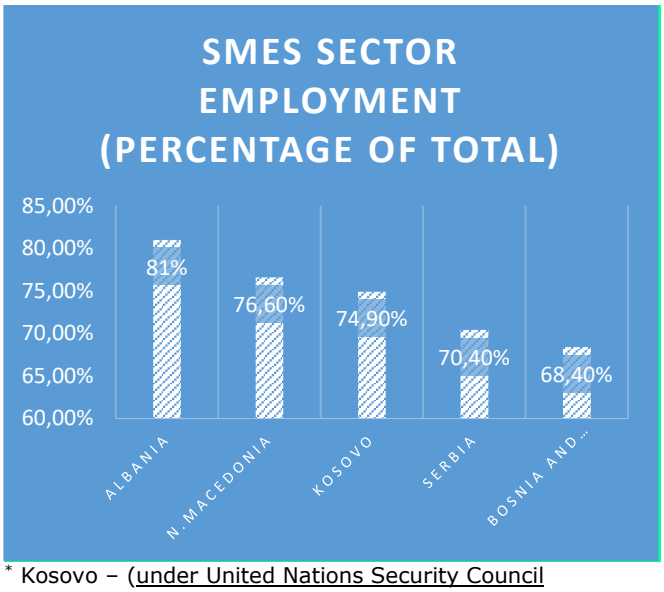
Table 1. GDP growth per countries in Western Balkans

Real GDP growth (%)	2019	2020	2021 estimate	2022 forecast	2023 forecast
Albania	2.2	-4.0	7.2	3.8	3.7
Bosna and Herzegovina	2.8	-3.2	4.0	3.0	3.2
Kosovo*	4.8	-5.3	7.1	4.1	4.4
North Macedonia	3.2	-4.5	4.6	3.7	3.4
Montenegro	4.1	-15	10.8	5.6	4.8
Serbia	4.3	-0.9	6.0	4.5	4.0
WB (6)	3.6	-3.1	5.9	4.1	3.8

* Kosovo – (under United Nations Security Council Resolution 1244/99)

What is noticeable is that in 2020 in each of the countries individually as well as the total GDP has a negative sign. This is a result of the pandemic caused by Covid 19, from which both the countries of the world and the dragons of the Western Balkans felt negative consequences.

The driving force in these economies are small and medium enterprises, i.e most of the employment is realized within these enterprises. The future entrepreneurs are the owners of exactly this type of enterprises, so the need for development of entrepreneurship education is seen as a branch of the Universities. Innovation is started and developed by SMEs, and students are the ones who should be encouraged to innovate activities (awareness and perception). SMEs provide jobs for around three-quarters of the total number of employed, as can be seen on graph 2 what percentage of total employment is generated by this sector.



* Kosovo – (under United Nations Security Council Resolution 1244/99)

Figure 1. *Employment by SMEs sector*

Looking at these results it can be seen that most of the young people in these countries end up in these enterprises. However, good readiness and support will influence them to take steps and be employers in the future. In the Western Balkans there are other problems and obstacles that affect the opportunities as well as the desire and persistence of young people to become entrepreneurs.

The emergence of courses, programs and directions at universities in these countries will encourage young people to get involved in this educational process and certainly make them professional entrepreneurs who will not be afraid to start their own businesses, ie to generate their own ideas.

3.2. Entrepreneurial education in the Western Balkans – challenges

As we said before WB is composition of 6 countries, which are similar in many parameters: economic growth and development, number of inhabitants, GDP per capita, etc. Also, a common feature for them is the low level of technology development, digitalization of the private and public sector. An annual forum is held at the level of the Chambers of Commerce and Industry of the 6 member states where proposals, solutions and initiatives for entrepreneurship development are given. Safet Gërxhaliu, Secretary General expresses the need to link entrepreneurship and education. He believes that the business sector should be more involved in the educational process, ie. to financially support young entrepreneurs. But in order to discover and develop such entrepreneurs it is necessary to have specialized education. Formal study programs at universities in the field of entrepreneurship education are found, but they are very few and are usually part of existing study programs. In the direction of this education in the territory of the Western Balkans, there are several initiatives that provide assistance and support in terms of education and preparation of young people to become good entrepreneurs. One of those initiatives is REGIONAL INCUBATOR FOR SOCIAL ENTREPRENEURS (RISE), this is regional three-year project that intends to open new spaces of reconciliation for the youth of the Western Balkans Six (WB6) through a regional program to support social entrepreneurship. The support program for social entrepreneurs aims to promote dialogue and cooperation between actors and territories through the mobility of participants, organization of regional trainings, exchange workshops and events, as well as through the creation of a real network around ideation and incubation of the RISE. According to them there is no direct support, ie encouragement of young people by institutions within these countries such as universities. In fact, young people here idealize their business innovations based on their personal motivation.

Another encouraging initiative on the territory of the Western Balkans is from the Foreign and Commonwealth Office, that is a project named project "Encouraging youth entrepreneurship in Western Balkans". The purpose of the project is to support young people from the region to start their own businesses and improve employability skills through quality training programs and UK experiences, and to influence Western Balkans decision makers to empower the next generation of young entrepreneurs [12].

There are several such initiatives that mainly come from highly developed countries that direct their human capital and resources to the development of emerging countries such as those in the Western Balkans. Each such initiative emphasizes the need and necessity of connecting, ie including education in entrepreneurship as an area on which the development of the country depends. It should be mentioned that within the study programs within the education at universities there are various programs that enable international mobility of students in highly developed countries. The reason for that is gaining direct experience among young people, and thus encouraging or motivating them to get ideas and their realization. Some of these programs are developed by the European Union such as ERASMUS+, COSME and others. Their presence in the education system is to be welcomed and certainly of great importance, but the need for formal pre-primary education still remains.

The main challenge these countries face is brain drain, ie in each of them the number of emigrated young people is increasing daily. There are a number of reasons for this, but the most important are mistrust in the system, lack of sufficient financial resources and inability to get good jobs - according to their qualifications.

4. YOUNG MIGRATION – RESULT OF GLOBALIZATION OR URGENT NEED TO REFORMING ACADEMIC ENTREPRENEURSHIP

Modern cultural and social conveniences, facilitated by the emphasis on international migration flows, have blurred the boundaries and differences between young people in the world, in terms of country of origin. In the era of globalization, people's mental horizons have expanded, and they are eager to move to other places and countries to realize their full productive potential, and increasingly so in Europe [13]. At the same time conflict, poverty, inequality and lack of decent jobs are among the reasons that compel people to leave their homes in search of better futures for themselves and their families [14]. The problem with the migration of young and educated people is especially pronounced in the Western Balkans.

Migration has contributed to the richness in diversity of cultures, ethnicities and races in developed countries. Individuals who migrate, experience multiple stresses that can impact their mental well-being, including the loss of cultural norms, religious customs, and social support systems, adjustment to a new culture and changes in identity and concept of self. Indeed, the rates of mental illness are increased in some migrant groups [15].

One of the difficulties encountered when trying to tackle this challenge is the lack of data (regarding the brain drain phenomenon only scarce data is available, both in the country of origin as well as in the country of destination). Those people leaving Western Balkan's region, but migration process is still grown and other countries in South-Eastern

Europe. The impact of the exodus of a large proportion of highly skilled individuals from the developing and transition countries remains controversial. A mass exodus arguably weakens local knowledge networks and reduces social welfare (hence, brain drain or white plague) and adversely affects institution building so crucial for the transformation into liberal democracies (Elster et al., 1998) [16]. For studies abroad are not able to provide a definitive answer regarding the timeframe of their stay abroad, as most of them also aim to find employment in the country where they will study. In same time, we have and one other phenomena, there are countries enjoying the effects of brain gain, such as Austria and Germany, and the inflow of highly qualified workers on their labour markets (with the help of special legislation in this field).

However, as antimigrant feelings continue to increase throughout Western Europe, affecting the political discourse and power relations in various countries, the best solution for all stakeholders is to have strategies for brain circulation encouraging international studies and mobility, but also return to the country of origin. Most of the students that are living their countries for study abroad make plans in advance to stay in that country or some other that is more developed. The main reason is because they are thinking that their capacity after the studies in that country will be waste of time if they came in their country of origin. They think of their countries as areas where they cannot improve. Regarding the destination countries that the students prefer in case of migration for any intended purpose, the results indicate that most of their chosen countries are the developed countries of the European Union and the United States of America. Going abroad and studying in developed countries can be seen as a positive thing, as they can return their experiences and knowledge to their home countries [17].

The return of young people, the brains that have flowed to other countries can greatly contribute to the development of these countries. In fact, their return offers certain advantages such as: overflow of knowledge and experience in the country of origin; if the student has stayed in a foreign country for a long time and has managed to increase his / her capital assets, he / she can "return" them to the country of origin, ie to invest them. The most important thing they can do is to develop entrepreneurship, ie to start businesses in their countries of origin, encouraged and motivated by foreign markets. Another way that can contribute to the development of entrepreneurship as well as this type of education is the return of the diaspora. Within these countries the number of people leaving the diaspora is huge and the impact they can make on their countries of origin (mainly from the Western Balkans) is significant.

Research shows that in some countries of the Western Balkans, larger investments have been made by the diaspora within their countries of origin, and in some less. For example, Albania and the Republic of Northern Macedonia have a higher percentage of returnees investing funds at home, unlike Kosovo*.

The return of the diaspora and especially of those highly qualified and educated people is very important for these countries. they can be seen as a way to develop entrepreneurship education and entrepreneurship in general. As we said previously percentage of returnees, in Republic of North Macedonia as the part of Western Balkans countries, is high. That means that in these countries the potential of developing the entrepreneurial education in the future is high.

However, it remains to be seen how entrepreneurial education can become part of everyday life and improve with the population that is already in the country. It is also considered how to reduce the trend of emigration of young people and certainly not to drain the brain in other countries. This will mean greater opportunities for the development of entrepreneurship in the Republic of Northern Macedonia. In addition, we can see the efforts that this country is making to develop this type of education, and thus to influence young promising students and young people.

5. CONCLUSION

The role of higher education in global economic and social development is a primary incentive resource that will decide the future economic positions of each country. Such competencies will increase from year to year, and this will continue in the coming decades. Quality higher education, enriched with modern practices and skills, is an essential need for every society, especially in emerging countries whose economic gap is widening precisely because of inadequate competitiveness in industry. In practice, universities must be in sync with business and entrepreneurship. Only academic programs that promote knowledge, competition, and digitalization can be competitive and relevant to the market. What real change can happen, depending on the symbiosis of study programs and business needs.

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PLM Education: The Role of Engineering Management Study Programs

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Abstract: *Due to its ability to support the achievement of operational and strategic business excellence despite complex business conditions, growing globalization, demanding customers, and shorter product lifecycles, the Product Lifecycle Management concept (PLM concept) is becoming the most significant industry initiative today, while PLM education is becoming an essential strategy in the education of future engineers. The paper emphasized the necessity for the promotion of PLM education by academic communities, discussed PLM education issues, and identified key PLM competencies. It also explores the role of Engineering Management study programs in educating professionals with comprehensive PLM competencies.*

Keywords: PLM education; PLM concept; Engineering Management study programs

1. INTRODUCTION

Increasingly intense globalization, growing competition, demanding customers, shorter life cycles, and increasing complexity of products necessitate stronger control over the product life cycle in order to reduce costs, accelerate innovation processes, and enhance product quality.

These circumstances give product information the status of a strategic corporate resource, while the effective management of such information over the entire product life cycle becomes essential for overcoming the aforementioned challenges.

The combination of all of the previously mentioned factors and the development of information technologies has resulted in the emergence of a new, IT-based business paradigm for the integrated management of product information from product conception to its disposal, so-called Product Lifecycle Management (PLM). The PLM is considered a business model based on a strategic approach to managing processes, information, and resources to support a dynamic configuration of the product lifecycle [1]. According to Lee et al. [2], PLM is a strategically oriented approach that provides a complete product lifecycle definition, including all information and processes required to plan, develop, manufacture, and operationally support a product from conception to the end of its lifecycle, integrating people, processes, business systems, and information. Ming et al. [3] define PLM as a business model that supports the collaborative creation, management, dissemination, and use of intellectual capital related to a product, including data, information, knowledge, etc. PLM is interpreted as a specialized information system that supports all product-related processes, from their development to disposal.

In recent years, there has been a surge in interest in the adoption of the PLM concept. Attracted by PLM's ability to contribute to the attainment of operational and strategic business excellence despite complex business conditions, an increasing number of companies are launching the PLM initiative. PLM transcends traditional application boundaries such as aviation, automotive, and general processing industries, penetrating into other sectors such as fashion or the food industry.

According to the reports of the CIMdata company [4], the global leader in the field of PLM consulting, PLM software market is the fastest growing IT market today with a total investment value of $57,51 billion in 2021 and an estimated growth rate of 8.5% for the next five years.

However, despite significant investments in PLM technologies, many businesses are still struggling to adopt a PLM philosophy and reach higher levels of PLM maturity.

The successful implementation and consistent application of the PLM approach are mostly determined by the human factor. According to Ameri & Dutta [5], the implementation of PLM does not begin with the introduction of PLM software solutions, but rather with the development and adoption of the PLM vision by people involved in PLM-oriented processes.

Given that PLM is a rapidly growing business paradigm, driven by its strong influence on improving the management of business systems, incorporating all relevant PLM topics into

educational processes is imperative in the education of the so-called engineers of the future. These educational processes must go beyond simply the processing of PLM theoretical assumptions and principles. Namely, the consistent application and control of the PLM approach requires extensive analysis and understanding of information flows, business activities, specific methods, and concepts used in different phases of the product life cycle.

This necessitates the education of engineers with sophisticated and multidisciplinary competencies pertinent to the various stages of the product life cycle.

Given their multidisciplinary nature, Engineering Management study programs appear to be the most pertinent for educating experts capable of implementing and coordinating the application of the PLM approach and successfully working in a PLM environment. However, there is a scarcity of considerable discussion in the literature about how the existing Engineering Management study programs' curriculums are aligned with this vision. This paper attempts to fill this gap in the literature and make a certain contribution to the development of an appropriate education strategy for producing engineers with advanced PLM competencies.

The paper first discusses the main issues in PLM education, then it investigates the key PLM topics that must be included in curriculums for the education of future engineers capable of implementing and coordinating the PLM approach, and finally, it discusses the role of PLM academic platforms in the education of future engineers. The last section examines the extent to which PLM topics are covered in Engineering Management bachelor's study programs. The research looked at 19 study programs in Engineering Management from technical and polytechnic universities.

2. PLM EDUCATION ISSUES

In the absence of a systematic, well-organized, and well-conceived PLM education, industry PLM competencies are being developed through long-term employment in various positions throughout the product lifecycle, which is actually the process of absorption and learning about products and operational strategies through experience [5]. This is a fairly drawn-out process and delays the attainment of higher levels of maturity in PLM adoption.

This necessitates the strong promotion of PLM education by academic communities. Additionally, by incorporating PLM education into the university education processes, the academic community might significantly accelerate the process of increasing industry comprehension of the significance of the PLM concept through newly educated staff.

According to the findings of several significant studies in this area [5, 6, 7], several strategic issues must be considered when designing PLM-oriented educational programs in order to close the gap between the industry's true requirements and the student competencies that educational institutions provide:

- It is essential to educate professionals in engineering and business who are aware of the significance of the PLM concept in driving new economies, markets, and technologies.
- It is critical to raise awareness that PLM is more than just an engineering-focused approach; as a result, PLM education must include business and operational strategies that use product and related process information.
- Specific topics must be integrated into the curriculum to promote an understanding of how PLM influences areas outside of product engineering, such as marketing, procurement, product support, project management, costing, manufacturing, supply chain processes, etc.
- PLM education must provide an understanding of how PLM impacts a company's ability to support the use of new initiatives in product engineering, such as model-based approaches. (Model Based Systems Engineering - MBSE, Model Based Enterprise - MBE)
- The emphasis should be on preparing students for tomorrow's business reality through training in a real PLM environment.

The current priority is expanding PLM education beyond a purely engineering focus to include other areas of business where the PLM approach has a significant influence, as well as enhancing students' PLM digital competencies. This will be discussed in more detail in the sections that follow.

2.1. The PLM competences

According to an extensive survey conducted by the CIMdata [6] consulting group, which included a large number of universities, the scope of topics covered in the PLM courses implemented by these institutions is mainly focused on the product engineering and production areas, including topics such as mechanical CAD, documentation, and product design, etc., indicating that this education has not progressed beyond Product Data Management (PDM) focused topics. More precisely, it is mainly focused on the management of information about product definition for the needs of engineering processes and does not enable the preparation of future engineers for all the challenges of product realization and optimization.

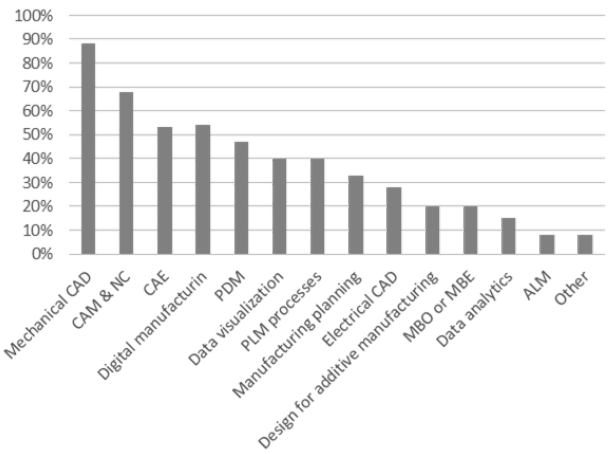

Figure 1. *Topics covered in PLM related curriculums [6]*

From an educational point of view, PLM technologies have long been viewed as sophisticated analytical and visualization tools, helping engineering students to improve their problem-solving and design skills, but more importantly, to better understand the behavior of engineering systems [7].

Companies, on the other hand, demand students to grasp industrial practice beyond the technical focus, as well as how PLM integrates different aspects of the product life cycle and to be able to effectively perform tasks in a self-sufficient manner in a real business environment; in other words, to possess comprehensive PLM competencies. In the matter of engineering education, educational programs must evolve to meet these demands.

Several studies deal with the issue of defining omprehensive PLM competencies [8, 9, 10, 11].

For example, Tamaki et al. [11] are dealing with the development of educational programs aimed at developing the competencies required for the cultivation of the so-called "global-PLM producer." The definition of the comprehensive competencies required for cultivating such an expert is illustrated by a matrix (Table 1) consisting of six phases of the product life cycle (product strategy, business model, global market sensing and the new product plan, product architecture strategy, supply chain management, manufacturing, and quality control, global marketing channels, sales, and maintenance service), and four levels of business administration (global business environment, business creation, customer creation, and product development and operational management). This matrix can be used as a guideline for educational institutions when developing PLM-focused curricula, indicating that competencies such as marketing research, system architecture design, competitive strategy, manufacturing process planning, and so on must be the outcomes of these educational processes.

Table 1. *Educational goals corresponding to whole "competency" required for cultivating Global-PLM producer [11]*

Product lifecycle phase

PLM level	Product strategy	Business model	Global market sensing	Product architecture strategy	SCM, manufacturing and QC	Global marketing channel, sale and maintenance
LEVEL 1 Global business environment	Product line-up strategy Platform strategy Product line strategy Variation management					
LEVEL 2 Business creation		Analysis of business environment New business concept Global business model Competitive strategy				
LEVEL 3 Customer creation			Marketing research Market segment positioning Customer behavior analysis New product planning			Global logistic strategy Local market cultivation Local market promotion Local service promotion
LEVEL 4 Product development and Operational management				Technological benchmark Product specification Concept development System architecture design Integrated PLM business process model	Global framework building of production and SCM strategy Mass production planning Manufacturing process planning	

- Design and methods of industrial engineering
- Technologies and production systems
- Industrial plants
- Economics and management Engineering
- Information elaboration systems

- Computer science

In order to connect industrial realities with the widely acknowledged PLM theory, it is essential to develop an educational model that demonstrates how the PLM theory operates in practice in a way that is comprehensible to students. For this purpose, Fradl et al. [9] developed a scenario around the product in its eco-system in classroom conditions, namely, the product was physically made using easy-to-use technologies, where all relevant organizational aspects, processes, and IT tools from the real PLM environment are present. Through this educational model, students gain competencies in five areas that are considered critical for preparing future engineers for the PLM reality. These competencies include:

PLM basic:

- Product structure vs MCAD structure
- Collaboration
- Change management

PLM advanced:

- Product structure with modular product architecture
- Engineering change management
- End-to-end PLM processes

PLM system:

- Configuration of a PLM-system
- Realisation of connectors
- IoT and cloud data pipeline

Series manufacturing:

- CAD to BOM to release
- Engineering change management
- Production management
- Supply chain management
- Service

Mechanical CAD/CAE:

- Managing files
- Checkin / checkout
- Update properties vom PLM

2.1. PLM digital competences and the role of PLM academic platforms

PLM is a strategic business approach and a product management paradigm, as well as a technological concept supported by advanced ICT technologies. The totality of the IT infrastructure that supports the PLM strategy is most often defined as a PLM solution or a PLM system. It is a complex technological solution that supports a wide range of PLM-oriented processes, enabling a PLM strategy, which is defined as a consistent set of business solutions to support the collaborative creation, management, sharing and use of product information across the enterprise, integrating people, processes, business systems and information [12]. Considering its functionalities, according to dos Santos et al. [13] PLM system could be defined as:

- Infrastructure for information management, i.e. modeling, centralization, manipulation and sharing of product life cycle data;
- A set of business applications to support the use of data and knowledge about the life cycle of products in different organizations and at different stages of the life cycle;
- A knowledge management system for generating and disseminating knowledge about the product life cycle;
- A collaborative environment for integrating business units across the value chain network.

Acquiring digital competencies for dealing with such technologies is an essential aspect of PLM educational procedures that contributes considerably to preparing students for tomorrow's business reality and working in a real PLM environment. However, the technology employed in educational processes by universities today has long been technologically and functionally incompatible with that used in industry. Actually, education is most often carried out on technology solutions that cover only the domain of PDM functions; nevertheless, PLM has long outgrown the engineering focus. Namely, at the current stage in its technological evolution, PLM systems are viewed as comprehensive business solutions whose functionalities span all aspects of the product lifecycle, including integration along the entire supply chain.

A substantial barrier for educational institutions trying to simulate a real PLM environment is the high cost of these technologies. This is the stage where the PLM vendors are anticipated to give major assistance. Namely, via so-called PLM academic platforms, PLM vendors provide educational institutions with comprehensive PLM systems tailored to the demands of educational processes for a fairly low price.

Some of them even went a step further. Siemens PLM Software, for example, is developing curriculum and specialized software support to help universities build qualified PLM enablers to participate and thrive in the evolving digital future.

As part of its education program, Aras Academic also offers online learning courses in the hottest PLM topics, including: Component Engineering, Manufacturing Process Planning, Quality Planning Essentials, Product Engineering Essentials, Program Management Essentials, Visual Collaboration, Self Service Reporting, and Technical Documentation.

Also, Dassault System Company provides various services that are available for institutions, educators and students to increase learning efficiency and improve education process including:

- 3DS academy website
- Peer Learning EXPERIENCE
- Project-centric learning
- Dassault Systèmes Certification Program

In addition, Dassault Systemes Company is constantly striving to contribute to the creation of educational innovation. As a result of these aspirations, it arises Edu Hub, which conducts educational research by global collaboration to envision future trends in engineering education.

It is inevitable that engineering education must take a step forward using advanced educational models based on students' work in a real-world PLM environment. A good way to achieve such an educational model is through the use of PLM academic platforms, which have become an indispensable part of PLM educational processes. According to a survey conducted by Bedolla et al. [10], 62.5% of European educational institutions that have implemented PLM education use such software support in their educational activities.

The use of PLM academic platforms is aimed at supporting the education of future engineers by providing students with a comprehensive PLM experience and advanced digital competencies. PLM platforms intended for educational processes deliver a multitude of commercial PLM solutions' capabilities, covering the gamut from planning to engineering design to manufacturing. Namely, they provide IT support for major PLM aspects through a variety of commercial applications integrated into a single platform that spans the entire product lifecycle.

By introducing PLM academic platforms into the classrooms, students are enabled to acquire skills, knowledge, and advanced digital competencies by working in a real PLM environment. It also enables the preparation of future engineers for PLM roles beyond engineering, leading to a comprehensive understanding of the PLM concept and how it could be used to establish integrated management of product data throughout the entire product lifecycle or to drive company growth.

That way, students can transition to the professional workforce, which will be competent to implement and enforce PLM concepts within companies.

It is also important to note that the use of the PLM academic platform during the educational process supports the implementation of the project and problem-based educational learning models. These pedagogical strategies are widely accepted in various fields in educational contexts to promote critical thinking and problem-solving skills, so they play an important role in educating engineers in line with contemporary industry requirements.

Some of the most commonly used PLM academic platforms in educational institutions with PLM-oriented courses are platforms provided by PLM software vendors such as Aras, Siemens, and Dassault System. Figure 2 presents the functionalities that the Aras PLM academic platform spans.

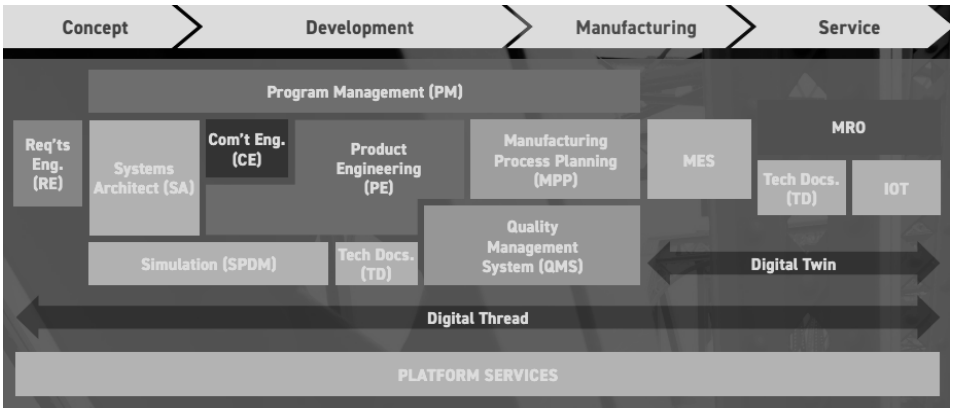

Figure 2. *Aras PLM Platform [14]*

Engineering Management graduates are competent to support a variety of innovative industrial initiatives, and it is believed that they play a crucial part in the consistent application and control of the PLM approach. The research question addressed in this section is: to what extent may Engineering Management study programs contribute to the education of professionals with comprehensive PLM competencies?

Engineering Management, according to the Missouri S&T [15], is a discipline that prepares professionals to successfully combine engineering and management expertise while optimizing the utilization of people, equipment, material resources, energy, and information.

This study program has received significant attention in recent years owing to its potential to educate professionals for today's industrial reality who will be able to effectively respond to the demands of technical progress, an increasingly complex business environment, and new industrial initiatives.

The pertinence of Engineering Management study programs stems from the necessity to consider the business unit as a complete, technology-driven organization and to successfully integrate system components, guaranteeing that the company succeeds in a competitive environment.

The Study program supports the STEM concept in education. STEM refers to educational institutions that prioritize education, which is essential for scientific and technological sphere of development, through offered educational programs. STEM refers to several academic disciplines: S – Science, T – Technology, E – Engineering and M – Mathematics. This also strengthens the connection between engineering management as a discipline and the PLM concept.

The analysis included Engineering Management study programs from 19 universities. The list is presented below.

- University of Groningen, Netherlands
- University of Lincoln, United Kingdom
- WSB University, Poland
- University of Perugia, Italy
- Sirindhorn International Institute of Technology -Thammasat University, Thailand
- Poznan University of Technology, Poland
- Stevens Institute of Technology, New Jersey
- Missouri University of Science and Technology, Missouri
- University of Maryland, Baltimore County, Maryland
- Massachusetts Institute of Technology, Cambridge, United Kingdom
- University of Illinois Chicago, Illinois
- Michigan Technological University, Michigan
- Southern Methodist University, Texas
- Loughborough University, United Kingdom
- Clarkson University, New York
- Illinois Institute of Technology, Illinois
- Faculty of Technical Sciences Cacak, Serbia
- Faculty of Technical Science Novi Sad, Serbia
- Faculty of Mechanical Engineering Nis, Serbia

This research question was considered based on an empirical screening of these programs' curriculum structures. The aim was to identify courses through which students could acquire some of the core PLM competencies and also assess the acquired competency level based on the analysis of the predicted outcomes of these courses. The analysis made use of the PLM competencies concept established by Bedolla et al. [10], which covers the following areas:

- Design and methods of industrial engineering
- Technologies and production systems
- Industrial plants
- Economics and management Engineering
- Information elaboration systems
- Computer science

Figure 3 depicts the representation of competencies from these areas by study programs (a. by categorization of the *high, medium, and low*, and b. by the total strength).

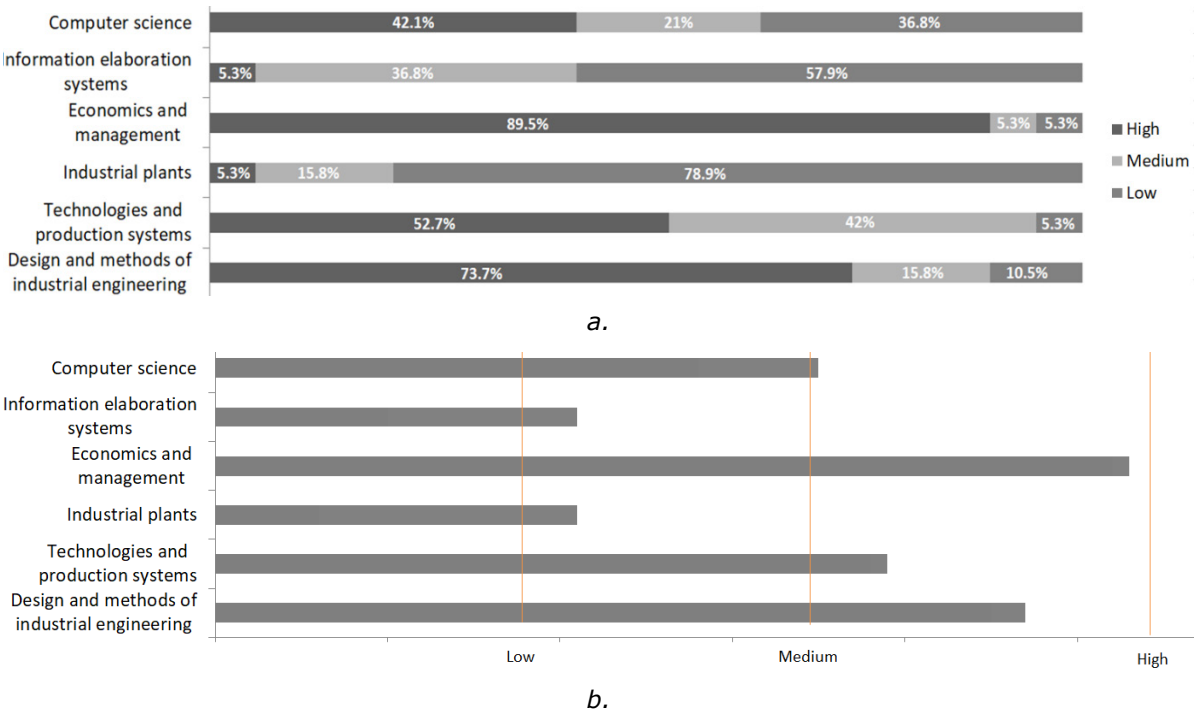

Figure 3. *PLM competency representation in Engineering Management study programs' outcomes*

These competencies are highly represented in almost 90% of the analyzed study programs. The situation is comparable to competencies in the field of design and methods of industrial engineering (74% - high represented). This discipline also strongly emphasizes competencies in technologies, production systems, and computer science. On the other hand, these programs somewhat underrepresent the competencies related to industrial plants and information elaboration systems.

This indicates that Engineering Management programs provide multidisciplinary competencies, enabling understanding of information flows, business and engineering activities, specific methods, technologies, and concepts used in different phases of the product life cycle, and also provide education beyond a purely engineering focus, including other areas of business where the PLM approach has a significant influence.

This undoubtedly supports the hypothesis that Engineering Management study programs are among the most pertinent for educating experts capable of implementing and coordinating the application of the PLM approach.

4. CONCLUSION

The research findings provide proof that Engineering Management study programs have a significant role in educating engineers with comprehensive PLM competencies, providing education beyond a purely engineering focus, including other areas of business where the PLM approach has a significant influence.

Thus, more emphasis should be placed on promoting these study programs as the main generators of engineers with advanced PLM competencies. The introduction of courses that will more intensively study the theoretical settings and practical implications of PLM is also necessary in order to develop students' awareness of the importance of the PLM concept in achieving operational and strategic business excellence.

However, there is currently no evidence that students can acquire digital competencies for work in a real PLM environment through the analyzed study programs. This could be an important direction for future research, which also should highlight the importance of PLM academic platforms in the education of future engineers.

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The Impact of Global Changes on the Transformation of Politics, Economy and Education

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Abstract: *Society faces many challenges in transitioning toward sustainable development, and education is key to make this transition happen. Through education we influence on human consciousness, create their needs and changing behavior. One of most important educational programs is environmental education. It brings motivations, skills, values and commitment that people need to efficiently manage their earth's resources and take responsibility for maintaining environmental quality and understand the problems they face. The limitation of access to certain resources is getting closer and we need to be aware of those limitations and put those in center of our life and work. The most effective way for doing it is throught environmental education started from earliest age. The limitation of access to certain resources is getting closer, and this fundamentally changes our relationship to economics, politics and ecology. This paper discusses the imperative of action within the limits of the finite world. The paper emphasizes the pressure on natural resources, which means that politics and the economy will have to undergo a radical transformation in order to be suitable not only today, but also in the future.*

Keywords: *global changes; ecology; environmental education; sustainable development*

1. INTRODUCTION

The role of education is of great importance in creating future socio-economic trends. Global changes inevitably bring with them changes in the traditional approach to education. The speed with which the world is changing means adapting to new principles, norms, and values.

Looking at the causes and consequences of such changes through the education system is a necessary way to prevent far-reaching consequences for both the planet and humanity. If the growth trend does not fundamentally change, we will witness an increasingly frequent occurrence of pandemics, an increasing number of ecological refugees who, with the instinct of survival, will start an exodus from devastated areas to areas where they believe they can ensure their existence.

In this case, mixing cultures, traditions, religions, habits, politics, education is the most important common content and the most important bearer of future social changes and development. Here we are not only talking about the need for changes in the structure of the materials, but about the necessity of understanding the political-economic wishes of global powers and knowledge of national possibilities and capacities. No matter how much we think that globalization will bypass us with a passive approach to global changes, it is impossible. Every open economy suffers the impact of global changes. And if we don't want globalization, globalization will come to us. Only with an adequate structure of the educational process, which includes clearly defined criteria and values, can we ensure the preservation of national sustainability and the future development of our society.

As the main actors of the current situation in which humanity found itself, the pandemic of the Corona virus COVID-19, we are responsible for everything that was, for what we are currently experiencing, and regardless of the outcome of the current crisis, we are absolutely responsible for understanding the meaning, value and future actions so that such disasters do not happen again. Throughout history, man has found various ways to survive and adapt the ecosystem to his needs. Obviously, finding a balance between human needs and pressures on the ecosystem has not borne fruit. Uncontrolled use of naturally non-renewable resources (deforestation, unplanned expansion of settlements, uncontrolled growth of pollution, draining of wetlands, reduction of the abundance of many plant and animal species, unreserved exploitation of hydro potential, development of technology and its impact on the environment, such as the introduction of the 5G network...) they led to immeasurable damage, the cause of which is exclusively human.

K. Potting [1] describes how ecological damage caused by the human factor led to the disappearance of the conditions for the survival of the population. The very rapid development of the industry due to the increased demand, and thus the volume of production, leads to frequent accidents to the health of the population. Looking at the causes and consequences of such damage is a necessary way to prevent far-reaching consequences for both the planet and humanity. If the growth trend does not fundamentally change, we will witness an increasingly frequent occurrence of pandemics, an increasing number of ecological refugees who, with the instinct of survival, will start an exodus from devastated areas to areas where they believe they can ensure their existence. This leads to numerous problems, not only in the social and organizational sense, but also in the economic sense, starting from the increase in costs due to leaving the traditional place of living, to their questionable assimilation in the new environment.

The disruption of the natural balance is so great that some authors believe that it is impossible to predict what will happen in the future. Ćirković, M. states: "Devastating events completely destroy predictability. The consequence is that absolutely devastating events, which humanity has no chance of surviving, completely destroy the reliability of predictions based on past events." [2, pp. 114-123] The anthropogenic burden on the planet has become so burdensome for predicting the future, that every planetary catastrophe is first characterized as a conspiracy theory. From a social point of view, the antogenic burden ultimately leads to humanity becoming condemned to inhumanity, and closing our eyes to this planetary problem is justified by irrational value judgments based on the interests of the great powers. But let's take a look at what kind of forecasts and scenarios were created in the past period, what of the anticipated events came true, and where such forecasts lead us in the future.

In 1990, according to research by the Harvard Business Review, a world dialogue was started on the important issues that companies and managers face in their policies in the 1990s. The results were published in "Transitional Frontiers of Business: 12,000 Global Managers Look at Change" The survey concluded that managers around the world believe that government should put the needs of business first in decision-making and policy-making. Protecting companies that create wealth, in their opinion, should be the priority of any responsible government. However, we are of the opinion that such an attitude had to be changed with a sustainable approach, and that every company must correct its business policy by including corporate norms that harmonize the company's policy with the environment and the global business and eco system. In modern conditions and new business models within the framework of sustainable development, the coherence of business policy implies management in new ways.

2. FURTHER RESEARCH

By means of mathematical computer modeling, a group of scientists Donnell and Dennis Meadows (USA), Jorgen Raders (Norway) and others, studied the behavior of the world system in the period of the 20th-21st centuries. The following factors were investigated in numerical form:

- Population,
- Resources,
- Volume of industrial production,
- Volume of food production,
- Level of environmental pollution.

In the book "The Limits of Growth" from 1972, which has been translated into 35 world languages, the results of research on the above factors are presented. After that, in 1992, the results of a new research were published in the book "Beyond the Limits of Growth". Both books caused polemics, interest and achieved unusual success. As authors state: "Our book was discussed in parliamentary and scientific circles. One major financial company has dedicated funds to a series of critical publications, another has established an annual award for the best research in the field. The book "The Limits of Growth" caused stormy criticism, many analytical reviews and a flurry of attacks from the right, from the left and also attacks from the position of the center. The book was accepted by many as a prediction of the near end of the world, but it is not a prophecy of that kind at all. It does not speak of a future that is predetermined, but of the choice of that future. It certainly contains a warning, but also hope..."

Considering the analysis of the development of the world and the system that, according to the results, would indicate the optimal growth model, the authors developed a computer model called "World 3", and the results of the research were published in the book "Growth Limits". Based on the study and analysis of the development of the world in the period 1970-1990, due to the changed circumstances of the environment, the model was supplemented and corrected, so that a new version of the "World 3/91" model was created. However, regardless of minor changes, the results obtained by applying "Svet 3/91" are very little different from the results obtained 20 years earlier.

In the "World 3/91" model, the behavior of system elements such as:

- Population,
- Industrial capital,
- Pollution,
- Arable land.

The mentioned elements are variable because they are the result of the life cycle, they move from birth to the end of the life cycle, such as birth and death in the case of the population, or say investment and depreciation in the case of capital. For example, the amount of food produced per capita affects the death rate. As we stated, their Survey of the Five Elements of the World (population, volume of industrial production, volume of food production, resources, level of environmental pollution) are average. It should be noted that in the population survey there is no difference between Chinese and Italians, poor and rich. World industrial production includes world production and other parameters are simplified in a similar way.

resource deposits will increase as we move towards limits.

Also, a time delay is introduced for many processes in the model. Let's say - a delay in the change in the number of the population, conditioned by the age structure. In modern society, the number of young people is significantly higher than the number of old people. Therefore, even if the birth rate decreases, the number of the population will continue to grow over the decades as a result of growing up. Although the number of children in families is decreasing, the number of families is growing.

Here's how it looks on the example of a rough calculation of the process of destruction, where we

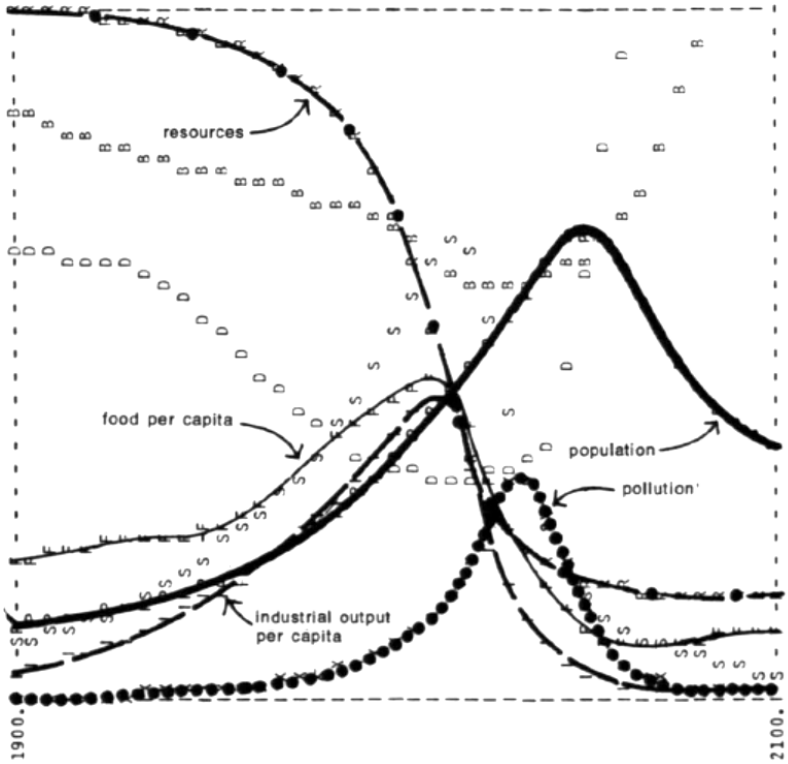

Figure 1. Traditional model-Scenario 1 [3, p.124]

- Processes of population growth,
- Economy,
- Latency limits,
- Destruction processes.

It is also important to explain that there are certain limitations, in the form of a limitation of the arable area of 32 million km2 (land without Antarctica 131.3 million km2). Limits of Earth's productivity... Non-renewable resources (mineral raw materials, fossil fuels) enough for no less than 200 years, if their extraction remains at the level of 1990. The Earth's ability to absorb pollution is such that, in the event of a tenfold increase in the level of pollution registered in 1990, life expectancy is reduced by only 3%, soil fertility by 30%. However, the costs of land development, yield enhancement, exploration and exploitation of non-renewable

are practically spinning in a vicious circle. Suppose there is a shortage of food products. In that case, people could exploit the land much more intensively, in order to produce more products in a short time, to the detriment of long-term soil conservation programs. The result is a decrease in the productivity of the land, so when you look at the facts, it again leads to a further decrease in the amount of food products.

In order to be able to comment on the "world 3/91" model, we will first present certain general characteristics. The total number of interactive variables is 225. When calculating a scenario of the state of the world, the computer calculates the meaning of each variable for each half-year of the considered period, from 1900-2100. More than 90 thousand values are generated by the calculation of this model for each scenario.

Fig. 1 presents Scenario 1 of the state of the world. These are the results of the standard scenario of the state of the "real" world as shown here. World society is developing in a traditional way, it is developing as it developed during the 20th century.

Scenario 1, the behavior of the world in the period 1900-1990. yr., as stated in the book, is characterized by the following:

• The population increased 3.3 times from 1.6 billion people to 5.3 billion people.

• The total volume of industrial production increased 20 times.

• In that period, 20 percent of the world's reserves of non-renewable resources (fossil fuels, oil, coal, gas; materials: iron, aluminum, copper, chrome, nickel) were used.

• The average volume of industrial production per capita, which characterizes the material standard of living in 1990, was 260 dollars per year.

The authors predict problems will arise as time passes. The world is gradually reaching its limits. According to this model, research results suggest that from 1990 to 2020, the volume of industrial production will increase by 85%, and the rate of consumption of non-renewable resources will double. If in 1990 the reserves of non-renewable consumption were sufficient for 110 years, this scenario predicts that at the rate of their consumption at the level of 1990, in 2020, the reserves would amount to only 30 years, due to the rapid exponential growth of consumption.

Shortly after the year 2000, the level of pollution will become high enough to cause a massive decrease in the fertility of the earth. If the fertility of the soil was reduced by only 5% from 1970 - 2000, starting from 2010, the annual rate of degradation will amount to 4.5%.

In Scenario 1 of the traditional world, it is forecast that around 2015-2020, economic growth stops and economic decline begins. Capital (physical and not monetary) decreases faster than the inflow of investments. Also, the volume of industrial production and production of food products is decreasing. In proportion to the decrease in the production of food products, the level of health care falls, leading to a decrease in life expectancy and an increase in mortality.

According to the same scenario, the population, having reached its peak around 2030, of around 8.4 billion people, will start to decrease. The delay of the peak of the number of inhabitants in relation to the peak of the volume of industrial production, and the production of food products of about 10 years, is explained by the age structure of the population and social regulation. It is interesting to note that in the scenario of the traditional world, the volume of industrial production in 2100 will fall to the level of 1990.

When we look at all this from today's point of view and the current situation, during the pandemic, we cannot help but notice that the model does not take into account possible social restrictions that can lead to tragic consequences (world wars with the use of weapons of mass destruction, pandemics), so from for this reason, this scenario can even be considered optimistic.

The mentioned traditional model and its publication, indoctrination and implementation are more receptive to the population compared to other scenarios. There are several reasons why this is so.

If we are looking for a way to motivate the population to accept a new resource model scenario within the limits of sustainable development, we believe that this very sensitive issue requires a review of Max Weber, who defines four types of human social behavior:

1. Objective rational behavior - implies setting a rational goal with equally rational means of achieving that goal.

2. Value-rational behavior - implies a conscious belief in the absolute value of a set goal, regardless of the possibility of its realization.

3. Affective behavior - implies behavior primarily defined by affects and emotions with the absence of rationality.

4. Traditional behavior - based on habit, also with the absence of rationality.

Looking at the mentioned types of social behavior, we point out that it is very difficult to adapt the entrenched traditional behavior to changes in the environment, regardless of their necessity and rationality. It is this traditional utopia that could lead to poor implementation of the newly offered scenarios. Therefore, from a theoretical point of view, it is necessary to act strongly on the motives of the population, on awakening their awareness of the possible possessions that will arise if the world functions and grows in the way it has been. Acquainting the population with the real dangers and the real causes of such an assumption, which will be more receptive and meaningful to them after the Corona virus pandemic - COVID 19, we can establish a social regularity in relation to the resource model of the world, which will be woven both through the life habits of the population and through their business activities, company policy, through national state policy. Without class and status divisions, without divisions by activities, without divisions according to the level of development of companies and countries, everyone must have the same motive of preserving the resource potential of the planet in accordance with the limits of growth. The social reality is different. Social stratification will have its impact on any proposed model. The question arises, how to define the boundaries in that segment, the zone of indifference within which the complexity of the

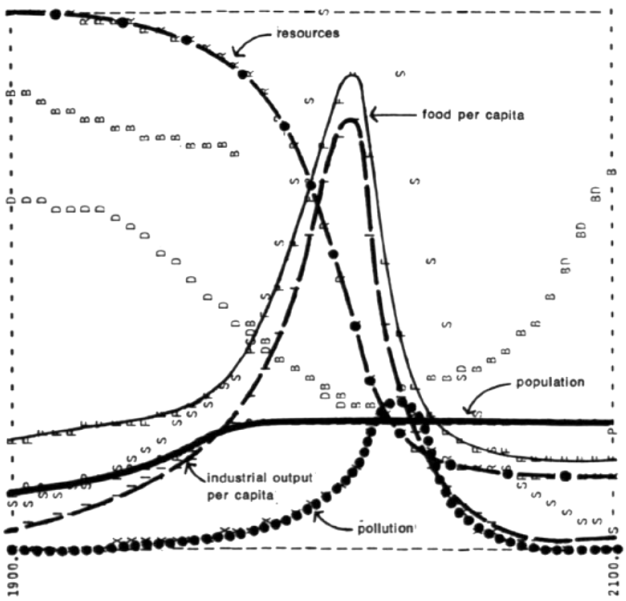

Figure 2. *Scenario 10, Sustainable World* [4, p.160]

social structure (the influence of power, rich, uneven knowledge...) will not affect the final reach of the proposed model? Can the preservation of humanity become a higher goal that exceeds the power of economic influence?

Otherwise, we will have a situation that Medowsy calls a collapse. The following Scenario 1 describes uncontrolled population decline or economic decline, caused by going beyond the bounds of the sustainable limit. An unambiguous and important conclusion follows from the analysis of Scenario 1, that the traditional system with its growth rate of the economy and population, with its ruling method of production, although we consider it optimistic, is NOT SUSTAINABLE. The question arises, in what way should the traditional world, which is doomed to fail, be transformed into a sustainable and habitable world?

Meadows offers an answer in one of the scenarios, the so-called Scenario 10 shown in Fig. 2, in which, compared to Scenario 1, numerous and significant changes have been introduced. This scenario starts from a doubled change in natural resources. It is also based on the assumption that after 1995 all families to be limited to two children. It is also important that since that year the volume of stabilization of industrial production has been accepted at the level of 350 dollars per capita per year. Technologies are being introduced that reduce the emission of harmful substances, soil erosion and increase the effectiveness of the use of natural resources.

A new sustainable society, which in the XXI century has a stable volume of industrial and food production and a stable population, is the result of this scenario. A stable population of 7.7 billion people can be adopted as the allowable population of the world, in the resource model. We can call Meadows' model of the world a resource model, since he considers the Earth as a source of resources.

From his explorations of the world, D.H. And D.L: Meadows draw the following conclusions:

This necessarily leads to the conclusion that without a significant reduction in the flow of material and energy resources in the coming decades, there will be a reduction in the following indicators per capita:

- Production of food products,
- Energy consumption,
- Industrial production.

2. That reduction is not inevitable. And it is precisely in this segment that we come to the necessity of transformation and a comprehensive revision of politics and economics, and practices that contribute to the growth of the number and level of material consumption, then a rapid and sudden increase in the effectiveness of the use of material resources.

3. The authors point to the technological and economic construction of a sustainable society while it is still possible. Compared to a society that solves all problems at the expense of constant quantitative growth, this solution will certainly be more appropriate. It requires a transition to a sustainable society, a carefully balanced strategy that bases its goals and accents on sufficiency, equality and quality of life, and not on the volume

of production (which was not the case with China in previous decades). Great caution and a caring approach make conclusions and not ominous predictions. And to finish the analysis of the results with the last thought of D.H. and I D.L. Meadows," our ideas lead to a new world. Sustainability and not an increasingly perfect weapon because the struggle for power and material wealth is the last challenge of energy in the creative abilities of the human race."

In 2020, regardless of model I variations, it is imperative to operate within the confines of a finite world. The pressure on natural resources means that politics and economics will have to undergo a radical transformation in order to be suitable not only today, but also in the future.

Recent UN projects and reports suggest that the population will reach 9.3 billion by 2050 and over 10 billion by the end of the century. Most of this growth will take place in emerging markets - until 2050. Asia may have 60% of the world's population [5]. In this regard, Alexandra Boakes Tracy explains that the UN's Food and Agriculture Organization anticipates a 50% increase in food demand by 2030, even if urbanization on an unprecedented scale could displace up to 30 million hectares of prime arable land. As he states, there will be much higher meat consumption in emerging economies, and more extensive livestock farming will help increase water demand by as much as 30%, the International Food Research Institute has shown [6].

Also, in numerous reports, consumer appetite for many products is already testing the limits of supply. This will inevitably affect the company's operations and concern about the implications for future operations. This was confirmed by a survey of companies from 24 sectors, conducted at the end of last year by Ernst and Young and Green Biz, in which 76% of respondents declared that they "predict that the basic business goals of their company will be affected by the lack of natural resources in the next 3-5 years".

3. CONCLUSION

Looking at the mentioned types of social behavior, we point out that it is very difficult to adapt the entrenched traditional behavior to changes in the environment, regardless of their necessity and rationality. It is this traditional utopia that could lead to poor implementation of the newly offered scenarios. Education as a process of teaching, learning and practice is the most important way to overcome this problem. Therefore, from a theoretical point of view, it is necessary to act strongly on the knowledge, on the motivation of the population, on awakening their awareness of the possible consequences that will arise if the world continues to function and grow in the way it has been.

In 2022, regardless of model I variations, it is imperative to operate within the confines of a finite world. The pressure on natural resources means that education, politics and the economy will have to undergo a radical transformation in order to be relevant not only today, but also in the future.

Perhaps this COVID-19 pandemic will lead to increased concerns about the impact on the environment. The fact that we continue to consume more resources than the planet can naturally replenish, the fact that there are more of us every year, the uncontrolled population in the form of chaotic poliss and a host of other wrong things means that we are currently consuming the equivalent of 1.6 planets per year which some authors call "overrun day - the day every year when demand exceeds natural supply - comes earlier and earlier".

The limitation of access to certain resources is getting closer, and this fundamentally changes our relationship to education, economics, politics and ecology. Already during the next decade, access to certain resources will become increasingly difficult and expensive. Perhaps now is an important moment to stop, think, notice something more and wisely determine new priorities and strategy for a new scenario.

The necessity of introducing changes in the educational system in which, depending on the level, this topic would be brought closer to the population so that they would understand the consequences of the current approach, is not only desirable, but urgent. Education must be the hallmark of future changes and a modern approach to sustainability.

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Session 6:

ESP and Technics and Informatics: Challenges and Perspectives

Notes:

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Key ESP Words and Phrases

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Abstract: *We frequently mention or use the concept of keywords. However, many are unaware of the possibilities of dealing with them on a different level, which would include accurate statistics and a justified selection of words and phrases (n-grams) that can be considered specific vocabulary and word clusters for a certain type of text. The paper aims to present a possible and reliable method of providing such lexical information for specific technical genres. In our case, it would be a collection of marine engineering technical manuals for tanker ships. The purpose of the methodology presented is to provide a lexical tool that can be applied to any technical genre or more of them and that provides us with useful and concentrated ESP vocabulary material to be used in ESP classes and courses.*

Keywords: *keywords; n-grams; marine engineering; technical manuals.*

1. INTRODUCTION

Technical vocabulary is what the specifics of a Language for Specific Purposes (LSP) mostly pertain to. Therefore, special attention is always paid to the selection and design of vocabulary teaching material. On the assumption that our language learners have mastered the basics of their target non-native language, the main idea is to provide them with "early specialization" in their professional language [1]. New momentum in vocabulary research has been brought by information technology assets enabling practical and fast collection and creation of electronic corpora, along with computer software solutions for lexical analysis of texts. This has provided us with the opportunity to gain more accurate statistical analysis and justification of data used in vocabulary analysis and teaching material. The concept of keywords, for example, has been widely used and applied, as implied by the meanwhile created and parallelly used compound (*keywords*). Here, however, we present the possibility of statistically justified, software-based extraction of key words (or *keywords*) and phrases (word clusters) from a technical genre.

1.1. Target language learners

The syntagm *language learners* here and, as usual, does not necessarily refer to those studying a foreign language, but generally to non-native speakers who need the second language to accommodate the professional discourse community they belong to. One of the most effective examples is the maritime community sharing English as their *lingua franca* around the globe. Maritime English comprises many different registers and communicative purposes. In this paper, we deal with English for Marine Engineering Purposes, which proved to be one of the most demanding ESPs vocabulary-wise [2][3]. Our target language learners are therefore the students of Marine Engineering and active seafarers during their lifelong learning process and particular courses they undergo during their professional careers.

1.2. Corpus

One of the main professional tools of marine engineers, once they sign on vessels, are ship's instruction books and manuals. They are indispensable in familiarizing with the ship's systems and devices, as well as for their regular maintenance, repairs, and overhauls. Having in mind the current and prospective trends in shipping, we opted for technical manuals of tanker ships. Following the expert advice, we provided a comprehensive selection of 61 technical manuals from a modern tanker ship. Due to practical reasons, as well as to avoid the commercialization of the data, we are not presenting the corpus selection in more detail. In general, the Corpus of Tanker Ship Technical Manuals (CTSTM) contains instruction books and manuals for the main engine, generators, lubrication system, separator, economizer, incinerator, sterilizer, valves, steering gear, shafting, condenser, filters, pumps, and other auxiliaries, gears, and systems. In total, the corpus amounts to 1,109,080 running words or tokens, obtained after an attentive "cleaning" and preparation of the corpus for further analysis.

2. METHODOLOGY

The intention of this paper is to present a methodology that can provide us with statistically

accurate lexical information on a type of text. It is shown on the example of a markedly technical and actual type of marine engineering publications (CTSTM). It aims to tackle the demand of such a text vocabulary-wise, as well as to provide a recommendation for the extraction of words and phrases (n-grams) that can justifiably be considered key for the particular text or genre.

To investigate the lexical profile and demand of the target Corpus of Tanker Ship Technical Manuals, we used the freeware tool AntWordProfiler, version 2.0.1. [4]. To accommodate the software requirements, the *.pdf* files were converted to the *.txt* format (plain text). The referent General English (GE) word lists used for the process were the Nation's word lists produced from the British National Corpus and Corpus of Contemporary American English (BNC/COCA). These 25 lists contain about 1,000 word families[1] each, and, for this kind of research, they are usually accompanied by additional lists of the most frequent proper names, abbreviations, transparent compounds, and marginal words [5][6][7].

For keywords specifically, we used AntConc, version 4.1.0. by the same developer [8]. This software provides us with the opportunity to obtain the list of corpus keywords, comprised of the words unusually frequent as compared to a referent corpus of General English (GE). As such, these words are considered to reflect the nature of a text or genre and enable its better and proper comprehension [9]. As for the referent GE corpus, we used the Freiburg-Lancaster-Oslo/Bergen Corpus (FLOB). This GE corpus was developed aiming to produce a contemporary British English corpus serving as a counterpart of the Brown University Standard Corpus of Present-Day American English [10].

In addition, we used the same software to examine then-grams or multi-word units most frequently occurring in this specific professional genre and therefore worthwhile pursuing.

3. LEXICAL PROFILE OF CTSTM

Firstly, we wanted to examine the lexical profile and demand of our target corpus, thus we tested it against the GE word lists (BNC/COCA) as per the methodology given above.

Having in mind the findings and agreement of relevant authors of the area that adequate reading comprehension is expected at the level of 95% of known vocabulary [11], we can see that in our target corpus it is not reached even with all the available 25,000 General English words2, not to mention the ideal threshold of 98% [12].

Table 1. *Coverage of GE word lists in TSTM*

BNC/COCA Word Lists	Coverage %
2,000 + proper names, abbreviations, compounds and marginal words	61.54
3,000 + proper names, abbreviations, compounds and marginal words	85.32
4,000 + proper names, abbreviations, compounds and marginal words	88.25
5,000 + proper names, abbreviations, compounds and marginal words	90.39
6,000 + proper names, abbreviations, compounds and marginal words	91.17
7,000 + proper names, abbreviations, compounds and marginal words	91.9
8,000 + proper names, abbreviations, compounds and marginal words	92.46
25,000 + proper names, abbreviations, compounds and marginal words	94.25

If we take into consideration that about 4,000 GE words are considered sufficient for adequate reading and understanding of, for example, newspapers [13] or for successful listening and understanding of academic lectures and TED talks related to physics [14], or that as many as 12,000 are needed for some highly professional genres [3], the results point to the challenges imposed by the technical nature of our target corpus of tanker ship technical manuals. Taking into account the recommendations for early language specialization when it comes to ESP [1], our aim here is to explore the most frequent keywords and phrases found in technical manuals meant for marine engineers on tanker ships.

4. KEY WORDS IN CTSTM

Unlike the frequency counts, the keyness of a word does not necessarily anticipate a high but rather unusual frequency of that word as compared to its use in the general language, in our case – General English. Keywords are consequently those with a "special status" [15] in a genre, reflecting its specificity when compared to other types of texts. The tools enabling us to relatively easily extract keywords from a text or corpus especially come in handy, providing us with meticulously organized lexical and syntactical material [7].

The initial and total keyword list counted 92 lemmas. The keyness in our approach, however, does not refer to an individual lemma, as presented by the software. Lead by the principle of learning burden or effort put in mastering a word [16], we put and counted together word family members, adding the members to the one with the highest frequency. That way we added, e.g., *setting* to the *set* "family", *cleaning* to *clean*, *operating* to *operation,* and similar (Table 2), adding their

[1]A word family includes the head or base word with all its inflected and derived forms.

[2]A word here denotes a word family.

keyness and frequency values, as well. We also excluded the most frequent English words from the list such as: *if*, *be*, *is*, which mostly belong to the 10 most frequent words of the English Language [17][18]. Also, regardless of our best efforts to remove proper names, single letters, symbols, and abbreviations from the initial corpus, some still occurred in the list, so we removed those as well. Finally, we are presenting the list of 78keywords in CTSTM, arranged by their cumulative frequency ranging from +2 to +8,906, as per the previously explained process (Table 2).

Table 2. *Key words in CTSTM*

No.	Word	No.	Word
1	oil	40	position
2	valve, valves	41	must
3	pressure	42	fig
4	pump	43	load
5	operate	44	ring
6	control	45	language
7	water	46	output
8	step	47	screw
9	check	48	actuator
10	air	49	compressor
11	separator	50	signal
12	manual	51	maintenance
13	boiler	52	bar
14	speed	53	level
15	burner	54	replace
16	fuel	55	sensor
17	system	56	instructions
18	start	57	note
19	set, setting	58	remove
20	engine	59	hydraulic
21	unit	60	supply
22	motor	61	piston
23	temperature	62	shaft
24	installation	63	bearing
25	type	64	cable
26	stop	65	page
27	safety	66	filter
28	alarm	67	cylinder
29	flow	68	turbocharger
30	mode	69	feed
31	parts	70	clean, cleaning
32	menu	71	terminal
33	bowl	72	data
34	input	73	shut
35	governor	74	service
36	switch	75	gasket
37	figure	76	inlet
38	panel	77	value
39	steam	78	spindle

For practical reasons, we are not presenting additional data such as respective keyness and frequency counts. Nevertheless, for illustrative purposes, we are giving a shortened overview of data obtained through the software in Table 3. The example covers the highest-ranked keywords in the corpus:

Table 3. *The five highest-ranked keywords in CTSTM*

Rank	Word	Keyness	Frequency
1	oil	+8,906	8984
2	valve	+7,113	7,120
3	operation	+6,610	6,766
3	pressure	+5,164	5,796
4	pump	+ 4,907	4,921
5	operation	+4,378	4,492

As we have a closer look at the composition of the keyword list (Table 2), we can see that most of the words reflect the specificity of the marine engineering lexicon, especially that of a tanker ship, such as *oil*, *valve*, *operation*, *pressure*, *pump*, *maintenance* and similar. However, we also come across a few notions that belong to other or general registers, such as e.g. *language*. Being curious about the unusual frequency of the word language in a highly technical genre, we explored another software advantage referring to collocations. We found out that the word *language* here frequently collocates with *selection*, *English*, *menu*, *table*, *on,* etc. Its frequency is therefore explained by instructions on settings the corpus is abundant with. A similar examination can be done for any of the words, seeking their collocations or word clusters, which can be of additional use to material and course designers, as well as for the language learners themselves.

5. THE MOST FREQUENT N-GRAMS IN CTSTM

Bearing in mind that word semantics is context-dependent, our further interest would be driven towards the most common combinations of words we can come across in this specific type of manual. For this purpose, we sought to detect the most frequent n-grams consisting of 2–5 members (words). The examples presented in Table 4 are the most frequent ones with each cluster including either (at least) two nouns, an adjective and a noun or a verb and a noun, in order to avoid the most frequent n-grams in general language, such as *of the*, *to the*, etc. and also to pursue the examples of the most frequent collocations in the corpus. Again, since the software provides lemmatized results, we put together similar expressions, including those with additional prepositions and/or articles (e.g. *(if) this is not the case*). With additional content words, we retained a separate count (e.g. *direction of rotation* and *check the direction of rotation*).

Interestingly, there were no distinctive 3-grams in the final list (Table 4).

Table 4. *Most frequent n-grams in CTSTM*

No.	N-grams	Frequency
	5-grams	
	in such a way that	62
	(if) this is not the case	50
	it is not possible to	40
	it is recommended that the	24
	the serial number of the	18
	attention must be paid to	16
	work must be carried out	12
	4-grams	
	as described/shown in chapter/section/figure	144
	(check) the direction of rotation	94
	failure to comply with	34
	the first start up	34
	check the oil level	32
	from time to time	32
	state of the art	26
	2-grams	
	fuel oil	1,366
	control system	1,204
	oil pump	778
	spare parts	691
	operation manual	600
	oil flow	576
	solenoid valve	550
	set point	504
	safety valve	486
	data sheet	480
	stop valve	460
	control unit	450
	compressed air	438
	control valve	432
	oil pressure	430
	technical data	422

6. GE PHRASES IN CTSTM

However professionally and technically oriented, English courses, naturally, cannot be strictly focused on the technical vocabulary, but must also be accompanied by General English skills, adapted to the practical needs of our language learners. As we could see in Sections 4 and 5, we were seeking primarily technical collocations and word clusters typical (or key) for our target professional corpus. However, the above-described and applied methodology can greatly assist language teachers in extracting the most frequent GE phrases worth focusing on (Table 5). Additional exercises can then be developed to help language learners master them in terms of productive language skills.

Table 5. *The most frequent GE phrases in CTSTM*

No.	Phrase	Frequency
1	by means of	1072
2	in (the/this) case (of)	588
3	(should) be carried out	512
4	in order to	416
5	in accordance with	316
6	as well as	274
7	make sure that	138
8	it is recommended	114
9	care should be taken	106
10	in such a way	86

7. CONCLUSION

When selecting and organizing vocabulary teaching material for language learners, different approaches, more or less deliberate, are applied. It is of particular importance and challenge when it comes to ESP, such as, in our case, a very specific English for Marine Engineering Purposes. We, therefore, presented a software-based corpus linguistic method for the extraction of target or key technical vocabulary, as well as the most frequent word clusters. From the technical corpus of 1,109,080 tokens, we obtained the keyword list of 78 words (word families) with an additional list of 2—5-grams. In addition, we used the same methodology to elicit the frequency list of GE phrases most frequently found in our target corpus of tanker ship technical manuals. The methodology presented is replicable in the case of any ESP and can be of assistance to both language teachers and learners. Special attention, however, should be paid to each step of the process and its justification, from the proper selection and preparation of representative corpus, through the software settings and operation, to the organization of the final results, their adaptation, and proper use. Above all, the practical and professional needs of our language learners should be born in mind throughout the process.

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Exploring ESP learners' self-efficacy of writing skills in IT context

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Abstract: *In the context of its application in engineering fields, language learning is an insufficiently researched area. Language competencies are a highly significant aspect of professional performance, business communication, and professional development, especially in Information Technology. The paper gives insight into the analysis of differences in the self-efficacy measured among three groups of students classified according to their achieved grades. The aim of this paper is also to investigate the correlations between the students' self-efficacy observed for five categories of writing skills in ESP and the students' assessment graded by the teacher during the summary writing task. Besides, the paper provides an analysis of correlations between different categories of writing skills. The total number of students who participated in the research was 94, and the participants were the students of Information technology at the Faculty of Technical Sciences Čačak. The research instrument was English language self-efficacy scale for writing skills. Three types of analyses were used: descriptive analysis, correlative analysis and the analysis of variance (ANOVA). The results of the research indicate that the higher the students' assessment is, the more skilled in writing in IT context they are considered in comparison to the students with lower assessment. The skills of writing fluency were estimated lowest over the entire sample. Positive correlations were obtained between all the analysed categories of students' self-efficacy for writing skills and the teacher's grades.*

Keywords: *self-efficacy; foreign language learning; ESP; IT.*

1. INTRODUCTION

Self-efficacy can be considered as an aspect of self-esteem which is "a well-researched psychological construct", and a significant factor affecting both the success and failure in life in general, therefore it constantly raises academic attention [1].

According to Bandura self-efficacy designates „beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" [2]. Habrat states that "self-efficacy is the expression of self-confidence in competence and skills to complete specific tasks" highlighting the fact that, compared to self-esteem, self -efficacy is the highest level of specificity [1]. In addition, Coopersmith proposes that self-esteem is an expression of "an attitude of approval or disapproval and indicates the extent to which the individual believes himself to be capable, significant, successful, and worthy" [3].

Literature suggests that there are two factors which affect self-efficacy, within the broader term of self-esteem, and those imply cognitive and affective domains [1]. Brown proposes that affect, usually opposed to rational cognition, suggests an „emotion-ridden sphere of life", which commonly relates to "the emotional interpretation of perceptions, information and knowledge'" [1].

The interactions between cognitive and affective processes are sophisticated and complex. Dörnyei notices that cognitive processes such as analyses, perceptions and evaluations can produce affective states, whereas affective factors including emotional experiences, beliefs and attitudes can cause cognitive consequences, due to the fact that they shape an individual's thoughts and evaluations [4].

Since language acquisition and learning is an interaction between cognitive and affective domains, self-efficacy, if observed and measured correctly, can be not only a significant factor influencing foreign language learning but also an indicator of the ways in which students engage with the linguistic content within a specific context. Therefore, besides cognitive, affective factors need to be thoroughly considered as well. According to Brown the most relevant affective factors related to foreign language acquisition are: anxiety, inhibition, extroversion–introversion which infers a need for the confirmed self-esteem, motivation, learner styles and self-esteem [5]. Self-efficacy is closely related to the notions of assessment and inner feeling of progress, as well as the ability to cope with mistakes and reflect on own values [6].

Lau et al. propose that English as a foreign language includes the concept of the self, such as

self-perception, self-esteem and self-efficacy, to name but a few, which are all related to four main language skills — reading, speaking, writing and listening [7]. Therefore, a vital correlation exists between self-efficacy and language acquisition, obtainable in evaluating writing skills.

Language acquisition, as "a genuinely ego-involving experience", requires personal expression, as it creates one's identity, and is a means of communication with the environment [8]. Therefore, it can also be a reason why inexperienced language users encounter discomfort and frustration when trying to express themselves in a foreign language. The perception of own abilities has a considerable role in managing a new language task, as it accounts for self-esteem and affects both motivation and the necessary cognitive processes [9]. The role of self-perception in second language acquisition is crucial, as it affects all aspects which are involved in language learning, including cognitive processes, evaluations, attitudes and behaviours [10]. Recent studies have shown that self-perception in foreign language learning reflects the expression of own confidence and self-efficacy related to foreign language abilities [11]. Gabillon proposes that "beliefs interfere with a student's cognitive performance in language processing" and thereby correlate with general second language achievement, considerably affecting the success or failure in learning [12]. Language anxiety is also closely correlated with self-efficacy and it signifies "the feelings of tension and apprehension experienced in second language acquisition in the classroom context, arising from the necessity to learn and use a foreign language that has not been fully mastered" [8]. This is specifically evident in a classroom in speaking and writing tasks, as these activities imply solving contextual ambiguities either in written or spoken language usually within a specified amount of time. Thus, such activities, which are likely to bear the potential for language users to slip into mistakes, cause anxiety, feeling of apprehension and discomfort [8].

Recent studies have shown that insufficient knowledge of the language and insufficient language practice cause lower self-esteem and higher language anxiety [1]. Avila claims that low self-esteem is crucial for the intensifying of language anxiety, thereby correlating both with "lower foreign language achievement and negative attitude towards the language" [13].

Vonk and Smit also confirm that high self-efficacy is closely related to high motivation to cope with learning issues and solve problems [14]. Moreover, Rosenberg proves that high self-efficacy is likely to result in successful outcomes [15].

Research in ESP shows that written language for specific purposes foreshadows not only linguistic features of a specific professional context, but the values and practices related to the professional environment [16]. Written texts in the field of Information Technology are distinguished by the use of specific rhetorical conventions, structure of arguments, tone of narration and grammatical features [17]. English language in IT is specifically targeted to language forms as a means to accomplish specific purposes. Moreover, English for specific purposes also designates not only the demand for communication, but also the study and deep analysis of the context targeted texts [17].

Furthermore, some authors found that practising summary writing skills have a positive influence on reading skills and comprehension as well as on writing skills [18], [19], [20].

Despite the fact that the task of summary writing presupposes more than grammar and vocabulary, the results of some research show that students instructed how to use grammar and stylistic corrections while writing their summaries make a better assessment in language learning, thereby creating a basis for the professional development [21].

Owing to the fact that one's native language and previous knowledge and experience significantly influence the way one structures own arguments and ideas in a foreign language [17], adequately instructed summary writing skills can affect students' learning process and contribute to students' language development, which can be evidenced in the linguistic features of the texts [21]. The texts assigned and required to be mastered at ESP courses are professional texts, which are characterized by their "expert character, its specialized goal orientation, and its conventionalized form" [17].

According to the previously said, the aim of this paper is to explore how students of different achievements in writing in English language perceive their self-efficacy in the ESP context and how self-efficacy, as an aspect of self-esteem correlates with teachers' assessment of students' writing skills.

2. RESEARCH METHODOLOGY

The aim of this research is to investigate the differences among students' attitudes on self-efficacy of their own writing skills in English language, depending on the grades obtained on the task of writing texts in IT field. In addition to this, the paper aims to find both the correlations between different categories of self-efficacy for writing skills (style, terminology, grammar, composition, writing fluency), and the correlations between students' self-efficacy and their assessment measured by the teacher.

Based on the objectives of the research the following hypotheses can be elicited:

- There are differences in students' self-efficacy of the writing skills in the field of IT, which relate to their real achievement measured by the teacher during the summary writing task in their professional context;
- The correlations between certain categories of self-efficacy of writing skills in IT (style, terminology, grammar, composition, writing fluency) are detected.
- The correlation between students' self-efficacy and their assessment measured by the teacher, i.e., the grade obtained during the summary writing task can be confirmed.

2.1. Sample and context of the research

There were 94 IT students who participated in the research. The research was conducted in May and June of 2022, at the Faculty of Technical Sciences Čačak, University of Kragujevac. The students filled in the questionnaire at the end of the semester upon the realization of the course English language for IT 2. All students have previously passed the course English language for IT 1. The course covered by this research is in the summer term in the curriculum of the first year, entitled the English Language for Information Technology 2. Summary writing is an important segment of the course and students are expected to be able to summarize academic articles taken from the information technology context at the end of the course. The students are assessed summatively. The assessment scale ranges from 6 to 10 for the students who pass.

The students were divided into three categories according to their assessment evaluated by the teacher: group of students who obtained grade 6 or 7 at the summary writing task (39 students); group of students who obtained grades 8 and 9 (33 students) and group of students who obtained grades 10 (22 students). The grades given by the teacher were formed according to their knowledge of English language which students demonstrated through the written lexical and grammatical corpus in the IT context.

2.2. Research variables

Interdependent variables of the research are the subcategories of the self-efficacy of writing skills in the English language in the field of IT. These variables relate to subcategories classified as: style, terminology, grammar, composition, and writing fluency. Style as a subcategory was perceived through four statements and is a variable which presents using language differences, functions and shifts in meaning. Terminology implies a subcategory of four statements related to the analysis of words and parts of the words in context. Grammar is a variable perceived through three statements related to the proper use of English grammar, spelling rules, verb tenses, voice and mood. Composition relates to structuring sentences and clauses and this variable is defined through five statements. Writing fluency refers to the appropriate use of word patterns, vocabulary and content and is determined by three statements.

The independent variable of the research was students' assessment in summary writing in the IT field measured by teacher's evaluation.

2.3. Instrument

The scale used for the research was the English language self-efficacy scale for writing skills which was adapted from the Self-Efficacy Scale for Scholarly Writing in English [22]. The scale was used to assess the self-efficacy of 94 University students from the Faculty of Technical Sciences Čačak. The scale takes a form of a 19-item Likert-type items scale (Appendix). The students were requested to respond and evaluate each statement using a 5-point-Likert scale by marking one from five given options from 1 – I strongly disagree to 5 – I strongly agree).

The Scale consists of 19 statements in total, items classified into five subcategories of self-efficacy for writing skills in the field of IT:

- Style relates to skill models which measure the use of language universals, language differences such as mixed metaphors, functions and shifts in meaning, the use of dictionaries (varieties and kinds of thesauruses) [23] (4 items). Cronbach's coefficient for this subscale is 0,77. Example: I can use words and phrases that signal transitions effectively.
- Terminology refers to vocabulary which reflects analysing words in context and analysing word parts [23] (4 items). Cronbach's coefficient for this subscale is 0,78. Example: I can write on the topic of the ESP text clearly and intelligibly in English.
- Grammar implies spelling rules, capitalization, punctuation, verb tenses, voices and mood, subject-verb-agreement, using pronouns and modifiers correctly [23] (3 items). Cronbach's coefficient for this subscale is 0,83. Example: I can write a text in accordance with the rules of English grammar.
- Composition which relates to clauses and sentence structure, phrases, content and structure check, tone analysis [23] (5 items). Cronbach's coefficient for this subscale is 0,78 (5 items). Example: I can organize paragraphs effectively while writing English texts.
- Writing Fluency signifies the accuracy of text and the appropriate use of word patterns, vocabulary and content in a specified amount of time (3 items). Cronbach's coefficient for this subscale is 0,75. Example: I can produce English texts in the same amount of time I produce texts in my mother tongue.

Cronbach's coefficient for the whole scale is 0,94 which indicates the high reliability of the used instrument.

3. RESULTS AND DISCUSSION

In order to determine both the students' self-efficacy for writing skills through five different subcategories, and the differences in the self-efficacy among students that achieved different grades, we used descriptive analysis together with the analysis of variance (ANOVA) and their results are shown in Table 1.

Table 1. *Differences in students' self-evaluations for writing skills in the field of IT*

Scales	Groups	Mean	Std. Dev.	F	Sig
Style	6-7	3.23	0.5933	15.597	0.000
	8-9	3.71	0.5918		
	10	4.12	0.6104		
	Total	3.61	0.6857		
Terminology	6-7	3.33	0.4566	22.646	0.000
	8-9	3.76	0.6090		
	10	4.32	0.5834		
	Total	3.72	0.6629		
Grammar	6-7	3.18	0.5837	28.624	0.000
	8-9	3.96	0.6449		
	10	4.37	0.6403		
	Total	3.73	0.7836		
Composition	6-7	3.39	0.5587	11.049	0.000
	8-9	3.79	0.6361		
	10	4.13	0.5708		
	Total	3.71	0.6524		
Writing Fluency	6-7	3.06	0.6617	12.708	0.000
	8-9	3.7	0.7921		
	10	4.05	0.9331		
	Total	3.51	0.8698		
N=94					p<0.05

The results shown in Table 1 show that students evaluate their own writing skills in the English language in the IT context field as moderately high (total mean values for all subscales are above 3,5). The category marked with the lowest students' grade relates to writing fluency (M=3.51), i.e. the accuracy of text and the appropriate use of word patterns, vocabulary and content in a specified amount of time. As for all other categories, the estimations are rather similar (almost all values are close to the mean value which amounts to 3.7). This result indicates that the affective factor could be the possible reason why students consider their skills within the category of writing fluency lowest, as the students need to cope with many aspects of foreign language rules while expressing themselves in a limited amount of time and thereby expressing a limited feeling of self-efficacy as an aspect of self-esteem. The results of the conducted research are in compliance with the results of other authors who investigated the interdependence between self-efficacy and academic achievement [15]. Sanchez and Roda pointed at the correlation between self-esteem and achievement in mathematics and text reading, and concluded that academic performance is less significant than self-esteem in corresponding areas [24]. Moreover, Marsh, and Craven also confirmed the strong link between self-esteem and academic achievement, highlighting the fact that academic self-esteem highly affects academic assessment [25]. In addition to this, Pullmann and Allik investigated the correlations between the academic assessment and university students' self-evaluations, and concluded that the students who demonstrated high academic assessment were also rewarded by the teachers [26]. All the mentioned studies show that self-esteem correlates with the assessment in the respective field of research.

The results of the present research also indicate that statistically significant differences occur in the assessment of all five categories between the three groups of students classified according to their obtained grades (grade categories: 6-7, 8-9 and 10). The value for all the estimated categories is p = 0.000 (<0.05). Mean values indicate that the students with the highest achievements (group of students who obtained the highest grade, 10) are assessed as the most skilled in all the investigated categories, compared to the remaining two groups of students, which was a rather anticipated result (mean values for all categories are above 4). Therefore, students who are more successful self-evaluate more positively their own writing skills in the English language in the IT context, in comparison to less successful students. On the other hand, the group of students who were assessed with the grades 6-7, evaluated their own writing skills lowest in comparison to the other two groups according to all categories, which is also in compliance with the evaluations of the most successful students.

In order to determine where statistically significant differences occur (between which of the groups of students), the posthoc analysis was carried out, and the results are shown in Table 2.

Table 2. *Review of statistically significant differences in self-assessment of writing skills among three groups of students*

Dependent Variable	(I) grades	(J) grades	Mean Diff. (I-J)	Std. Error	Sig.
Style	6-7	8-9	-0.476*	0.1407	0.004
		10	-0.889*	0.165	0.000
Terminology	6-7	8-9	-0.434*	0.1286	0.004
		10	-0.987*	0.1452	0.000
	8-9	10	-0.553*	0.1624	0.004
Grammar	6-7	8-9	-0.785*	0.1456	0.000
		10	-1.189*	0.1688	0.000
Composition	6-7	8-9	-0.394*	0.1426	0.022
		10	-0.733*	0.1524	0.000
Writing Fluency	6-7	8-9	-0.637*	0.1739	0.002
		10	-0.986*	0.2254	0.000
					*. p< 0.05

The results obtained from the analysis of the differences between the groups indicate that the group of students who achieved grades 6 and 7 differentiates according to categories of assessment in comparison to the groups of students who obtained higher grades (8-9 and 10) (all p values are below 0.05). The greatest difference is obtained between the students marked with the grades 6-7 and 10 for the category of correct use of grammar during writing text in English in IT context (Mean differences = -1.19), whereas the slightest difference was established between the group of students marked with the grades 6-7 and 8-9 for the category composition, which suggests sentence and clauses structuring and structure check (Mean differences = -0.39). The group of students marked with the grade 10 is significantly distinguished from the group of students marked with the 8-9 only in one category which relates to vocabulary development (the application of IT terminology in its specific field) (Mean differences = -0.55). For all other categories statistically significant differences were not found between these two groups of students.

In order to determine possible links between estimated categories of writing skills in the English language in the field of IT, the correlative analysis was conducted and the results are shown in Table 3.

Table 3. *Correlation between categories of self-evaluation of writing skills in English language*

Subscales	2.	3.	4.	5.
1. Style	0.75**	0.66**	0.73**	0.62**
2. Terminology	1	0.71**	0.82**	0.84**
3. Grammar		1	0.71**	0.61**
4. Composition			1	0.71**
5. Writing Fluency				1

The conducted analysis indicates moderately strong and strong correlations between all five categories of writing skills (r=0.61-0.84). The strongest positive correlation was evinced between the categories which relate to the use of terminology and writing fluency (r=0.84), whereas the weakest correlation (although moderately high) was noticed between the categories of grammar and writing fluency (r=0.61). Therefore, the higher the students' mark on the self-efficacy statements related to the category of terminology (which implies the ability to analyze words and word parts in context), the higher the self-efficacy statements related to the categories of style, writing fluency, grammar and composition. This suggests the integral role of self-efficacy in enhancing students' achievement in language. Tsao also explores and confirms the link between writing self-efficacy in the foreign language and the learner's engagement with the teacher and written corrective feedback [27].

In this research correlative analysis was also used in order to determine the correlations between students' self-efficacy in writing skills in the English language in their context field and the objective assessment obtained by teachers. The results of the analysis are shown in Table 4.

Table 4. *Correlation between students' self-efficacy and grades given by teachers*

Subscale	Teachers' grades
Style	0.51**
Terminology	0.58**
Grammar	0.61**
Composition	0.44**
Writing fluency	0.46**

The results suggest that there is a statistically significant positively directed correlation between the grades given by the teacher to students on the summary writing task in their professional context and the students' self-efficacy for all five categories of writing skills (r=0.44 to 0.61). The strongest positive correlation with the final teacher's assessment (grade given by the teacher) was obtained for the category which relates to the adequate use of grammar rules (r=0.61). Such results show positive correlation between teachers' assessment and students' self-efficacy, which indicates not only the objectivity of students' achievement evaluated by the teacher but also the objectivity of the students' self-efficacy estimations. Other studies also show positive correlations between students' self-efficacy and their real assessment [12], [15]. Thus, the higher the interdependence between the skills estimations, i.e. self-efficacy for the use of the written language in the professional fields, the greater the students' assessment.

4. CONCLUSION

The results of the conducted research proved the presupposed hypotheses. The main results give insight into students' evaluations of self-efficacy for writing skills in an IT context. The skills of writing fluency were estimated lowest over the entire sample, which was the anticipated result, as writing fluency implies more writing skills which permeate each other. Therefore, the teachers should pay more attention to developing writing fluency skills with their student, since they themselves notice gaps in this particular domain.

The results show that there are differences in the evaluations of students' self-efficacy of the writing skills in the field of IT depending on their real achievement measured on the summary writing task.

There are significant positive correlations between all the categories of writing skills in the ESP context, which suggests that there is a connection between skills such as text style, vocabulary knowledge, the application of grammar, text composition and writing fluency, so the mentioned categories should not be observed or developed separately. This finding suggests that the improvement in one category positively affects the development of all the observed categories related to writing.

The found correlations between students' self-efficacy of writing skills and their assessment measured by the teacher during summary writing in the IT context indicate that students' perceptions of self-efficacy comply with their real achievement, and consequently the objectivity of estimation. The statistically significant positively directed correlations between the grades given by the teacher to students during the summary writing task and the students' self-efficacy observed for all five categories of writing skills indicate both the objectivity of students' assessment evaluated by the teacher and the objectivity of the students' self-efficacy estimations. Bearing in mind that the students were not given preliminary instructions on self-efficacy, the present results indicate that they would considerably benefit from self-efficacy training.

Such results confirm the already explored links between self-efficacy and assessment, especially in the context of language, where various affective components, as well as personal characteristics, can significantly influence the language learning process. This also suggests the integral role of self-efficacy in enhancing students' achievement in language.

The implications for future research could imply the analysis of other language learning factors, such as anxiety, motivation, learning styles, personality types, etc., which affect not only students' achievement but the process of language learning in the area of ESP and IT in particular.

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Appendix

English language self-efficacy scale for writing skills in ESP context

	Skill
1.	I can write on the topic of the ESP text clearly and intelligibly in English.
2.	I can write a text in accordance with the rules of English grammar.
3.	I can express the main idea of the text in ESP clearly
4.	I can express the aim of the author of the given text intelligibly in English.
5.	I can clearly express the gap(s) in the text and emphasize its significance.
6.	I can organize paragraphs effectively while writing English texts.
7.	I can avoid word repetitions while writing English texts.
8.	I can form accurate sentences while writing English texts.
9.	I can use English spelling rules accurately.
10.	I can use words and phrases that signal transitions effectively (e.g., in addition, nevertheless, furthermore, notwithstanding...)
11.	I can use boosters appropriately while writing English texts (certainly, indeed, always, undoubtedly, clearly, actually, obviously, conclusively, definitely, evidently).
12.	I can use hedges appropriately while writing English texts (perhaps, possibly, probably, presumably…).
13.	I can use expressions that make my English text appealing and interesting for the readers.
14.	I can produce English texts in the same amount of time I produce texts in my mother tongue.
15.	I can produce English texts as easily as I create in my mother tongue.
16.	When I read English articles, I can guess the meaning of unknown words.
17.	I can make new sentences with the words just learned.
18.	I can make sentences with English idiomatic phrases.
19.	I can find out the meaning of new words by using English–English dictionaries.

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ICT assisted English learning in preschool education

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Abstract: *Society development and globalization, nowadays, imposes the need to master foreign languages. An increasing number of parents insist for their children in kindergarten to have the opportunity to learn English. It is well known that preschool children mostly learn and adopt new concepts by playing. Playing is an integral part of a child's upbringing and for that reason it is used in kindergartens, i.e. in preschool education. Computers and information and communication technology (ICT) have got a dominant role in many aspects of our lives, and the most numerous population of new technology's users are children and young people. Using of ICT can greatly facilitate the achievement of teaching goals and learning outcomes in the process of implementing the preschool program. ICT is recognized as suitable for use in the learning process, so they can be used effectively for the purpose of learning English in kindergarten. Lecturers and educators can easily and simply use or create content that will be interesting to children and that will encourage their desire to learn. The successful application of ICT in the realization of the educational process with preschool children requires the appropriate IT expertise of preschool teachers.*

Keywords: *computer; information and communication technology (ICT); English learning; kindergarten; preschool education*

1. INTRODUCTION

Modern society, also called the knowledge society, is based on information and communication technology (ICT). The most popular form of communication today is done through the Internet, and almost all human activities take place through computers. As today's society is increasingly exposed to the accelerated pace of technological development, there is a need to adapt the learning process to such needs. Children start learning a foreign language very early (at the age of four or younger), and the number of parents who express their desire to enable their children to learn English in preschool institutions is increasing. It is known that the early years of life are of crucial importance for laying the foundations of learning. Preschool children learn the easiest and fastest through activities that are adapted to their needs and through play. In this sense, some computer and internet applications, as they are simple, easy and mostly free to use, are very suitable for creating materials and content that help kindergarten children master the English language more effectively. Educators and lecturers have a numerous tools and services at their disposal, through which they can easily adapt the teaching content to children and encourage them to interact. The game is an integral part of a child's growth and for this reason it is used in preschool institutions, i.e. in preschool education. As such, play is classified as a child's basic needs that enable proper development and learning. Computer games are software, or programs, accessed on personal computers or other mobile computing devices. The main purpose of games is for entertainment, but more and more computer games are used in education and learning. Computers and ICT can greatly facilitate the achievement of teaching goals and learning outcomes in the process of realizing the preschool program. Carefully selected educational software can positively influence the development of children's symbolic thinking and can increase the decision-making ability. When ICT is used for cooperative learning and working in pairs or groups to solve problems and exchange ideas, such activity facilitates the emotional and social development of the child [1]. Also, if such engagement is successful, there is an increase in children's self-esteem. At the same time, care should be taken that the child also activates the brain, in addition to the active finger, during the game and the use of ICT. We should not forget the following: "Learning happens only when the child is

mentally engaged, when activities mediated by digital devices encourage him to think, connect new information with previously acquired knowledge, compare, see similarities and differences, etc." [2].

2. LEARNING OF PRESCHOOL CHILDREN

Learning represents a complex process through which knowledge, skills and habits are acquired, and which is directed by education, and which begins immediately after birth and lasts during the lifetime. Young children begin to learn in the sensory motor and emotional, and later in speech and cognitive areas. "The basic role of learning in preschool childhood must not be the memorization of isolated facts, but learning should be strategic (structural). It should create a rich and flexible model of reality for the child, to form general ideas about the world, nature, society and human." [3] Play is the child's primary and main activity. Children get to know the world in which they live and which surrounds them through play. Thus, educators place the game in a central position, because in this way they provide a stimulating environment for learning. Children are adequately motivated to learn and have the opportunity to explore in such an environment. "Preschool children learn through interaction with other children and adults from their environment, observing the world around them, getting to know their environment and creating their own personal experience. However, instead of supporting the dedicated learning of children, today learning even at preschool age becomes an activity, which if not based on play and children's interests becomes boring, stressful and frustrating." [4].

Early childhood is a period of intensive development of the child in all aspects. The first years of a child's life are of crucial importance for the whole life, because there is no other period of life during which they grow and learn so quickly and during which they change in so many different ways. All over the world, early childhood is covered by a special phase of upbringing and education for children up to six years of age. This is the age when children are particularly active and eager for new knowledge. Children of preschool age achieve visible and accelerated progress in all spheres of life (physical, intellectual, emotional and social).

2.1. Learning through play and exploration

Children are curious by nature, they like to explore and get to know the world around them. Parents and educators should encourage and support children in this activity and thus help them make progress in all areas of knowledge. Children learn spontaneously, while exploring, and this especially applies to children up to three years old. They learn by example, following the example of their parents. They learn by copying, how to behave, what is good and what is not, first words, colors, numbers, concepts, animals, objects... Children develop their skills, knowledge and emotions through play and exploration, get to know the world around them, improve their communication skills.

2.2. The role of kindergartens in children's early learning

Thanks to new scientific evidence that points to the importance of supporting children at an early age, supporting development and learning in early childhood has become one of the priorities of educational policies in many countries of the world, including our country. It is accepted that preschool education has a dual nature, i.e. education and childcare in the countries of the European Union. Parents have the primary role in home learning from the first day, but the teacher takes the main role in the child's learning process in the preschool institution. Parents and educators should encourage and support children in this activity and thus help them make progress in all areas of knowledge.

The aforementioned knowledge led to the creation of a different attitude towards the early development of children. Today, there is an awareness that early learning and experience are of great importance for further development and that they depend to a significant extent on the quality of the social and cultural environment in which children live. This emphasizes that waiting to start school in order to provide children with quality programs for development means precisely missing important opportunities in preschool age [5].

The "Years of Ascension" program [6] promotes learning through play and exploration, which means that children are given the opportunity to take initiative and choose what and how to learn. The teacher is the one who will implement the game so that it is in the zone of the child's future development and as such becomes the basis of the development of the potential and the manifestation of all dimensions of the child's well-being. The activity of preschool institutions is defined as multifunctional, that is, it consists of three basic functions: social, educational and preventive-health. All three functions are realized simultaneously and interpenetrate, so they should be viewed in unity, mutual connection and conditionality. Unlike other educational institutions, only preschool institutions support and encourage the overall psychophysical and psychosocial development of young children. In order to ensure the quality of the preschool program, it is necessary to create a stimulating environment in which children will have the opportunity to explore different topics, learn from different fields. All of this should be realized with a constant review of whether and to what extent it is important, interesting for children and whether it captures their attention.

3. LEARNING FOREIGN LANGUAGES IN PRESCHOOL AGE

The preschool period begins with birth and ends with the child's departure to school. The advantages of early foreign language learning in the kindergarten environment have not been sufficiently explored in preschool pedagogy. However, due to the globalization of society and the increasing need for communication with people from different parts of the world, the necessity for knowledge of foreign languages is becoming more and more pronounced. This makes it necessary to encourage interest in foreign languages, already at an early age, in order to acquire the basics of the language and, more importantly, to build a positive attitude towards language learning. Many pedagogues believe that young children in preschool age have a great ability to master foreign languages, and that they can learn as many languages as the preschool system is capable of introducing in its educational activities. A large number of linguists agree with this, and they believe that it is best to start learning foreign languages as early as possible, in preschool age, because the ability to imitate pronunciation is characteristic for that age [7]. The learning of foreign languages in preschool age has been insisted upon through numerous recommendations and strategies, for many years, in Europe. Thus, the norms governing the educational policy of the European Union emphasize that, in order to master a foreign language as successfully as possible, learning should start as early as possible. A large number of children start learning a foreign language as early as the age of four. This also stems from the fact that most parents insist that their child learn a foreign language (mainly English) from an early age. English as a Foreign Language (EFL) is taught in our schools from the first grade of primary school, but there is an increasingly pronounced need to provide children in kindergarten with an institutionalized opportunity to learn the language. The child learns, develops and acquires knowledge exclusively through his experience, and the basic form of learning for children is play in the preschool age. In this sense, an effective system of learning a foreign language in a preschool institution should take place first through play. The child should be placed at the center of the learning process and encouraged to actively participate in all phases and segments of learning, i.e. mastering a foreign language. If learning a foreign language takes place through play and effective interaction, children are intrinsically motivated, because they are motivated by a natural desire to acquire new knowledge. The process of learning a foreign language for young children should be made up of numerous stimulating and challenging activities for children. In this way, children learn new vocabulary and grammatical content, often without being aware of the very goal of learning. Numerous pedagogues point out that every subject for younger children can and should have the character of a game, which would include various experiences, continuous change of activities, as well as interaction with the educator (lecturer) and peers [8]. Preschool children develop four English Language Skills while learning EFL:

Listening, Speaking, Reading and Writing, which are in accordance with their age. When it comes to language acquisition, the child's capacity to learn a language (both native and foreign) is closely related to the physical maturation of the central nervous system and the unique degree of lateralization of function. This means that we can talk about a critical period in language acquisition. In addition to organic factors, i.e. prerequisites, psychological and social factors are particularly important for language acquisition. Under social factors, the importance of the environment, i.e. the child's environment, is emphasized more and more. Thus, the speech and cultural environment of the child and the overall activity of the child and its experience stand out as the most important part of the social factor [9].

4. ICT USE IN PRESCHOOL EDUCATION

Information and communication technology (ICT) include computer hardware and software and means of electronic communication used to collect, process, store and exchange information, including corresponding services and contents. There are numerous examples of the application of ICT in pedagogical practice and as such they have been the subject of discussion and research for many years. The field of ICT is constantly changing and improving, and at the same time it is becoming more and more extensive and complex. General principles for the use of ICT in educational work are given through the guidelines of the education and training system, but not as a final category, but represent guidelines that are variable and in constant development, like the field of information and communication technology itself.

With the help of ICT in the educational process, access to information and knowledge increases (electronic books, scripts, articles, simulations, virtual laboratories, intelligent training systems), and the application of ICT should be based on valid principles, goals and standards of preschool education and upbringing.

The use of ICT in working with children should always be a tool for developing knowledge and skills in children, and not just an aim for itself. It is important for the teacher to know various ICT tools, to be able to integrate this technology into pedagogy and to use it in the learning process centered on the child. The teacher will be helped by the recommendations of traditional learning

theories that are also valid in new conditions - in electronic learning, for the creation of teaching materials or the design of electronic contents to complement the activities in the room/classroom. For effective and successful integration of ICT in early childhood years there should be active engagement of children, interactivity between teacher and children and among children, positive feedback by adults or teachers, group participation and connecting technology with the real-life context [10].

Educators are increasingly using ICT in their work with children, and children are happy to accept technology and the Internet, because they can handle it easily and without fear. Before starting school, children acquire more and more knowledge, because children easily absorb the content they see, hear and understand through direct experience. When using computers in preschool education and education of children, it is of great importance that educators and professional associates in preschool institutions continuously monitor the impacts and effects of ICT on the development and learning of children, to monitor events and changes in educational work and to constantly seek better ways in which children will develop and enrich their experiences living and learning surrounded by ICT. An individual approach to the child's age and educational needs can be achieved by using ICT.

5. ICT ASSISTED ENGLISH LEARNING IN PRESCHOOL EDUCATION

The advantages of using computers in English language learning (CALL) are indisputable. This way of learning a foreign language with the use of computers and multimedia (CD/DVD) has been around for a little over 25 years [11]. However, the use of only computer programs for these purposes falls into the background with the advent of the Internet and ICT. With the development of ICT and the definition has changed, CALL is now an international discipline exploiting the application of digital technology in language education [12]. New technologies provide almost unlimited possibilities, especially if the teacher is committed to his pedagogical work, and at the same time has appropriate professional and digital competences. If ICT is used in the room/classroom, the teacher's work usually takes place in a traditional way, with partial use of technology. When computers, the Internet, various teaching materials in electronic form are used in educational work, then we are already in the field of electronic learning. Many resources, such as activity scripts, teaching materials and content, can be found on the Internet, which are publicly available and can be used to modernize work with children. In doing so, they can be used in their original form or modified and modified.

Even that today's society is characterized by an accelerated pace of technical and technological development, it can be said that the "old" classical way of learning is incompatible with the time in which we live. In this sense, it is necessary for learning supported by modern technology in the Internet era to find its rightful place in the educational system. Modern society is driven by information technology, so the computer is becoming a teaching tool that cannot be done without. Information technology, through the interaction of lecturers and students, but also between students, and through the exchange of information, guide learning and provide an incentive for constant deepening of knowledge in the learning process [13]. From the aspect of education, the Internet as a global knowledge base has great educational potential. Electronic learning has been applied in practice for more than ten years, as learning using modern information and communication technology. E-learning has foundations in both psychology and pedagogy, so it is possible to determine the purpose, outcome and goal of learning itself. The main meaning of e-learning is the achievement of educational goals, while respecting individual interests and needs. E-learning can be defined as: "educational interactive communication between lecturers and students, which is realized using modern information and communication technology" [14]. It should be emphasized here that e-learning does not challenge standard learning methods, but seeks to enrich and supplement them.

In order to master a foreign language, experts believe that it is necessary to master four language skills, namely: speaking and writing as active skills, and then listening and reading as passive skills. The standard teaching of a foreign language, when it comes to learning to speak, meant that the lecturer would determine the topic, while the students would conduct some form of communication. This kind of communication is far from spontaneous, so it often happens that students have difficulties, especially if they are not motivated or if it is about a topic that is not interesting to them. For this reason, the Internet is emerging as a rich and easily accessible source of material for learning a foreign language [15]. Preschool age is the age when children are particularly active and eager for new knowledge, they need to understand the world around them and are naturally curious, so this is a period that should be used to build a positive attitude towards learning a foreign language. When it comes to learning English, it is most important for young children to learn the basics of the language through play and content adapted to them, on which they will later build their learning. The basic value of kindergartens can be seen through providing the child with the opportunity to actively participate in the educational group as a community of children, in conditions that are

adapted to him, his capabilities and developmental needs. Given that young children first learn through play, and interesting content tailored to them, learning English using ICT offers great opportunities.

The CALL environment provides a variety of materials to motivate children to read, such as auditory and/or visual materials, animated materials, music and sound effects and other materials. These tools help increase visual attractiveness, flexibility, responsiveness and supports [16]. "Playing computer games, as part of learning, motivates students to practice and learn new vocabulary and often challenges teachers to create innovative ways of learning a foreign language, especially in a foreign language context." It also challenges them to connect playing computer games with the curriculum for foreign language learners. If you were to ask whether students should play computer games or learn, in this case the answer would be that students should play computer games to learn." [17]. In addition, ICT can play a role „on stimulating pre-reading skills. Using pictures and sounds, the emerging reader is introduced to the concept that there is more to words than their meaning. The children's vocabulary is expanded by means of exercises using pictures and high quality digitized voice"[18].

Some of the basic applications from the Microsoft Office suite can be used when working with children in kindergarten: Paint and PowerPoint. Web 2.0 tools are also widely used in EFL learning because of their interactivity and two-way communication. The most popular of them, which are used for the purpose of learning English at an early age, are certainly blogs and YouTube.

Educators can create blogs and enter adequate content in them or use other users' blogs. Children can learn letters, words, reading, practice pronunciation, learn songs and so unconsciously enrich their vocabulary by watching video materials posted on YouTube. In addition to them, there is educational software, i.e. educational applications, intended for learning EFL through play, which can be divided into three categories:

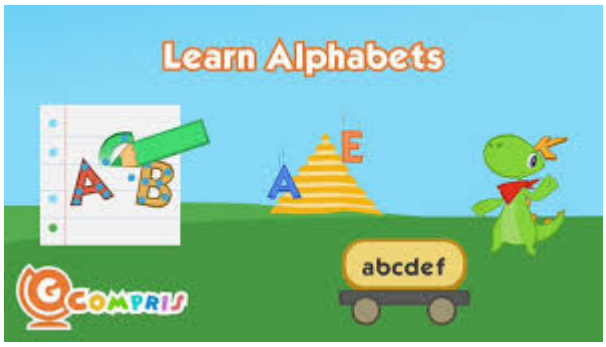
- Educational applications for the computer
- Educational applications for mobile devices
- Educational applications on the Internet (online applications)

5.1. Educational applications for the computer

Educational applications are software designed to be run and used on personal computers (desktop or laptop). These applications are available on the Internet, are installed on the computer and can be used. There are a number of free applications that can be used to learn English in kindergarten:

GCompris [19] is a set of educational software for children aged two to ten. GCompris (Fig. 1) has been translated into several languages and is free to use. The current version of the GCompris software package is divided into seven educational units, and each unit has its own categories and subcategories that represent various activities and educational games.

The second unit (Fig.2) is reading, in which children learn to read or recognize letters and numbers. All games are designed so that children gradually acquire knowledge. They especially learn uppercase and especially lowercase letters and they also learn numbers through the written words of their values. An example of a game from this unit is the game "Missing letter" in which children have to find which letter is missing in the name of an object.



eduActiv8 [20] is a set of educational programs for children from 3 to 10 years old (Fig. 3). The former name of PySioGame has recently been changed. This software is divided into the following areas: language, mathematics, time management, art, memory and entertainment.

Figure 3. eduActiv8/PySioGame

5.2. Educational applications for mobile devices

Educational applications are software designed to be run and used on mobile or portable devices (phones, tablets). In addition to encouraging cognitive and sensory motor development, children's socially empathetic behavior towards people, plants and animals, we can use them for counting and practicing phrases, words and sentences in English.

Peg + Cat [21] - with these application (Fig. 5) children learn number recognition, counting forward and backward from 1 to 100, playing and singing with Peg and Cat.

Monkey Preschool Lunchbox [22] – through six different activities, while helping the monkey to pack the fruit in the lunch box, the child will learn letters, colors, shapes, to count and recognize different patterns with this application;

A Parcel of Courage [23] is an interactive story in which family members help their grandmother overcome her fear of flying. The application is designed to help children through telling a story to better understand its content and improve their ability to navigate in space, working memory, hand-eye coordination, listening skills, following the course of action and solving problems;

Alphabet Flashcards [24] is an application for learning letters. The game encourages the development of children's memory and develops listening skills. Children will learn how to pronounce a letter and will be able to associate it with an object whose name begins with that letter (e.g. A - airplane).

Preschool Arcade [25] the app contains four games: ABC Invasion, Pinball 123, ClawCrane Matching and Whack-a-Mole. With interesting animation and sound effects, children learn to recognize small and capital letters, to count and improve their cognitive abilities.

5.3. Educational applications on the Internet (online applications)

Online educational applications do not need to be installed on a computer, but to access them, all you need is the Internet. The Internet is full of many online applications and sites for interactive online English learning. Among the most famous are the following:

LearnEnglish Kids [26] is the most famous site of its kind set up by the British Council and which contains a set of games through which children can: listen and learn songs and stories, read and write, speak and spell, learn grammar and all this through play, using coloring books, puzzles, counters. The games are also classified by scientific fields, so children can learn the basic concepts of mathematics, geography, natural sciences and art, in English.

Gus on the Go and **Stories by Gus on the Go** [27] is an application intended for children aged three to seven years. The user follows the adventures of an owl that travels the world and learns languages. It contains ten lessons and the child can learn about 90 new words.

Pili POP [28] is an application intended for children aged three to ten years. The child learns different topics (fruits, vegetables, colors...) through 200 activities, following curious aliens who have just arrived on our planet. The voice recognition program allows you to practice reading and pronunciation. This application also provides parents with the possibility of monitoring their children's progress through monthly reports.

Little Pim [29] is an application intended for children up to six years of age and was conceived based on the opinion of experts that a child at an early age can easily acquire three languages, naturally and without difficulty. Pim is a panda with the help of which the child can learn up to 360 words and phrases in the English language (12 languages are available).

Safekidgames [30] is an application that can be used to learn letters or numbers and works by clicking on the appropriate letter, or number, hears the pronunciation in English.

6. CONCLUSION

A successful educational system must unconditionally follow and apply modern trends and technological achievements. Information and communication technology is our actuality and reality. Children grow up surrounded with ICT, that is, they are exposed to modern technical devices, mobile phones, tablets and computers from an early age.

Information and communication technology enable children's play, through guided activities, to overlap the real world with the virtual world and lead to spontaneous and immediate acquisition of knowledge and learning of new concepts.

The aforementioned knowledge led to the creation of a different attitude towards the early development of children. Today, there is an awareness that early learning and experience are

of great importance for further development and that they depend to a significant extent on the quality of the social and cultural environment in which children live.

In learning English with young children, the most important thing is to help them master the basic concepts, encourage their desire to learn and build a positive attitude towards the language.

In order to achieve the successful application of ICT in learning English for preschool children, it is necessary for the teacher to have both professional and digital competences.

Only a teacher who knows well the achievements and possibilities of applying ICT in the processes of play and learning will be able to apply them in a proper way in his work.

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ESP educators in the post-pandemic e-environments: Teaching Presence and English for IT

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Abstract: *The Covid-19 pandemic fundamentally changed the educational landscape, since an almost immediate switch to online learning was the only way to keep education moving and bridge the physical distance between teacher and students. Technology has permeated every aspect of teaching to the extent where there is no going back to the "before the pandemic", therefore, in the post-pandemic times, a number of higher education institutions has introduced a policy that hybrid mode of instruction has become a "new normal". The instructor's role in hybrid teaching appears vital, so educators must amalgamate the advantages of online instructions with the goals relevant to face-to-face teaching. Teaching Presence, as an overarching aspect of Community of Inquiry (CoI) that incorporates the course design, facilitation and organization, can significantly affect learning outcomes and course satisfaction. Within the CoI framework, the paper investigates students' (n=83) assessment of Teaching Presence and satisfaction with the English for IT course. The study adopted an exploratory mixed-method research design and the data were collected through an online questionnaire. The findings of the research indicate that students highly rated the Teaching Presence in the course English for IT, and that there was a positive correlation between Teaching Presence and Satisfaction.*

Keywords: *Community of Inquiry, Teaching Presence, English for Specific Purposes, Satisfaction, Tertiary Education*

1. INTRODUCTION

Across the globe, online teaching during the COVID-19 pandemic was marked by the general idea that mere continuation of education was what was essential, whereas recommendations to invest time and energy in additional effort to support student achievement and learning satisfaction were tentative and seemed insignificant when compared to the ongoing global threat. In those circumstances, as the related research suggests, teachers were mainly interested in just delivering their courses anyhow (as they were not trained and, reportedly, had poor digital literacy), being unaware of whether the learning outcomes had been achieved at all [1].

However, things dramatically changed in the post-pandemic period when a number of universities still opted for hybrid or online modes of course delivery, which in the post-pandemic period could not be denoted Emergency Remote Teaching English Language Teaching [2], but defined as courses deliberately re-designed to be delivered online (initially f-2-f courses that were hastily adapted for online delivery and then with smaller adjustments proceeded with online/hybrid mode of delivery). As the potential benefits of online instruction during the pandemic were estimated as substantial, it was expected that in the post-pandemic period universities would try to work out its downsides and implement novel instructional strategies to secure better results. Drawing upon the experiences from the Emergency Remote English Language Teaching (ERELT) [1], [3], the educational focus has now been shifted to establishing more-meaningful and successful instruction in the e-environment. Through indicators of course quality, opportunities for improvement were called for across various disciplines, one of them being English for Specific Purposes (ESP).

Next to meeting specific needs of learners and focusing on the appropriate language, one of the absolute characteristics of ESP refers to its making use of underlying methodology and activities of the discipline it serves [4]. Following the quantum leap forward that the technology took, in the context of English for IT during the ERELT this has reached a literal level, since the teachers had to delve into the very core of the discipline, and master the technology necessary for online lecture delivery, which the students mostly felt more familiar with than their language teachers.

The post-pandemic education will, arguably, require ESP teachers to be fluent in using both teaching modalities – online and offline, as expectations have significantly increased for distance education. In that sense, Teaching Presence (TP) as a conceptual aspect derived from the Community of Inquiry (CoI) framework, appears as a critical component of e-teaching that can significantly improve the instructional setting and enhance the learning experience, or as Gurley aptly puts it ''Course quality is influenced by teaching presence'' [5]. As establishing Teaching Presence emerges mainly as an effort of a lecturer/instructor, more scholarly attention should be paid to investigating to what extent TP affects e-learning and students' satisfaction.

2. THEORETICAL BACKGROUND

2.1. CoI and Teaching Presence

Over the past few decades, following the rise of technology which subsequently opened new possibilities for online education, scholars have sought to create updated models of a learning process in e-environments, which would formalize the available research on teaching and learning and, at the same time, capture the novelties and uniqueness of the online medium. Community of Inquiry (CoI), first introduced by Garrison, Anderson, and Archer in 2000 [6] was one of the models that has generated avid interest from the researchers dealing with online learning.

Designed to assist educators and guide and facilitate online learning, CoI framework is best understood as the interconnection of three presences, cognitive, social and teaching, which have to be established if "a worthwhile educational experience" [6] is to occur. In other words, as Swan in [7] argues, appropriately designed, encouraged and carried out interactions between these presences, i.e. instructional content, students and instructors, result in achieving effective online learning outcomes. While cognitive presence refers to the ability of learners "to construct meaning through sustained communication" [6], social presence is mostly defined as the capacity of the participants in e-environments to present themselves as "real people" [6], [8]. Teaching presence can be broadly identified as the virtual "visibility" of a teacher/instructor in an e-learning environment, as perceived by students [9]. Garrison et al. posited it as "the binding element in creating a community of inquiry" and "essential in balancing cognitive and social issues" [6]. They even further highlighted the importance of Teaching Presence by claiming that when online education fails, "it is usually because there has not been a responsible teaching presence" [6]. However, this concept has been the least researched among the three presences [9], [10].

In order to establish their successful online presence, instructors must develop consistent patterns of interaction, promote accessible communication, provide consistent and meaningful feedback, moderate discussions effectively, and demonstrate content expertise [10]. Furthermore, they should identify and clarify areas of confusion, correct misinformation appearing in discussions and online posts, move the discussion along and focus it on the topic, all the way encouraging students to participate. According to [11], Teaching Presence even begins before the course commences as the teacher plans and prepares the course, and it continues during the course.

All of these activities can be gathered under three core elements of Teaching Presence, which are discerned from its most widely used definition, offered by Anderson, Rourke, Garrison, and Archer in 2001, which posits it as "the design, facilitation, and direction of cognitive and social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes" [11]. The first element, instructional design and organization, refers to the decisions that instructors have to make regarding course objectives, curriculum, teaching materials, etc. If the instructor clearly communicates the learning outcomes and ensures a strong connection between activities and assessment, the students will navigate the course more efficiently and construct meaning from the materials offered more successfully.

The second element in which the instructor also plays a crucial role is the facilitation of discourse, prompting students to actively participate in the discussions that challenge, personalize and expand on learning materials. The instructors should set the climate for productive discourse, raise apposite questions, encourage students' contributions and help them reach consensus [12]. However, teachers should restrain from being overly present so as to reinforce cooperation among students (see [13]).

Finally, direct instructional activities refer to coherent content presentation, the interjection of comments, providing students with the resources, and evaluative activities done by the teacher, such as assessment and feedback. As Bernard et al. in [14] point out, direct instruction does not have to be synchronous, as the asynchronous approach often results in better student achievement.

2.2. Previous Research

Since student satisfaction is basically defined as "a concept that reflects outcomes and reciprocity that occur between students and an instructor" [15], the relationship between Teaching Presence and satisfaction with the online course has triggered the interest of researchers ever since the concept of CoI was first introduced. Khalid and Quick in [16] analyzed the correlation between Teaching

Presence and students' satisfaction, though not in the language learning context. The results suggested a significantly positive correlation between the two variables. That the Teaching Presence is a strong predictor of students' satisfaction is also confirmed by the studies of Akyol and Garrison [17] and Kyei-Blankson et al. [18]; although they investigated the whole CoI framework, yielding differing results. For example, the survey conducted in [17] proved significant relationships between all three presences and satisfaction, where Teaching Presence followed Cognitive Presence which was shown to have slightly stronger relationship with satisfaction, while [18] showed that learners perceive Teaching Presence as the most influential factor in achieving their learning outcomes and satisfaction.

When it comes to language learning, CoI framework was discussed by Diaz and Miy (2017) [19], regarding the development of oral skill in online English courses. Their findings revealed that it is the "teaching presence itself that showed a connection with the grammar, accuracy, and vocabulary indicators of oral skill". The study of Puranen and Vurdien (2020) [20] examined how the students' perceptions on feedback and Teaching Presence in online ELT courses differ from those of teachers, and how TP influences students' engagement and behavior in online courses.

Although the Covid19 outbreak and shift to online education intensified the research regarding the presences within CoI framework, the studies exploring the Teaching Presence in online language learning still remain scarce. Ghaemi (2021) investigated the ways in which Teaching Presence affected EFL learners' perceptions of cognitive and social presences in online EFL courses and found significant correlation between the three variables [21]. Morales, Frenzen and Bravo (2022) ''sought to evaluate how much of a mediating factor online teaching presence could be in the context of test preparation within a language course" [22]. Although their results indicated that TP is perceived as a relevant aspect of online learning experience, they also warned against possible challenges that hinder the expected benefits of online language learning. Nagdhipour and Manca (2022) explored the features of Teaching presence in students' WhatsApp groups "for designing, facilitating, and guiding cognitive and social processes conducive to their language learning" [23]. Krsmanović et al. (2022) investigated the relation between social presence and students' satisfaction in online ESP course and found out that students' satisfaction "was mainly due to the teachers' successful guidance" [3], which indicated the need for further studies regarding Teaching Presence.

Finally, there is evidence that Teaching Presence is a strong predictor of cognitive presence and social presence. In the Sen-akbulut et al. research conducted during the pandemic at a Turkish university, 745 students highly evaluated courses in which Teaching Presence was high despite the fact that Social Presence and Cognitive Presence were rated as low [24]. On the other hand, other research indicates that the researcher/instructor's efforts to create a greater sense of Teaching Presence were not an effective use of her time and energy, as the findings demonstrate minimally significant differences between student grades and the criteria of the instructor evaluations [25]. This discrepancy implies that more research needs to be conducted that examines Teaching Presence in different contexts, ESP being one of them. Moreover, although the available research mostly highlights the importance of Teaching Presence in ELT, its role in students' satisfaction with the online ESP courses and the ways to establish it are yet to be explored, and this study attempts to address the indicated gap.

3. METHODOLOGY

This study was designed as an exploratory mixed-method study. Quantitative and qualitative data were used to explore learners' perceptions of Teaching Presence and their satisfaction with the course.

The study seeks to address the following research questions and test the following hypotheses:

RQ1: What is the perception of IT students of the Teaching Presence during the English for IT course?

RQ2: Is there a correlation between the perceived Teaching Presence and Satisfaction of the students who attended the English for IT course?

Hypothesis 1: IT students have positive attitudes toward the Teaching Presence during the English for IT course and are satisfied with the course.

Hypothesis 2: There is a correlation between Teaching Presence and satisfaction of the students who attended the English for IT course.

Using the Community of Inquiry (CoI) framework, this study aims at examining learners' perceptions of the Teaching Presence in the English for IT course that they attended at the Faculty of Technical Sciences in Čačak, Serbia.

The data were collected through a survey instrument which comprised 2 sections: 1) the Community of Inquiry questionnaire developed by Arbaugh et al. [26] which was further validated by Yang and Su [27], and 2) a questionnaire adapted from the Collaborative Learning, Social Presence and Satisfaction questionnaire developed by So and Brush (2008) [28] and further adapted by Pritchett et al. (2014) [29]. The wording of the questionnaire was slightly changed and translated into Serbian. Finally, the questionnaire ended with 4 open-ended questions designed by the researchers.

Upon the completion of the English for IT course (which correlates with the treatment), a questionnaire was administered to the participants who volunteered for this study. The first section of the questionnaire is the CoI instrument, consisting of 3 demography questions, 13 statements with a 5-point Likert scale related to Teaching Presence, and 11 questions with a 5-point Likert scale related to Satisfaction. The following range of Means with its descriptions was used: 1.00 – 1.44 = strongly disagree, 1.45 – 2.44 = disagree, 2.45 – 3.44 = neutral, 3.45 – 4.44 = agree, and 4.45 – 5.00 = strongly agree. The reliability of the scale for the instrument was determined by the Cronbach Alpha's Coefficient, with the result of 0.95, which indicates significant consistency. The second part consisted of 4 open-ended questions.

Data were collected through the Google Forms tool. For the CoI part of the research, a software package SPSS and descriptive statistics were utilized for obtaining and describing the results. The items of the questionnaire were then grouped into two categories related to Teaching Presence and Satisfaction respectively and Pearson's product-moment correlation coefficient was utilized to analyze the relationship between the two. Finally, for the open-ended questions, a Thematic Analysis (TA) of the responses was conducted.

3.1. Course description and the sample

The course English for IT was held in the summer semester of 2022 in a hybrid model. Out of the total of 15 teaching weeks (3 hours per week), only three weeks were held as in-person instruction (the first - welcome week, the mid-term week, and the final week). The course was delivered via MS Teams platform, and it incorporated both synchronous and asynchronous online communication. The course had elements of Project-based learning and in terms of course preparation and instruction, the lecturer was guided by Fiock's recommendation on how to successfully establish Teaching Presence [13]. The assessment was completely carried out in person.

The convenience sample of the study consisted of 83 undergraduate students of Information Technology. As for demography, among the respondents, 48.2% were male, while 49.4% were female, and 2.2% did not reveal their gender. In terms of age, 24.1% were between 17 and 20 years old, 69.9% were between 20-25 years old, and 6 % were older than 25. The respondents also self-assessed their computer skills; 61.4% believe that they have an intermediate level of knowledge, 33.7% believe that they are advanced, and 4.8% think they are beginners.

4. RESULTS AND DISCUSSION

The first part of the questionnaire referred to the Teaching Presence established during the online English course as perceived by the students of IT, and it was divided in three sections which analyzed three core indicators of Teaching Presence: Design and Organization (4 statements), Facilitation (6 statements) and Direct Instructions (3 statements). The results (Table 1) indicate that the students strongly agreed with almost all of the statements.

The highest score was given to the statement reading "The instructor provided clear instructions on how to participate in course learning activities" (M=4.74), followed by the statements regarding the instructor's clear communication of both important course topics and course goals (M=4.73). All three of the statements belong to the first section of TP scale, which refers to the Design and organization of the course, which, when all the scores are combined together, has the highest mean value (M=4.73) among the three sections. It is followed by the section labeled "Direct instructions'' with the overall mean value M=4.66. The statements in this section referred to the timely and appropriate feedback provided by the instructor. Although assessed with the lowest overall mean value (M=4.57), all but one statement regarding the facilitation of the discourse belong to the 'strongly agree' range.

The ninth statement ("The instructor encouraged course participants to explore new concepts in this course") was the only one with the mean value slightly below 4.5 (M=4.42). These findings are compliant with those of Saadatmand whose sample also had greater Teaching Presence scores in Design & organization and facilitation segments of the scale [30].

The second part of the questionnaire deals with the students' satisfaction with the ESP course delivered via MS Teams. While almost all of the responses in the first part of the questionnaire belong to the strongly agree range, the situation is slightly different with the responses in the second part, since they are distributed within three ranges (Table 2): while the respondents assessed only two items as those they strongly agree with, the majority of the responses belongs to the agree range, with only one item that the respondents disagree with.

Table 1. *Teaching Presence scale, descriptive statistics*

Statement	*Mean*	*St. dev.*
Design & Organization	**4.73**	**0.53**
1. The instructor clearly communicated important course topics.	4.73	0.66
2. The instructor clearly communicated important course goals.	4.73	0.65
3. The instructor provided clear instructions on how to participate in course learning activities.	4.74	0.51
4. The instructor clearly communicated important dates/time frames for learning activities.	4.72	0.59
Facilitation	**4.57**	**0.59**
5. The instructor was helpful in identifying areas of agreement and disagreement on course topics that helped me to learn.	4.60	0.66
6. The instructor was helpful in guiding the class towards understanding course topics in a way that helped me clarify my thinking.	4.72	0.65
7. The instructor helped to keep the course participants engaged and participating in productive dialogue.	4.61	0.73
8. The instructor helped keep the course participants on task in a way that helped me to learn.	4.59	0.66
9. The instructor encouraged course participants to explore new concepts in this course.	4.42	0.84
10. Instructor's actions reinforced the development of a sense of community among course participants.	4.49	0.82
Direct instructions	**4.66**	**0.58**
11. The instructor helped to focus discussion on relevant issues in a way that helped me to learn.	4.62	0.66
12. The instructor provided feedback that helped me understand my strengths and weaknesses relative to the course's goals and objectives.	4.71	0.69
13. The instructor provided feedback in a timely fashion.	4.66	0.61

The highest score (M=4.53) was given to the first statement which reads "Overall, I am satisfied with the teacher's guidance during the discussion". This is followed by the statement "Overall, I am satisfied with the communication during the MS Teams English classes'' whose mean value was also above 4.45, which indicates that the students also strongly agreed with the way the communication was managed during online English classes.

Furthermore, the students agreed that they were able to learn through the CMC, that they are satisfied with what they learned in the online English language course in general and with what they learned from class discussions, and that the communication was a useful learning experience.

They also agreed that the diversity of topics in the discussions encouraged their participation in them and that they were stimulated to do additional readings or research about the topic discussed during online lectures, although the score for the latter statement was slightly below 4 (M=3.92). Similar score (M=3.93) was given to the statement regarding the students' willingness to participate in a similar course in the future, as a result of their experience with this English course.

The only statement that the students disagreed with is related to their investment of effort to learn CMC skills (e.g., how to use MS Teams) to participate in the classes, which was expected due to the results of their self-assessed knowledge of the computer skills in the demographic part of the questionnaire, and due to the fact that they are the students of the Information Technology study program, so they already possess certain digital skills.

When it comes to the relationship between the two main variables investigated in the study, the findings indicate that there is a moderate positive significant correlation between Teaching Presence and Satisfaction (r=0.524**, p=.000). By the results obtained using Pearson's correlation, the higher the students' value the Teaching Presence (M=4.64) the higher their Satisfaction (M=4.02) with the online ESP course appears to be. This is in line with the previous findings of Khalid and Quick [16] and Caskurlu et al. [31] that TP significantly predicts the degree of students' satisfaction, and that there is a correlation between TP and satisfaction.

Table 2. *Satisfaction scale, descriptive statistics*

Statement	*Mean*	*St. dev.*
1. Overall, I am satisfied with the teacher's guidance during the discussion.	4.53	0.77
2. I was able to learn through the medium of computer-mediated communication.	4.25	0.92
3. The communication was a useful learning experience.	4.08	1.19
4. I was stimulated to do additional readings or research about the topic discussed during MS Teams sessions.	3.92	1.19
5. Overall, I am satisfied with what I learned in the English language course through MS Teams.	4.39	0.96
6. Overall, I am satisfied with the communication during the MS Teams English classes.	4.45	0.99
7. I was able to learn from the MS Teams class discussions.	4.22	1.03
8. The diversity of topics in this discussion prompted me to participate in the discussion.	4.30	0.96
9. My level of learning that took place in the discussion was of the highest quality.	4.02	1.07
10. I put in a great deal of effort to learn computer-mediated communication skills (e.g., how to use MS Teams) to participate in the classes.	2.15	1.32
11. As a result of my experience with MS Teams in the English course, I would like to participate in another discussion in the future.	3.93	1.43

Table 3 presents the correlations between individual TP indicators and satisfaction. All correlations belong to the moderate positive range (the highest one being between satisfaction and facilitation (r=0.558**, p=.000)).

Table 3. *TP-satisfaction correlation data*

	Design and organization	Facilitation	Direct Instruction
Satisfaction	0.410**	0.558**	0.436**
Design and organization	1	0.830**	0.690**
Facilitation		1	0.785**
			**p<0.01

The results of the qualitative part of the questionnaire (responses to 4 open-ended questions) are presented in Table 4. The students were asked to write down what was badly/poorly organized during the course and discuss what the teacher could have done to better support their learning experience and satisfaction. By applying Thematic Analysis, we have grouped the responses based on their frequency of appearance in the respondents' answers.

Table 4. *Thematic analysis, questions 1-4*

What did you like the most about the way this course was organized and facilitated?	*What did you like the least about the way this course was organized and facilitated?*
-Interaction (12 responses) -Flexibility (9 responses) -The teacher's commitment (9 responses) -Regular homework assignments and the teacher's feedback (9 responses) -A pleasant and relaxed atmosphere (7 responses) -Course management (in terms of time, instruction, mode of delivery) (2 responses) -The fact that everyone actively participated in the discussions (2 responses)	-Technical issues (poor Internet connection, equipment malfunction etc.) (18 responses) -Lack of f-2-2 contact (9 responses) -Students unwilling to participate (did not want to turn on their cameras) (2 responses)
What are the things the instructor did to support your learning in the e-environment?	*What are the things the instructor could have done to better support your learning in the e-environment?*
-Relaxed atmosphere (11 responses) -The teacher's motivation, engagement and good mood (9 responses) -Regular homework and the feedback (9 responses) -Interaction/collaboration (3 responses) -The teacher's encouraging us to participate/prompting us to discuss (2 responses) -Variety of discussion topics (2 responses) -The teacher always met the needs of the students (1 response)	-It would have been more efficient if the groups had been smaller (1 response) -To criticize students more often (1 response) -To upload more pdf material on the platform (1 response)

The findings reveal that students were quite aware of the instructional strategies their teacher deployed in online classes to build a strong Teaching Presence, so they mention the teacher's commitment/enthusiasm to guide the interaction, their class management skills, flexibility and providing feedback (9 responses and more). The respondents elicited the teacher's activities that, by

their assessment, supported their learning experience such as; setting a relaxed working atmosphere, prompting everybody to engage/participate, showing motivation to collaborate, offering a variety of topics for discussion.

As key downsides of the process, the respondents mentioned only a few issues; class size, the teacher's attitude towards students, and inadequate handling handouts, but due to the small number of responses (1 response each), they are not relevant. To conclude, the qualitative analysis has showcased that the respondents felt the instructor managed to establish a strong Teaching Presence in the English for IT course.

The findings of both the quantitative and the qualitative parts of the research imply that both Hypotheses of the study are confirmed; IT students have had positive attitudes toward the Teaching Presence during the English for IT course, and there is a correlation between Teaching Presence and satisfaction.

5. CONCLUSION

While the pandemic shows signs of ebbing (does it really?), educational institutions share cautious optimism that teaching will approach some semblance of normalcy. However, after having been thrust into virtual instruction for almost two years, which has, undoubtedly, become what is now called "new normal", educators have acknowledged a paradigmatic shift in e-pedagogy that will not disappear once the pandemic really loosens its grip. Hybrid sort of instruction is what, arguably, is here to stay. Post-pandemic education must benefit from both online and in-person teaching, offering an educational experience that educates both holistically and flexibly, and that strategically prepares students to engage with a rapidly changing world.

Our findings support the assertion that educators in tertiary education in the post-pandemic period need to enhance their academic practices by utilizing not only innovative tools but also by improving instructional strategies so as to establish a strong Teaching Presence in their e-environments. In that way, challenges caused by ERELT will be addressed, and online or hybrid learning will come at least one step closer to the significance and quality that face-2-face teaching is reported to have.

Within the CoI framework, we investigated how students assessed Teaching Presence within the English for IT course they attended, and whether there was a correlation between Teaching Presence and course satisfaction. The research findings of our study showed that the respondents had high perceptions of the Teaching Presence in the English for IT course, and that Teaching Presence was successfully established by the instructor. The results also yielded significant relationships between Teaching Presence and satisfaction, as we found a positive correlation between TP and satisfaction: the higher the students' value the Teaching Presence the higher their course Satisfaction. These findings indicate that the teacher's conscious effort to establish and nurture TP through a mindful instructional design in an e-environment was acknowledged by the students, as they elicited some of the instructional strategies they benefited from, which further suggests that ESP instructors should prioritize course planning long before it is facilitated.

As for the practical implications of this study, these findings might provide useful guidelines for ESP teachers on how to build a strong Teaching Presence in e-environments and achieve greater student satisfaction. This research might also encourage policymakers to foster initiatives that will support ESP instructors to further broaden their digital literacy competence so that it includes enhanced Teaching Presence skills, which will, overall, accelerate a transition to a more flexible and sustainable education. Tertiary education policymakers, in particular, must invest in faculty development by providing additional training programs that will empower them to re-think the existing e-pedagogies and move toward more meaningful, socially engaged and fulfilling e-learning experiences they design and/or facilitate.

The pandemic has taught us that we have to further conceptualize collaborative online learning and address its specificity by expanding our knowledge of its shortcomings and potentials. It appears that the role of educators when online is more delicate than when in f-2-f instruction, due to the fact that in the e-space instructors have to make additional effort to compensate for the obvious lacks of socio-emotional dimensions and rich-in-cues communication that is characteristic of f-2-f instruction. In other words, broadly speaking, our post-pandemic educational mission is to call for joint efforts in training a new generation of ESP educators who will acquire upgraded e-teaching skills. By becoming upskilled educators, we would, arguably, take actions to prevent so-called "educational claustrophobia – a state of learners perceiving the educational process as worthless or confined, inadequate to enable their full personal and social development" [32].

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A Genre Analysis Approach in Teaching Marine Electrical Engineers Texts

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Abstract: *Genre analysis has become a prevalent approach in the linguistic analysis of various specialized genres. A concept of genre, emerging from literature, has received a broader dimension in the last decade, focusing on establishing recognized structures and language exponents of a specific genre in a particular discourse community. In addition, the expansion of ESP and the rise of subgenres in many rising professional vocations require users to have competence in the English language. In addition, language researchers need 'to dig into' the pragmatic context of genres. With this mind and resting on the concept of genre and discourse communities, the paper sheds light on how the genre analysis approach can be applied in teaching different marine electrical genres to students and future ETO officers. The marine electrical engineering discourse community is specific and relatively novel. In this paper, the focus is placed on seafarers, future electro-technical officers and the analysis of genres they utilize in their professional work on board ships. The results of the paper can be inspiring to ESP teachers involved in teaching specialized and technical genres.*

Keywords: *ESP; genre; marine electrical engineering; discourse community.*

1. INTRODUCTION

Relying on Swales's theory of discourse and genres in discourse community [1], the marine electrical engineering discourse community can be considered as a novel discourse community in seafaring whose members use many specific genres aiming to achieve specific communicative goals in future Electro-Technical Officer's (ETO) tasks on board ship [2, 3]. The skills and competencies required by the Manila 2010 requirements of the SCTW convention for the ETO officer (Standards of Training, Certification Watchkeeping for Seafarers) are specified in section A-III/6 [4]. Undoubtedly, the education and training process for the marine electrical students, most likely, future ETO officers, requires a synergy of many factors. Since the establishment of the Marine Electrical Engineering Department at the Faculty of Maritime Studies Kotor, the subject teachers and language teachers have been faced with the task of designing language courses that will be in line with the competencies set out in the mentioned amendments on the one side and the related courses such as Model Course 7.08 Electro-Technical Officer [5] and required language competencies laid down in Model Course 3.17 Maritime English, on the other [6]. These are constant education, lifelong learning and integration of practical training, simulators and laboratory exercises, particularly regarding the primary duties of the ETO officer and the work with electrical systems and propulsion plant controls [7]. Considering the above, the paper focuses on a genre analysis of a few documents obtained from the previous student of the Faculty of Maritime Studies Kotor, now sailing in the capacity of the Electro-Technical Officer on board foreign vessels. Although we have used a genre approach in the analysis of checklists of similar content, we may observe differences that vary not only in language, but also in aesthetic layout.

Given the above, the paper aims to establish peculiar features of genres used by ETO officers. The outputs are primarily pedagogical; that is, we tend to apply the obtained results in the classes aimed at learning authentic texts with the students of Marine Electrical Engineering. The patterns of schemata of a particular genre as a specific mechanism of communication [1] presented in this paper can be used as a valuable education tool in English for Specific Purposes classes (ESP). The first part of the paper provides a short review of the concept of genre and then, in the second part, we provide several examples of written genres used among ETO officers in their daily tasks on board ships.

2. A CONCEPT OF GENRE

The concept of genre in discourse studies has become popular with the rise of English for specific purposes (ESP), needs analysis, discourse analysis and genre analysis approach. According to Swales [1], humans strive to organize verbal behaviours through rules and repertories. The task of discourse

or genre analysts is to establish those genres within a particular communicative setting. Later on, with the emergence of critical discourse studies, genre analysis is employed to reveal the relationship between the textual patterns and broader communicative settings. Wodak, Fairclough and Van Dijk state that there are inevitable interrelations between social practices and power in the constitution of the genre. More precisely, genres and discourse organization reflect the needs of a specific discourse community or community of practice membership [8].

The analysis of genre for the sake of application in the teaching of ESP and establishing generic conventions of a text under analysis has advantages in that it helps ESP teachers to identify communicative tasks that the learner needs concerning a specific text, the texts and tasks they need to handle. Based on target communicative goals, an ESP researcher has to dig into real-life communicative situations in which a particular genre is embedded [9]. Therefore, an examination of discourse practices allows for the clarification of language exponents regarding the context. Exploring this connection, often referred to as intertextuality, the researcher comes up with generic or recurrent patterns but simultaneously explores pragmatic or subject knowledge lying behind the text [10].

3. METHODOLOGY AND CORPUS

The paper reviews several selected genres used by ETO in daily chores on a ship. Apart from the operative work conducted on board, deck, engine and electro-technical officers are responsible to record activities in checklists to ensure that the tasks were conducted step-by-step and in a prescribed order [11]. Checklists can be classified as follows: 1. Narrative checklists 2. The tick-off type 3. Instruction type checklists [11].

The second type of written document used among ETO officers refers to operative procedures or instruction manual forms. The instruction manual explains how to handle equipment and which safety procedure to follow. Instruction manuals differ from company to company, depending on the ship and cargo type. Their layout and content also differ from department to department. Thus, instruction books or procedures used among deck or engineelectro/technical officer.

Criteria used to analyse in the analysis are types of genres (instruction book, checklist), type of discourse (narrative, argumentation, and factual discourse), and linguistic features. We relied on the assumption that the text itself guides the researchers.

In this paper, we utilized genre mapping to present how the surface structure of genre can be presented and specific patterns discerned [12]. There are many language programmes available to researchers nowadays, one of which is Textanz software. This programme allows mapping the text in terms of readability and density parameters, syntax structure, word length and word frequency [13]. It presents a type of linguistic 'identity card' of a text analyzed and serves the purpose of the analysis conducted in this paper.

4. SOME DOCUMENTS USED ON BOARD AND THEIR ANALYSIS

4.1. Checklists

Checklists, as said, may be of three types and their main communicative goal is to verify (in writing) and therefore guarantee (by signature) that a particular task was fulfilled. Furthermore, should any disputes or damages arise regarding the work done on board a ship, checklists can be used as proof that the person carried out the assigned tasks. However, we should keep in mind that the ships have been using more autonomous systems and that language requirements have been changing respectively. This means that checklists are stored in the ship's computer and are generated with one click on the computer mouse requiring a user to change only details relating to the ship's characteristics. However, this does not relieve ETO officers from the responsibility to keep records of activities, enter data into ship logs and complete checklists, especially when ship computers are inoperative due to a malfunction of the power supply on board. We must also note that some companies still keep records of documents using an indelible pen. Also, with some genres, such as the deck log book, all recorded entries must be legible; if some parts are erased, they must be visible.

In general, each checklist contains the company's logo, whereas the name of the checklist is typed in colour, visible font and placed either in the top canter or the top left corner of a document.

The content of the checklist refers to operational functions conducted by the ETO specified in the amended STCW convention. All competencies include an adequate level of English, especially regarding the use of internal communication systems, operation and maintenance of electrical and electronic equipment [14]. It must be mentioned that the rise of sophisticated installations on board ships and new technologies imposes new communicative requirements for the members of this community. Constant changes in the work environment also reflect on the emergence of the new and disappearance of the old genres. These changes are due to the globalization of shipping and the uniform nature of documents enabling seafarers to get familiar with the new forms in case they embark on a ship sailing under another flag. In addition, the unification of ships' documents saves time in case of international

trials- ship forms and documents are used as valid evidence in court.

Each checklist or form has a title and number indicating that the company uses a quality management system. Mainly, the document has up to three pages and several segments. The first page contains general information such as the name of the ship and the name/surname of the person undertaking the work filling and therefore signing the checklist. As seen in Illustration 1, the High Voltage Permit to Work Checklist contains details about the type of work and person carrying out the work, a specific location on board the ship, the reason and the type of work done. Working with electrical energy, mainly with high voltage, requires compliance with safety procedures and thus must be evidenced in writing in a special HV Permit to work ship's form.

HV Permit to Work **PTW-010**

Permit to Work

Permit Initiation		
Ship Name	**Permit Number**	**Ship Location**
DD-MM-YYYY hh:mm **Date & Time**	hh:mm **Start Time**	hh:mm (max 24 hrs from start) **Expiry Time**
Work Location		
Work Type and Reason		
Equipment/System		
Work Description	*Describe the scope of work and any associated instructions. List all equipment, circuits and systems covered under this work permit.*	
Responsible Person *(appointed by Chief Elec Eng)*	*Name, Rank*	
Person Completing Permit	*Name, Rank*	
Work Team *(Name, function, company etc.)*	*Name, Rank*	
	Name, Rank	
	Name, Rank	
	Name, Rank	
	Name, Rank	

Illustration 1. Example of checklist High Voltage on board a ship

As seen from Illustration 1, the required information should be filled on the right side of the form which requires mainly factual information (the name and surname of the responsible person, work team details, position in the company). However, we noticed that a section titled Work Description requires a narrative or description of the scope of work undertaken regarding issuing a work permit.

Information in the last section of the checklist is of the tick-off type in which the authorized person carrying out operations guarantees that the stated action was or was not fulfilled.

Completion	
Work Completed *(HH:MM)* **Work Canceled** **Work Permit Expired**	
All tools and equipment were removed and secured.	☐
Equipment and circuits re-energized and returned to normal status.	☐
OR	
LO/TO to remain in place and entry made in ECR NAPA action log describing all systems/equipment/circuits that remain isolated and isolation measures that remain in effect.	☐
Authorizing Officer and ECR Notified	☐

Illustration 2. *Example of checklist on board a ship. The tick-off type*

Regarding the genre mapping, Table 1 contains information about the checklist explored. In addition to essential information presented in Table 1 obtained using the Textanz programme, such as the number of words and the longest word, the values showing readability and lexical density state that the text is readable and easy to comprehend.

The readability of texts varies according to genres and the audience to whom they are intended. Also, the readability parameters of literary texts differ from the parameters valid for technical genres. In general, as regards technical genres, many experts recommend that technical texts should be short and precise, avoid jargon, and utilize familiar words, simple sentences, active voice, preferably action verbs in imperative. Furthermore, the graphs should be easy to understand and visually as simple as possible with bullets or numbers, making the information in the text clear and accessible [15]. In addition, regarding the readability, physical factors such as layout, types of letters, diagrams, the size of the font, and the reader's knowledge about the text in question should be taken into account [16].

As regards lexical density, it presents a number of content (lexical) words divided by the total number of words. In technical texts, density has lower values making them easy to comprehend.

Table 1. *Genre mapping activity – The High Voltage checklist*

Genre type	Checklist (Technical)
Discourse type	Factual, narrative
Number of words	185
The longest word	Uninterrupted
Readability	8.44 - average
Density	0.38
Sentences	Simple sentences, block language
Communicative context	ETO doing electrical repairs
Communicative goal	Evidence of activities done

In order to provide further information about the text analysed, we added additional parameters to Table 1. For example, to motivate students to participate in the learning activities in the classroom actively, we may ask them to expand the information on the left side of the table (Table 1), which may be relevant for exploring the communicative situation in which a genre is embedded. For instance, they may add fields relating to the formality of genre or tone of communication (formal vs. informal), subject-specific specialized words, abbreviations or acronyms.

4.2. Instructions and procedures

The second genre analysed in the paper, the instruction manual, contains information on handling a particular device or part of the equipment. The first part of the instruction form contains general information about batteries and UPS, whereas the second part presents step-by-step guides about handling. One of the activities referring to vocabulary is to discern verbs as the most important content words for understanding the instruction form.

Table 2. *Frequent verbs in the HV (high voltage checklist)*

Verb	**Frequency**	**Collocation**
Open	175	Open swin 3, open battery, open swout switch 5
Close	91	Close the battery switch
Wait	52	Wait for 20 seconds; Wait for the ups to start up
Follow	49	Follow the switching order
Perform	30	Perform a battery test
Start (up)	27	Start up batteries
Ensure	20	Ensure the inverter is in normal operation

As seen in Table 2, the most frequent verbs are open, close, wait, follow and perform. We found 104 examples of the noun start-up, derived from the verb start-up, meaning setting up, putting into operation or motion [17].

As for genre mapping, we established the following information after analysing instruction forms providing information about battery operation. Compared to Table 1, we chose other parameters on the left side, such as verbs, lexis and aesthetic layout. In doing this, we intend to show that the genre dictates which information can be presented and explored. The teacher may decide which fields to add or erase during the class activities with students.

Table 3. *Genre mapping activity – An instruction manual*

Genre type	Procedure or guideline
Discourse type	Injunctive, procedural
Syntax	Instruction mode/ Imperative
Verbs	Action verbs
Aesthetic layout	Diagrams and bullet lists, pictures
Lexis	General and subject-specific (electrics and electronics)

The type of discourse prevalent in the procedures or instructions is injunctive discourse. The communicative function of the injunctive discourse is to inform the users about the components of the assembly and proper handling. Its primary communicative purpose is to oblige the user to obey the rules required by the procedure. Some recommendations regarding this kind of text are avoidance of wordiness or too technical words, avoidance of idioms and phrasal words and modals as they may undermine the mandatory nature of a specific action. Also, gender-neutral forms (he/she or s/he), abbreviations and instructions should be avoided, too [18]. In light of these recommendations, we noticed that instructions make use of imperative forms (Example 1), whereas personal pronouns are avoided.

Example 1: The use of imperative form in the instruction forms

START-UP

Close the following switches in the order below:

1. CB993 EMSWBD
2. *Press* SWIN input switch
3. *Press* SWOUT output switch
4. *Wait* for 20 seconds

We also established many subject-specific acronyms which required correspondence and the help of our former Marine Electrical Engineering students. These are SWIN (switch + in) SWOUT (switch+out), SWBM (manual by-pass switch), SWLA (line change-over switch). Notably, there is the intensive use of prepositions in the Instruction forms used by Electro-Technical officers. In addition, we found 111 instances of the preposition *out*, 111 examples with *off* whereas the preposition

on was established in 110 examples. This is because "how-to" instructions in electrical and engineering forms describe the condition and operation of the equipment (*on, off, out* of function). In addition, prepositions facilitate non-native speakers of English and speakers with poor English language competence on board ships to comprehend at least basic operative instructions regarding setting up, maintaining and closing the appliance. Concerning the instruction manuals, prepositions are sometimes vital for understanding the meaning, especially for the members of this professional community with expertise in subject-specific lexis [1]. We noted that prepositions are written in capital letters.

Example 2: The use of prepositions in the instruction forms

1. Change-over to By-pass - no interruption.

2. LED IN- flashing OFF when no voltage is present.

3. The line IN LED and the line OUT should illuminate steady green.

4. The LED will turn OFF completely.

Regarding the subject-specific lexis in the instruction forms, our search yielded the most frequent content words in descending order: switch (295), LED (253), line (180), battery (181), load (116), emergency (86), operation (76), capacitors (82), inverter (70) and voltage (70). By processing texts in an adequate language software available online can be a convenient tool for designing specialized lists of words and glossaries in the ESP classroom. In addition, regarding the diversity of materials available for collecting digital corpora owing to globalization and digitalization of shipping, the students and seafarers may participate in creating authentic corpora which can be the subject of linguistic research.

5. CONCLUSION

In recent years, the interaction between subject teachers and professionals has resulted in many benefits in designing ESP courses and teaching specialized genres [19]. Leaning on theories set forward by Swales [1] and Bhatia [9], we considered the concept of specific written genres in the case of the ETO discourse community and presented genres used among ETO officers on board a ship.

Genre mapping activities presented in this paper may show how genre activities may be applied to depict or define authentic genres used in the ETO discourse communities. We intended to show that using linguistic tools such as language programmes available online, we may obtain essential surface data about the required texts and later dig into a deeper analysis. In this way, the analysis is grounded in a particular context, communication rules and expertise of different communities of practice are exhibited [20]. The tables provided in the paper may be expanded as the parameters are not fixed (communicative setting, genre, discourse). This means that, depending on disciplinary specificities, this approach allows creativity and better involvement of students in the teaching process. Students are more likely to participate in the classes and learn patterns or genres used in real-life situations on a ship. Nevertheless, optimal results are obtained when former students, present seafarers sailing in the capacity of ETO, are involved in the teaching process. For instance, they may deliver authentic materials and help in the interpretation of the linguistic data.

We believe that the conclusions presented in this paper will help other researchers, especially those involved in teaching technical genres of a particular professional discourse community, to explore textual or verbal patterns that the specific users utilize to obtain specific communicative goals.

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Oral presentation as authentic material for providing ESP instruction

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Abstract: *The paper investigates some perspectives of oral presentation as an authentic task for providing instruction to students who create their own presentations on a specified topic. For that purpose, undergraduate students who attend ESP courses were exposed to oral presentations prepared by their colleagues in order to be instructed on how to prepare their own presentations. Upon the task completion, a survey was conducted to collect the students' opinions on the impact of the instruction that contains authentic material on their preparation strategies, self-regulation and self-evaluation in the process of fulfilling the task. The results show that oral presentation used as authentic material for ESP instruction positively affect the strategies and activities that students use during the preparation for the task completion. It also promotes students' self-regulation and self-evaluation within the same process.*

Keywords: *oral presentation; authentic material; ESP instruction; strategies; self-regulation; self-evaluation*

1. INTRODUCTION

The instruction in ESP has been developed to meet the learners' needs for achieving specific purpose language ability [1]. Thus, its main goal should be to enable students to communicate efficiently in a vocational higher education setting or in their future workplace [1].

In this research, teaching instruction is based on students' oral presentations which represent authentic material intended to be used in the classroom context. We tend to explore whether the students' exposure to authentic material in oral presentations positively affects their preparation strategies including self-regulation and self-evaluation. We consider oral presentation as a particularly efficient task since it promotes the integration of all the language skills, making decisions, preparation for real-life communication, learner-centeredness and know-how to use technology [1].

The following passages reveal the qualities of the oral presentation as a widely used task in tertiary-level education. We are also telling the difference between authentic and methodologically modified material. Further on, we are discussing the benefits and disadvantages of the authentic material used in the classrooms.

2. THEORETICAL BACKGROUND

2.1. Oral Presentation as a task

Nunan highlights communicative language teaching as the most complex change in the 20th century teaching tradition [2]. In the 1970s, a bulk of various pedagogical and linguistic research concerning curricula development, teaching methodology and assessment spurred the expansion of communicative approach [3]. Similarly, Byram implies that linguistic, psychological, sociological and philosophical research served as the solid grounds for its development [4]. Therefore, several pivotal concepts are related to communicative language teaching such as communicative competence, learner-centeredness, learners' autonomy, group work, process-oriented work, task-based learning, etc. [4]. Additionally, contemporary research shows that the communicative teaching approach along with digital technology use is suitable for multimodal learning and the development of multimodal literacy [5].

Task-based language teaching (TBLT) stems from communicative language teaching [2]. However, while the language activities represented the core unit of communicative teaching, the task has been developed to be the most important concept of TBLT [3]. A task can be defined as an activity which enables students to engage language skills at their disposal and use them in order to fulfil a non-linguistic goal, thus conveying the meaning in a way that is similar to the real-life communicative situation [6]. In other words, in order to

communicate students should be exposed to real-life language and motivated to use it [7]. It is also desirable to draw their attention to language structures with the aim to make their communication more accurate.

Tasks can range from a simple listing, ranking or sequencing to the more complex ones such as analysing company performances, telling stories, etc. [8] and the project-based tasks which require students' collaboration [9]. Using TBLT in ESP in higher education with the students of technology and engineering enables FL use in the context that they can easily meet in their future occupational environment [10]. In tertiary-level education a task can include writing reports, business emails, giving presentations, writing scientific papers, etc.

An oral presentation is a widely used task in foreign language courses in higher education [11]. The oral presentation is a productive activity that is received by an audience [12]. It can range from a project or a group-work task to an individual activity [13]. In any of the mentioned circumstances it involves several different phases: 1) searching for the relevant information, 2) collecting necessary data and their evaluation, 3) selecting the most important issues and creating the presentation, 4) rehearsal of the prepared material and 5) presentation delivery. Various e-platforms used by educational institutions are particularly useful because they enable wide availability of online presentations.

The abovementioned arguments show that oral presentation is a complex task which enables students to use a foreign language to fulfil non-linguistic purpose by conveying the topical knowledge to the audience. The activity is suitable for students of higher-education levels. E-platforms can as well be used for the improvement and transparency of oral presentations.

2.2. Oral presentation as authentic material

Teaching material in tertiary level education should be designed to serve the purpose of equipping students with English which they could use in the vocational context. The authenticity, the contextual and topical range, tasks or activities, participants and social and pedagogical prompts have a significant role in choosing proper teaching material [1].

On the one hand, methodologically modified or pedagogic materials are intended for teaching and are therefore artificially simplified while on the other, authentic texts contain real-life unmodified materials [14]. The most frequent explanation of authentic materials is similar to the one offered by Adams [15]. According to this author, the authentic texts whether spoken or written, contain the language produced by and for the native speakers and therefore do not have primarily teaching and learning purposes. However, in our research, we will confine to Morrow's definition which indicates that authentic material contains a real piece of language which enables a real speaker to convey a message to the real audience [16]. Gilmore accepts the same definition, adding that the concept of authenticity can also relate to the texts, participants, different social or cultural situations and purposes or their combinations [17].

Authentic materials in the classroom promote students' motivation due to their active involvement that enables learning and using language in a real-life manner by seeing, experiencing and practising [18]. Richards pays particular attention to videos as they are beneficial for students' comprehension since they offer both language inputs and a variety of non-verbal clues [19]. Macwan also indicates that the use of authentic materials, such as visual aids, as a teaching instruction promotes further communication that is similar to real-life situations [20]. As the main argument, he mentions that visual aids engage all the students' attention. Bajrami and Ismaili highlight the qualities of authenticity and originality as the most important benefits of using audio-visual materials in the classroom [21]. Videos can fulfil different teaching purposes such as providing the input information on the topics which students can use for further discussion, interactive tasks, self-study or evaluation. Borszéki agrees with the previous adding that besides raising students' interest, using visual aids as teaching instructions can help the retention of the knowledge acquired [22]. She refers to the pictures as clues for producing texts, making mind maps, authentic video clips, preparing Power Point presentations on ESP topics as the range of activities particularly suitable for promoting foreign language learning.

Furthermore, the advanced L2 learners show greater progress when being exposed to authentic materials [23]. Similarly, Jerković and Rakić explain that their research with technology and engineering students who were actively engaged in the tasks that included exposure to the authentic texts showed substantially better performance than the students who were taught on the basis of their usual coursebook texts [17]. The students' performance was measured within productive and interactive speaking activities that comprised oral presentations, business communication, telephone conversations and arranging business meetings.

The abovementioned arguments indicate that the use of authentic materials for teaching purposes is extremely valuable. It makes the process of learning foreign languages dynamic, interesting and natural. As such, it provides the necessary conditions for active learning and increases students' motivation. However, teachers should be cautious when choosing authentic materials for teaching purposes. In order to select proper

authentic resources, it should be considered whether they are suitable for students' age, interests, language knowledge and teaching goals [18]. Students will benefit from the authentic material only if it fits their language level, needs and expectations. It is also important to draw students' attention to language structures and the tasks teachers expect them to do, especially so when authentic material is used as instruction [19]. In other words, it is unrealistic to expect that mere exposure to authentic material will lead to language learning or acquisition.

Based on the previously exposed, one of the main ideas in this paper is to reveal the use of the students' video-recorded oral presentations as an authentic piece of material. The objective is also to check whether and to what degree such presentations promote students' preparation strategies, self-regulation and self-evaluation of their learning process.

3. Research design

3.1. Research questions

The research was designed in order to answer the following research questions:

- Will the oral presentations as authentic material used for teaching instruction positively affect students' preparation strategies necessary for the completion of the task of presentation?
- Will the oral presentations as authentic material used for teaching instruction positively affect students' self-regulation and self-evaluation of the learning process when preparing for the presentation?

3.2. Participants

The participants were 79 students of undergraduate vocational studies attending four different study programmes at the Faculty of Technical Sciences in Čačak (Production Management, Information Technology, Graphic Technology and Engineering Informatics and Computing). There were 57 male respondents and 22 female respondents. The majority of students, i.e. 58 of them were between 18 and 20 years old, while 12 students were between 20 and 25 years old. Only 9 of the students were older than 25. The students attended ESP courses for one semester. The research was conducted in the winter semester of the 2021/2022 academic school year.

3.3. The task

An oral presentation is a compulsory pre-examination assignment that students prepare in pairs or in groups within their ESP courses. It takes about 8 lessons to prepare the presentation since the task includes several different stages: 1) choosing a topic, 2) searching for the material relating to the topic, 3) selecting the appropriate material, 4) creating the presentation, 5) rehearsal and preparing for the report phase and 6) delivering a presentation.

During the winter semester of 2020/2021 five groups of students created their presentations, cam-corded them and posted them online using the MS Teams platform which we started using due to the Covid-19 pandemic situation. The recordings of their presentations were used as authentic video materials for the participants of the research to design their own presentations in the winter semester of 2021/2022. The main idea of using students' presentations as authentic material was to give instructions to their peers on how to prepare their own presentations.

In order to present a chosen topic successfully and efficiently, the students need to have background knowledge, language knowledge, clear structure and organization of the presentation, maintain eye contact with the audience, use the appropriate body language, be persuasive and enthusiastic, etc. [24]. Therefore, besides language knowledge and skills, a student needs to develop various communicative strategies and use paralinguistic clues to fulfill the task. We considered that video presentations would be a very useful source of authentic material used for giving instructions since the students would be able to pay attention to all the characteristics of a good presentation and use them to regulate their own process of fulfilling the task. Hence, for the sake of the research, the students were first given the opportunity to watch and listen to their colleagues' presentations and adjust their process of learning to suit their own needs.

The same group of students was subsequently exposed to instructions on how to prepare their presentations on the basis of the coursebook texts during regular classes. Students were able to read the texts, write down useful words and phrases and talk about their impressions and conclusions.

Thus, the students had the opportunity to use and compare two different types of instructions while preparing for their own performances.

3.4. Research method and analysis

After the students presented their topics, a survey was conducted and a questionnaire was used to collect their answers on the preparation process. The statements were designed on the basis of the literature review presented in the theoretical background and the conducted research design. A five-point Likert scale with choices ranging from 1 strongly disagree to 5 strongly agree was used in the questionnaire. The main objective of the questionnaire was to identify the impact of oral presentations as EFL instruction on the strategies that the students use when they have the task of creating their own presentations.

The first eight statements were designed to check the activities and strategies that the students perform when preparing their presentations and they mostly refer to language acquisition and use as well as the qualities of successful presentations. The ninth and tenth statements relate to self-regulation of the learning process, while the last two questions investigate the process of self-evaluation in the phase of preparation for the deliverance.

Descriptive statistics was used for the analysis of the obtained results.

3.5. Results

The results are presented in Table 1.

Table 1. *Students' perceptions of the oral presentation as ESP instruction vs coursebook material as ESP instruction*

It is easier to prepare my presentation when:	**1 I strongly disagree (%)**	**2 I disagree (%)**	**3 Neutral (%)**	**4 I agree (%)**	**5 I strongly agree (%)**
1. I can watch and listen to my colleagues presenting their topics.	6.33	0	3.80	8.86	81.01
2. I can read the instructions about creating presentations from the coursebook material.	75.94	13.92	3.80	0	6.33
3. I can select and write down the words and phrases I myself find useful in my colleagues' presentations.	26.58	5.06	0	3.80	64.56
4. I can write down useful words and phrases suggested by the coursebook material.	63.29	5.06	0	0	31.65
5. I learn useful words and phrases when watching and listening to my colleagues.	10.13	2.53	0	12.66	74.68
6. I learn useful words and phrases from the coursebook material.	62.02	22.78	0	2.53	12.66
7. I spot the qualities of good presentations when watching my colleagues' presentations.	1.26	1.26	1.26	1.26	94.94
8. I read about the qualities of good presentations in my coursebook material.	87.34	7.59	1.26	1.26	2.53
9. I learn by watching online presentations whenever it is convenient for me.	1.26	1.26	0	1.26	96.20
10. I learn about presentations during regular classes.	91.14	5.06	0	2.53	1.26
11. I can evaluate my performance by comparing my presentation with the presentations of my colleagues.	0	0	1.26	2.53	96.20
12. I can evaluate my performance by comparing my presentation with the examples of successful presentations offered in the coursebook materials.	88.61	7.59	1.26	0	2.53

The obtained results reveal that a great majority of students (89.87%) agree (8.86%) or strongly agree (81.01%) that it is easier to prepare their presentations by watching and listening to their colleagues performing the same type of task. The results for the second statement confirm the previous findings since only 6.33% of students consider that it is easier to prepare a presentation when the instructions were given in their coursebook material. When we consider the third statement, it turns out that a great number of students (68.36%) agree (3.80%) or strongly agree (64.56%) that they find it easier to prepare their presentations by selecting the words and phrases they themselves discern as useful while watching their colleagues' presentations. As many as 31.65 % of students strongly agree that it is easier to write down words and phrases suggested by the coursebook material (statement 4). When the process of learning useful words and phrases is considered (statement 5), the great majority of students (87.34%) agree (12.66%) or strongly agree (74.68%) that it is easier to prepare their presentations when they watch and listen to their peers presenting, as opposed to their colleagues who agree (2.53%) or strongly agree (12.66%) that it is easier to learn the words and phrases from the coursebook material, only 15.19% (statement 6). Also, the results of the seventh question prove that almost all the students (96.20%) agree (1.26%) or strongly agree (94.94%) that they spot the qualities of a successful presentation when they watch their colleagues presenting. Accordingly, only 3.79% of students agree (1.26%) or strongly agree (2.53%) that it is easier to discern the qualities of a good presentation on the grounds of the coursebook texts (statement 8). As far as the ninth statement is concerned, the results show that the greatest majority of students (97.46%) agree (1.26%) or strongly agree (96.20%) that they prefer preparing for the presentation when it is convenient for them. Only a small percentage of students, i.e. 3.79 %, agree (2.53%) or strongly agree (1.26%) that preparations during regular

classes are more suitable for them (statement 10). If we take into account the results of the eleventh statement, it turns out that almost all the students (98.73%) agree (2.53%) or strongly agree (96.20%) that they evaluate their performance more easily while preparing for the presentation when they have the opportunity to compare their oral production with the performance of their colleagues. Only 2.53% of students evaluate their presentation more easily when they can compare it with the examples of successful presentations described in their coursebook texts (statement 12).

4. Discussion

As far as the research questions are concerned, the previously exposed results suggest that the oral presentations as authentic material used for teaching instruction positively affect students' preparation strategies for the task of presentation since the majority of students confirmed that it is easier for them to prepare for their own presentations by watching and listening to their colleagues' performances and selecting and learning the useful words and phrases on their own. Also, authentic material used as teaching instruction promotes self-regulation of the learning process when students prepare for the presentations as well as self-evaluation during the process of preparation for the final report. The inferences based on the results imply that students can benefit from learning a foreign language when preparing presentations on the basis of authentic material even though the language is not produced by native speakers. This is probably due to the fact that the material is adjusted to their own level of FL knowledge, as well as to their own age and interest.

On top of this, we also showed that the purpose of students' presentations should not be restricted to eliciting their performance in order to assess their achievement. Presentations can also serve as a useful source of authentic material that can be used by other students as a model for assignment design and preparation activities. It is supposed that the students will produce the language suitable for their peers' age and interests. Thus, the teacher is encouraged to make the proper choice of authentic material that has already been made to suit their students' level of knowledge and understanding.

However, the study has its limitations. They mostly concern a small number of items that were investigated in the questionnaire. The other elements of successful presentations could also be investigated, such as the impact of video presentations on the development of paralinguistic qualities (eye contact, body language, enthusiasm and self- confidence while presenting, etc.).

5. Conclusion

This paper described oral presentations as a useful source of authentic material that can be used in ESP courses in higher education. It provided deeper insights into the benefits of using students' performances to promote their peers' engagement and motivation to complete the tasks.

The students were actively engaged not only during the task fulfillment, but also during their exposure to the corresponding instruction. In other words, the input enabled real-life context for language learning since the students were able to listen, watch and experience the same task they were subsequently required to complete.

Accordingly, the results show that the respondents of the research found it easier to create their own presentations if they had the opportunity to watch and listen to their colleagues performing the same task than when they are exposed to the coursebook material. The contribution is the most prominent in the domain of self-regulation and self-evaluation strategies where almost all the students confirmed the advantages of the use of authentic material.

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Students' perspective of ESP in IT classroom: challenges and opinions

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Abstract: *ESP has become a crucial part of every EFL curriculum. Hence, there are numerous challenges that both students and teachers encounter during their classes. This paper deals with potential problems that students face in ESP classroom, their attitudes towards the content and perspective of ESP classes and materials, as well as implications and recommendations for future methods and resources used in ESP classrooms. For the purpose of the study, we conducted a survey among students to examine their attitudes and to investigate their perspectives of ESP classes and materials. The paper presents the results of a survey conducted among IT students. The main research instrument used in our study was a questionnaire combined with a semi-structured interview and a small-scale needs analysis. The results show that students are aware of the importance of ESP and are motivated to improve their level of professional English in order to be successful in their future careers. The findings also show that most of the students' value authentic materials and speaking activities, which were both evaluated as positive aspects of ESP classes. These findings can help us design future ESP curricula and overcome difficulties and challenges in an ESP classroom.*

Keywords: *ESP, needs analysis, tertiary level of education, non-English majors.*

1. INTRODUCTION

ESP (English for specific purposes) has become one of the main areas of interest for both teachers and students.

Teachers have come to a conclusion that general English is simply not enough for students of non-English majors, and students (especially final-year students) realized that their knowledge of professional terms and language specific to their field of study is pretty modest. Hence, both teachers and learners have been trying to improve their approach to ESP teaching and learning.

However, there have been many difficult areas and challenges when it comes to ESP. General English itself can be challenging for non-natives and ESP has certain characteristics that differentiate it from both ESL (English as a Second Language) and EGP (English for General Purposes), which makes it even more complicated. In addition to that, ESP does not have a very long history, since it has been actively used since the 1960s and is still being reshaped and modified. It has survived many changes, in terms of materials, teaching methods, approaches and course books.

Nowadays, we have numerous options for teaching ESP for different fields, but there are still many discrepancies and areas to improve. Different institutions and different countries use different approaches. A more unified approach is something which is definitely needed, but in order to have that, we need to analyze not only the teachers' perspectives, but the students' opinions and needs as well, since ESP, more than any other field of English requires teamwork: well-prepared and trained teachers and students who are open to being actively involved in every step of the class.

In our paper, we are going to present the students' perspective of ESP classes, from their opinion on materials, didactics, drawbacks and gaps, to suggestions for further steps.

2. THE ROLE OF ESP TEACHERS

The role of an ESP teacher is not the same as a role of a General English teacher. As Hutchinson and Waters stated "in contrast to the General English teacher, the ESP teacher is faced by a group of learners with certain expectations as to the nature, content and achievements of the course" [1]. Very often, an ESP teacher needs to cooperate with other specialists from the field, in order to understand the vocabulary that they teach. Also, an ESP teacher is often a guide, a mediator, something more than a teacher, since in ESP classes, a student-centered approach is more valuable and better accepted than any other approach. An ideal situation would be for the teacher to use subject-specific materials, but unfortunately, resources (both in terms of time and

finances) are not always ideal, so teacher's role is to try to meet all demands and still fulfill everyone's needs and desires. Hence, systematic change is needed not only to change approaches to ESP teaching but also to change the role of ESP teachers and learners.

3. THE POSITION OF ESP IN HIGHER EDUCATION – THE NEED FOR NEEDS ANALYSIS

One of the main pre-conditions for a successful ESP course is to know who we teach and what outcomes we expect. In order to know that, we need to have proper needs analysis as the first and foremost step. Also called "Needs Assessment", needs analysis has one aim: to help us design a reliable and effective curriculum, by determining why a certain group of learners need (or want) to study a language.

The term "analysis of needs" was originally used in the field of language teaching by Michael West in 1926 [2]. However, many decades after that, needs analysis was completely disregarded, but it resurfaced again during the 1970s as a result of work and intensive studies conducted by the Council of Europe team [3]. This team wanted to help adult learners improve their knowledge of English and they intended to do so by implementing communicative approach [4].

What has been true from that moment on is that without proper needs analysis, we would never be able to improve the goals and outcomes of ESP classes. Precisely because of this reason, needs analysis requires more attention in the first place, and in accordance with that, research and discussion from everyone in the community of higher education, not only policymakers, but students and teachers as well. Only after that can we discuss course books and approaches to teaching and learning ESP.

As Basturkmen observed more than 15 years ago, one of the main problems of ESP (in the world and in Serbia) is the lack of literature [5]. With the internet and widespread use of online tools the situation is slightly improved but not so changed in the past 15 years.

So, in order to try to improve it, we need to gain insight into the students' and teachers' perspectives regarding this issue.

Our first step toward a better ESP education is to examine students' perspectives of ESP classes and to identify the main problems and difficulties when it comes to studying ESP.

For the purpose of this study, we conducted research, as it will be further described in the paper.

4. RESEARCH METHODOLOGY

In our research, we used a questionnaire, designed for the purpose of this study, which had both open-ended questions and closed-ended questions (Likert scale, yes/no questions) in order to investigate the students' perspectives regarding ESP classes and materials.

Since the survey was both quantitative (the questionnaires) and qualitative (open-ended questions), the methodology combined both approaches.

The questionnaire included 14 questions, which are further elaborated in the paper.

Questions one to three were given in order to obtain demographic data and observe the profile of the respondents.

Questions four to ten were designed in order to gain insight into the students' previous experience in studying English and their current status. Finally, questions 11-14 were open-ended and were designed to elicit the participants' attitudes about ESP in general and the ESP course, methodology and materials that were used during the course.

The purpose of this survey was to assess their needs, opinions and suggestions regarding ESP.

4.1. Participants

The participants of this study were 50 first-year students of Software Engineering at the State University of Novi Pazar. Initially, there were 67 of students who participated in the survey, but 17 questionnaires were discarded, since they were not fully completed. Most of the students share similar demographic data: 45 out of 50 participants are 19 years old, whereas 2 of them are 20, one is 21, and two of them are 22 years old. As for the gender, the majority of participants is male, as it is often the case in technical sciences, so there are 38 males, and 12 females in our sample. All of our participants have studied English before, either in elementary school, high school or in both schools.

When it comes to their current level of English, 37 participants assessed it as B1, 8 participants as B2, 3 as C1 and 2 participants thought that their level of English was at A2 level. As it was later observed on their final exam, most of the participants were in fact somewhere between B1 and B2 levels.

5. RESULTS

5.1. General English

In the following part, we asked our students to elaborate on their opinions, needs and attitudes toward General English. The detailed information about this part of the survey is given in Tables 1-3.

Table 1. *Students' opinions and needs regarding General English*

Question	To pass the exam	For future education	For future job	To be able to communicate with foreigners
Why do you need English?	2%	0	91%	7%

Table 2. *Students' opinions regarding their weak points in General English*

Question	Reading skills	Writing skills	Speaking skills	Grammar
What would you like to improve in your English?	1%	5%	85%	9%

Table 3. *Students' opinions on most and least useful activities in General English*

Question	Conversation practice	Reading professional texts	Listening to professional dialogues	Grammar activities	Writing activities
What kind of activities are most useful for you?	95%	3%	0	2%	0

Table 4. *Students' opinions on most difficult activities in General English*

Question	Conversation practice	Reading professional texts	Listening to professional dialogues	Grammar activities	Writing activities
What kind of activities are most difficult for you?	38%	7%	3%	29%	23%

As we can observe from our results, the students in our sample think that they need English in order to get a job or to be successful in their future careers, since more than 90% of them share that opinion.

This was not surprising, since they are aware that IT is a field where they cannot do much without solid knowledge of English. This might be the reason why most of them are actually motivated to improve their English, which can be seen by their attendance and exam results.

The majority of the students in the sample would like to improve their speaking skills (85%), whereas there is a small number of students (9%) who think that they have problems with their grammar and that it is something that they should work on.

Almost all of them (95%) also agree that speaking classes are the most useful classes for them, whereas there is a small number of students who value reading and grammar activities as the most important ones (3% and 2%, respectively).

However, what is interesting is that although writing activities are difficult for 23% of the students, that is not something that they think they should work on or consider useful for them. On the other hand, speaking activities are difficult for more than one third of our sample (38%), but remain both the most useful activities and activities that most of our student wish to improve.

5.2. ESP classes and needs analysis

In the following part, we present the results regarding the students' opinions on the course books and materials used in their classes, on their self-assessment of their vocabulary from the IT field, and finally we provide students' opinions on what they actually need when it comes to ESP classes.

Question number 10 (How well do you understand vocabulary from your field of study, i.e., IT English?) shows us the students' own perception of their knowledge. For this question, we used a 5-point Likert scale which contains 5 response options. It consists of two extreme sides and a neutral option linked to the middle answer options.

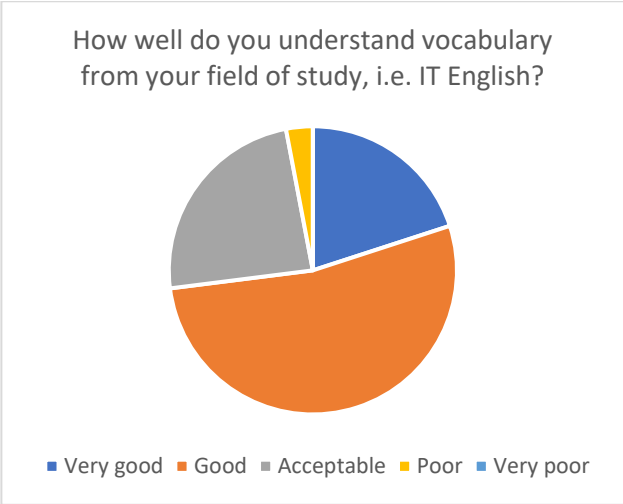

Figure 1. *Understanding ESP vocabulary*

As it can be observed from the chart, most of the students are pretty satisfied with their vocabulary from the IT field, since 53% of them chose "good", whereas 24% think that their IT vocabulary is on an acceptable level. On the other hand, almost 20% of them consider their IT vocabulary to be very good. Only 3% of our students chose the option poor and nobody chose the option very poor.

In the following part, questions 11 and 12 were two-choice questions, so it was simple to analyze the answers.

As for question 11 (Does the current book used in English classes meet your learning needs?), the students' opinions were divided, since almost half of the students were satisfied with the book used in their English classes and 51% of them responded with yes and the other half thought that General English book is not the best option for them.

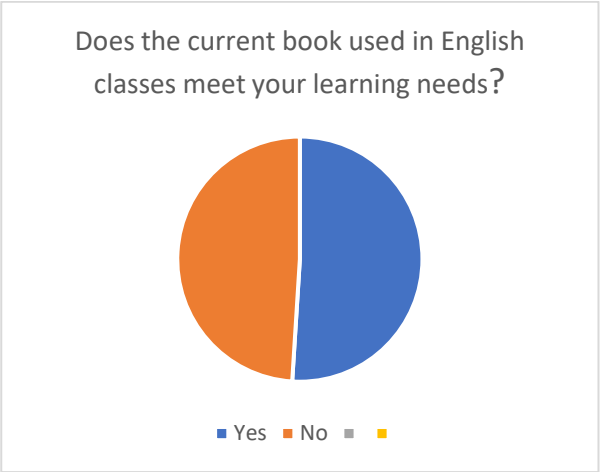

Figure 2. *Opinions on the book used in classes*

The following question (Question number 12) shows us that the students actually prefer ESP materials, or materials specific to their occupational field, having in mind that 78% of them chose that option over General English. However, they are still pretty satisfied with the current book they use, which is a General English book, since it gives them an opportunity to improve their grammar, whereas an ESP book was used to focus on their vocabulary and for some additional activities.

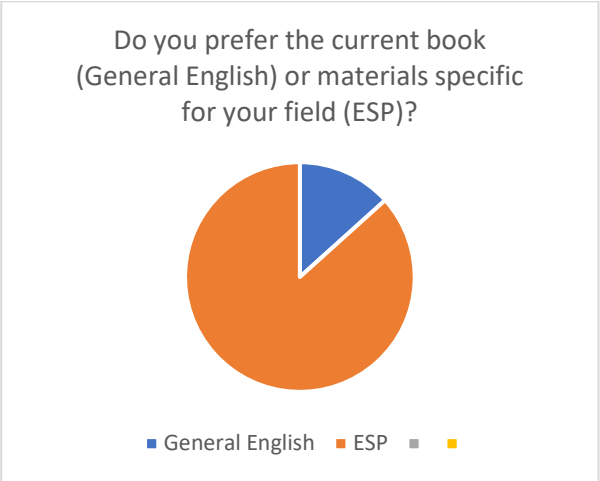

Figure 3. *Preferences regarding materials used in classes*

Questions 13 and 14 were open-ended questions and due to that, our respondents answered differently.

When it comes to question number 13 (What kind of materials would you like to use in English classes?), the most repeated answers were "ESP materials" and "business English materials", along with "debate materials" and "role play materials". It can be concluded that these students value speaking activities more than any other kind of activity.

Finally, one of the most important questions in our survey and the question which belongs to needs analysis is the very last question: What do you need to learn in English classes?

We are going to present only responses which were repeated more than 3 times in students' answers.

One of the most common responses was "I need to practice conversation for my future job" or "I need speaking to be able to communicate with clients", along with "for business communication". The answers that concerned future jobs or which mentioned the word career/business/clients were the most common, almost 50% of the sample.

In addition to these answers, some students think that they should learn more grammar, since there were around 20% of the respondents who wrote "a little grammar", "tenses" or just "grammar" in this part, 9 of them to be more precise.

The remaining part of our students responded differently; some of them think that they should learn more vocabulary (5 of them, or 10%), some think that they need to learn how to communicate better and some think that their listening skills and/or writing skills could be improved.

However, these answers were not in majority, so they were not representative.

6. DISCUSION OF THE RESULTS

Our results show us that the majority of the students who participated in our survey need English for their future jobs and that they are well aware of that fact. Hence, a great number of them would like to improve their professional vocabulary, along with their speaking skills, since they think that those are the most important aspects of their English.

ESP books are a better option for them, according to their responses, although half of them think that the book they use in their classes (General English) meets their needs. This answer, however, might not be completely honest, since the survey was not anonymous and maybe the students did not want to state that the book chosen by their teachers was not the best option for them. On the other hand, they did use materials from one ESP book and authentic materials, along with their course book, so they were able to assess what suited them better.

Based on the students' needs and desires, we can also conclude that they would like to use more

authentic materials in their classes since they wish to improve their Business English and to work on their IT vocabulary. This is not a surprise, since, as Blagojević points out, the introduction of authentic teaching material to the classroom is an important part of teaching ESP [6]. Since the use of authentic material implies reading, comprehension and interpretation of the texts which are written by native speakers for non-pedagogical purposes [6] but also real-life situations, debates, role-plays and interviews are good options for implementing these materials. Additionally, as Manić and Vučo [7] observed, student motivation to learn technical vocabulary increases when the ESP course is related to the subject matter of other professional subjects. And as it is commonly known among ESP teachers, a constant issue permeating the planning and realization of the course "ESP" has been the one regarding student motivation for this course [8].

So, if these materials could increase students' motivation, they should be implemented more and hence improve their overall results regarding learning and acquiring ESP.

All this should be taken into consideration when designing a curriculum for ESP, especially for IT students.

Since the majority of our students expressed their desire and necessity to improve the vocabulary needed for their field of study and future jobs, IT vocabulary is another area for improvement for them and teaching that vocabulary has to be approached carefully. It is very important, among other things, not to teach ESP vocabulary out of context, as individual words [9]. As it was noted by other researchers, the context in which those words appear, along with appropriate tasks and activities, increase not only the acquisition of the vocabulary but the students' motivation in general [10].

Finally, as it was previously stated, almost all of the students agree that speaking skills are something that they value the most and something that they want to improve further. Thus, more speaking activities are needed in their classes

7. CONCLUSION AND IMPLICATIONS FOR FURTHER RESEARCH

English is very important for IT students, since most of them will use it for their future careers and they will not be able to find a job without an appropriate level of English.

Based on our questionnaire, our students do have a certain level of General English, but they want to improve their professional English and our results are valuable in way that they show us what aspects should be taken into account when teaching them. Moreover, the data and the results obtained in this survey could help us improve ESP classes and, more importantly, design a better course syllabus, after taking into consideration the student's desires, opinions and needs.

However, our survey has certain limitations, the most important one being the sample size. Although 50 students are not a small sample, it would be more representative if there were more participants. Also, students who completed this questionnaire had already passed their English exam, hence their attitudes towards the materials might have been better due to that.

Additionally, the overall level of English of IT students is usually better than that of students of other majors, so it would be good to repeat the survey with students from other fields.

All things considered, it does provide some insight into ESP needs and areas for improvement, since ESP is one part of language teaching (and learning) which requires constant innovations and all of us who are part of it should be open to changes and improvement.

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Using Escape rooms in English classes

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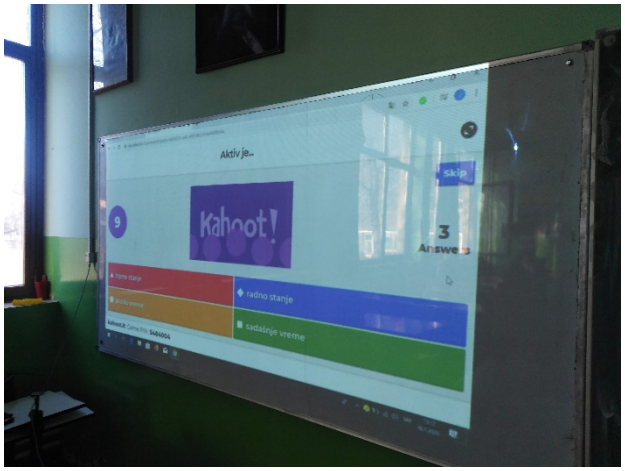
Abstract: *There must have been part of your childhood which reminds you of a video game you could not resist! Do you remember the thrill while playing games like Tetris, Pac-Man or Super Mario? Times have changed and games have become even more colourful, more demanding, and more complicated, but that feeling of playing games has remained the same. People who often practice this activity, especially children, become addicted in some way but they are not aware of that. There is a question: How can we use games as a learning strategy that can facilitate children's motivation of learning? When we create breakout games and escape rooms we reach our aim, students learn while they are playing games. They have to use their reasoning, knowledge, and skills to solve puzzles and challenges related to the content of the curriculum of native and foreign languages. What is more important, in these strategies, students must work as a team which leads to a better classroom atmosphere, and a better score in pro-social behaviours. If you go a step forward and involve students in creating games on their own, with contents from language classes, then you will succeed in creating STE(A)M classes.*

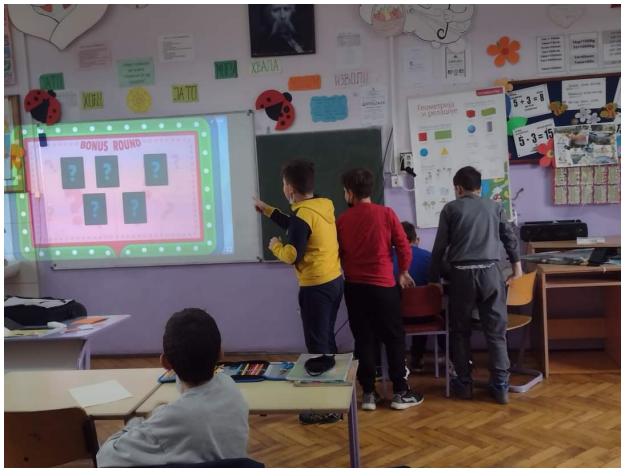
Keywords: *escape rooms; ICT; cross disciplinary; innovative teaching methods; gamification.*

1. INTRODUCTION

Students are keen on using educational games in classes because it reminds them of their favourite fun which is playing computer games. Interactive boards in the classroom make them feel like playing games on their smartphones so they find it rather interesting. Web-based tools like Kahoot, Educaplay or Nearpod are popular with students at elementary school because they get a pin code from the teacher and play on their phones.



There are a lot of templates for different types of exercises, not only quizzes. With Pro Profs for example you can create word search, crosswords puzzles, hangman, a jigsaw and many others. The biggest advantage of these activities is you can use them in classes but you can share them with students for additional exercises.



Mastery of specialized programming skills is not a requirement for using digital tools in teaching. The web is a wellspring of information that can be very useful if used in the right way. There are numerous websites with content already adapted to students' needs that can be modified further to be implemented in your classroom. For those who desire to use their imagination and create their own educational resources, there is a wide range of options available [1].

The most popular among my students are breakout games or escape rooms.

1.1. Escape room in English classes

Most escape rooms are purely recreational; however, educational escape rooms are becoming more popular with professional programs to involve students in their learning environment, and encourage collaboration and the development of social skills [2]. The results of recent studies show that games and the use of escape rooms have been effective in involving students in the learning process and helping them retain information [3]. Why are escape rooms so popular with students and teachers worldwide?

Game-based learning can involve students in a learning activity, thus achieving high levels of commitment (concentration, interest, and enjoyment). This can be accomplished by increasing the levels of challenges and skills during the game [4]. Ensuring the game is a challenge, therefore, is an especially strong predictor of learning outcomes. The motivation to undertake challenging tasks is related to the classroom flow. Flow is defined as a state of total immersion and fusion of action and consciousness [5], and is associated with positive emotional, motivational, and cognitive experiences [6].

When students have to work in a team and solve puzzles or riddles together they introduce new language knowledge in an unobtrusive way, and even when they make a mistake they will remember that clue. An escape room is a challenge and it makes them solve the problem so they can move forward to the next level. It is enjoyable not only for students but for teachers also.

A teacher's job is to find the appropriate web-based tool and fill in the templates with English language content. Those teachers who are creative can make a leap forward and create cross-disciplinary classes with other colleagues using escape games, making the game more challenging and interesting.

Problem-solving and critical thinking can be highlighted among the skills that can be developed with the use of escape rooms in the classroom. Critical thinking consists of being able to understand thoughts, make sense of ideas, and make logical decisions [7]. The escape rooms pose different challenges and tasks that make students question and evaluate their ideas, and solve problems. Escape rooms can generate intrinsic motivation in the players. Other advantages include favouring learning, improving attitudes and social skills, and involving students with the subject and teamwork [8,9].

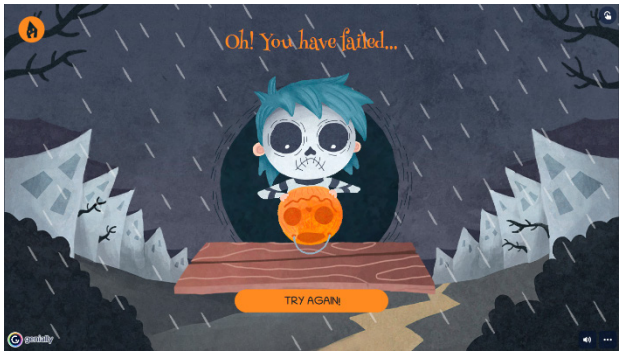
1.2. Escape room in practice

Guided by idea to create some new and innovative content for the students I created the first escape room with the Halloween theme. It was a revision class and a preparation for the test. I chose a Halloween background because it was the end of October. Students were astonished, they liked this game so much that we had to play it a few times. Though the most important is the fact they all took part in playing it, the team spirit was at a high level and they really enjoyed it while they were studying.

Background themes are various and teachers should pay attention to students' ages and interests but there is no doubt that escape rooms can be adjusted to all types of classes and subjects. There are numerous examples of good practice but I would like to highlight some of them, that our students liked the most.

Holiday themes are popular with all ages of students, especially Christmas holidays, everyone looks forward to decorating a Christmas tree. In one of the escape room quizzes the final award for students was to decorate the Christmas tree, students had to solve difficult grammar riddles before they reach the end, but that was even more challenging.

According to the popularity of escape rooms in the real world, I choose topics and missions. Students find interesting in saving missions, breaking out the codes of safes with some secret documents, helping solve environmental problems etc.



Using games makes classes motivating not only for students but for teachers also.

2. STE(A)M IN LANGUAGE TEACHING

Although it may seem to be inappropriate in the disciplines such as native and foreign languages provide fertile ground for STE(A)M-based teaching. Language teaching material, especially different texts are suitable for applying an interdisciplinary approach. In the course of the text analysis, students are instructed to engage in research and project-based activities and to incorporate the results of their research into the digital setting, finding ways to make the task they completed useful to others too. Web-based tools are adapted to students' needs and therefore are very user-friendly, allowing them to learn about digital presentations and design at the same time. All these tools are built for teamwork and collaborative editing enabling students to share content, work together and support one another during distance learning sessions. Analyzing texts belonging to the domain of literature and art develops students' critical thinking and teaches them to put forward their opinion and critically assess the value of a literary work. They then use the arguments acquired through research to justify their point of view. It is possible to make the first steps in the field of programming as part of this process by using microbit computers. When organizing student debates (one of the means of teaching that is quite successful in stimulating the development of students' critical), introducing microbit as value button (I do/don't like it, you are/ are not right, you do/don't follow the rules…) comes in very handy [10].

3. CONCLUSION

The use of gamification and playful strategies improves motivational learning because it allows students to experience and discover while practising skills and learning in a playful manner [11]. Other benefits of using escape rooms may be as a potential avenue for co-workers, classmates, or friends to explore and improve their collaborative skills, socialize with others, and develop team morale [12]. Collaborative learning is an effective approach to improving student outcomes. These tasks allow small groups of students to collaborate and share perspectives, discuss points of disagreement, question and understand the points of view of others, solve complex problems, and reach agreements [13]. Using escape rooms improves development of STE(A)M skills as we already mentioned and enhances the level of student interest in classes since these teaching aids are closely related to their everyday needs. This is how students are no longer simply passive participants. Instead, they become creators of the educational content and the teaching process as well. The emphasis is placed on achieving gender equality in the rural setting thereby ensuring a higher level of participation of girls in STE(A)M disciplines that used to be regarded as largely male-dominated! Innovative digital activities and the application of SEL make the inclusion of children belonging to vulnerable social groups easier [1].

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Digital Resilience and Psychological Wellbeing of Italian Higher Education Students: An Exploratory Study

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Abstract: *Covid-19 pandemic has increased the use of technology in the educational field. While previous literature has demonstrated the benefits of using technology in educational environments, the risks related to problematic digital behaviors have been less investigated. Digital resilience represents a protective factor for students' learning outcomes and emotional wellbeing. The main aim of this study was to explore Italian university students' digital resilience levels and their psychological wellbeing in terms of stress and psychological resilience. 94 students (F=57.4%) aged 19-57 (M=31.11, SD=9.04) completed an ad-hoc questionnaire on digital resilience which included the Perceived Stress Scale, the KOP-26, and the Brief Resilience Scale. Descriptive statistics, item analysis, and bivariate correlations were performed. Results showed that Italian students reported higher levels of stress (M=21.53, SD=6.92) than the Italian normative sample. In addition to this, they perceived good levels of both psychological and digital resilience: they reported being aware of potential strategies for preparing for and responding to cyber threats and how to face negative online experiences. These results could usefully inform interventions aimed at helping them to recognize and manage risks and threats when online.*

Keywords: *digital resilience; digital safety; psychological resilience; stress; higher education;*

1. INTRODUCTION

Since the beginning of 2020, the Covid-19 pandemic has increased the use of technology in different fields, including the educational one. While the benefit of using technology in educational environments are clear, less attention has been paid to identifying the risks related to students' problematic digital behaviors such as digital burnout, mental health distress related to digital failures, or negative online interactions in terms of cyberbullying and cybercrime [1]. Research has shown that the increased use of technology has led to a sudden surge in the levels of perceived webinar fatigue, technology-use anxiety, and digital burnout [2] due to the changes in work and learning imposed by lockdown and social distancing measures. In addition to this, spending more time online has increased the risk of coming across issues [1]. Interestingly, previous studies have shown that higher education students adopt a positive attitude and behaviors to cope with these negative outcomes, showing new forms of resilience in digital environments [1, 3].

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According to Eri and colleagues [3] digital resilience can be defined as the ability of students to overcome technological difficulties and continue with online learning while adapting to changes in higher educational contexts. Literature has shown a positive relationship between digital resilience and digital literacy, identifying digital literacy as a potential predictive factor of individual online resilience [4,5]. However, while digital literacy refers to the effective and ethical understanding and use of technologies, digital resilience is more related to *"the capacities of accessing, using, understanding, and spreading effective digital sources and common manipulative techniques, in particular, behavioral and attitudinal change aspects"* [1]. Specifically, according to the theoretical model developed by Sun and colleagues [1] digital resilience has five main attributes: understanding when you may be at risk online, knowing what to do to seek help, learning knowledge and skills from experience, being able to recover from stress and moving forward through self-efficacy in challenges.

1.1. Antecedents and Consequences of Cyber Resilience

Research has also identified several antecedents and consequences related to digital resilience that

can help to have a better understanding of this phenomenon [6]. With regard to the antecedents, it is possible to identify deviant use of technology, digital burnout, webinar fatigue [7], and external factors such as environmental facilities and barriers [3], national and international policies [8], and institutional and non-institutional support [9]. Moreover, individual factors such as digital literacy [10], self-control [11], self-efficacy [4], and self-esteem [9] could also impact digital resilience [1]. Considering consequences, instead, good levels of digital resilience can influence, on the one hand, students' learning performance. For example, students showing higher levels of digital resilience use social media more effectively [10] and get better achievements while overcoming stressful situations [3]. On the other hand, higher levels of digital resilience have been found to foster students' psychosocial functioning and a positive lifestyle adjustment [11]. For example, digital resilience has been demonstrated to moderate mental fatigue related to social and academic isolation [3].

1.2. The Current Study

In light of these findings, the main aims of this exploratory study were to (a) analyze the digital resilience levels of Italian higher education students and (b) their psychological functioning in terms of stress and psychological resilience. Previous literature has shown that during the Covid-19 pandemic Italian university students reported high levels of stress that significantly decreased their learning processes and negatively affected their psychological wellbeing [12]. In contrast, resilience skills resulted as a protective factor in overcoming difficulties in learning [12]. For this reason, we hypothesized that our students would report high levels of perceived stress and good levels of psychological resilience and that a negative association would occur between these two variables. Instead, concerning digital resilience, no previous studies have been conducted on the Italian population yet. Thus, we proceeded with explorative analyses.

2. METHODS

2.1. Participants and Procedure

Ninety-four university students (F=57.4%) aged 19 to 57 (M=31.11, SD=9.04) completed an online questionnaire in June 2022. Socio-demographic characteristics of the sample are reported in Table 1.

Table 1. *Socio-demographic characteristics of the sample*

Variables	n(%)
Gender	
Male	40 (42.6%)
Female	54 (57.4%)
Other	
Level of study	
Bachelor	27 (28.7%)
Master	46 (48.9%)
PhD	21 (22.3%)
Year of study	
1	52 (55.3%)
2	22 (23.4%)
3	14 (14.9%)
4	1 (1.1%)
5	2 (2.1%)
Field of study	
Business	5 (5.3%)
Humanities	9 (9.6%)
Natural and applied sciences	49 (52.1%)
Social sciences	31 (33%)
Studying in hometown	
Yes	63 (67%)
No	31 (33%)
Mode of study	
Full-time	78 (83%)
Part-time	16 (17%)
Worker	
Yes	61 (64.9%)
No	33 (35.1%)

2.2. Measures

The online survey was composed of the following questionnaires:

(a) A questionnaire created specifically for this study investigating students' digital safety in terms of digital resilience (12 items) and students' negative online experiences (9 items);

(b) The Perceived Stress Scale [13,14] measures individual perceived stress levels. It is composed of 10 items measured on a 5-point Likert scale (from 0=never to 4=very often) and Cronbach alpha for this sample was .88;

(c) KOP-26 [15] and the Brief Resilience Scale [BRS; 16] were used to measure students' perceived resilience. KOP-26 was composed of 26 items measured on a 5-point Likert scale (from 1=strongly disagree to 5=strongly agree) and Cronbach alpha for this sample was .93. BRS was composed of 6 items measured on a 5-point Likert scale (from 1=strongly disagree to 5=strongly agree) and Cronbach alpha for this sample was .75.

2.3. Statistical Analyses

Descriptive statistics in terms of means, standard deviations, frequencies, and percentages have been provided for socio-demographic data. Item analysis (means, standard deviation, frequencies, and percentages), total scores and scores for subscales (as means and standard deviations), and internal reliability (Cronbach's alpha) have been reported for each questionnaire. In addition to this, for each scale a chi-square test or t-test, or ANOVA (according to the type of data) have been performed to verify possible differences among participants in terms of sex, age, and course of study. Only significant comparisons have been reported in the tables. For the Perceived Stress Scale, Italian normative data have been found.
Thus, a z-test was used to compare our sample with the normative one. Finally, Pearson's *r* bivariate correlations have been performed to analyze possible associations between stress and resilience.

3. RESULTS

3.1. Cyber Resilience and Negative Online Experiences

Overall, the results from the item analysis showed that most respondents are aware of potential strategies for preparing for and responding to cyber threats (Table 2). For example, 51.1% of users set the privacy control of their social network and 84% regularly update their devices. In addition to this, 48.9% of students always get informed in detail about the application they are going to install on their device, and they reported that their account has never been hacked (86.2%), they have never been victims of a money transfer fraud or scam on the Internet (91.5%) and they have never replied to an email unrevealing their personal data (98.9%). The weakest areas seemed to be related to password management, backup of data, and reaction to web browser warning messages. No differences in terms of sex, age, and course of study have been found.
With regard to students' perceived negative online experience (Table 3) most of them reported being often exposed to content that shows people being a target of aggressive attacks or being insulted (36.2%). In addition to this, 79% reported making an effort to avoid content perceived as uncomfortable. After a negative online experience, the majority of students blocked people (76.6%), increased privacy settings (44.7%) or reported someone to a social media company or another organization (51.1%). When students were asked about their previous online negative experiences, most reported that they do not feel angry, afraid, helpless or powerless (51.1%), that they did not feel left out or lost some of their friends (68.1%) or that their reputation was not damaged (74.5%).

Table 2. *Digital Resilience*

Item	n(%)
How do you use your password?	
For most systems, I use distinct, strong passwords	26 (27.7%)
For important systems, I use distinct, strong passwords, and for non-important, I use	34 (36.2%)
simple passwords	
For important systems, I use distinct, strong passwords, and for non-important, I use	23 (24.5%)
simple passwords	
I use the same, strong password for most systems	3 (3.2%)
I use weak but different passwords for most systems I use the same weak password	
for most systems	8 (8.5%)
How do you manage your password?	
I use password manager software	14 (14.9%)
I keep the passwords in a secured file	20 (21.3%)
I keep the passwords in a plain file	5 (5.3%)
I keep the passwords on a paper	22 (23.4%)
I remember the passwords (memorize them)	33 (35.1%)
Did you set the privacy control of your social network accounts?	
I set it on all platforms I use	48 (51.1%)
I set it for some platforms and left it on default on other	32 (34%)
I left the default settings on all the platforms I use	7 (7.4%)
I am not sure	3 (3.2%)
I do not use social networks	4 (4.3%)
Windows	
I use Windows and I have an antivirus program installed on my computer	55 (58,5%)
I use Windows and I am not sure if I have an antivirus program installed on my	18 (19,1%)
computer	6 (6,4%)
I use Windows and do not have an antivirus program installed on my computer	14 (14,9%)
I do not use Windows	1 (1,1%)
Other ex. VPN	
Do you regularly install updates to your device	
No	10 (10,6%)
Yes	79 (84,0%)
I am not sure	5 (5,3%)
Ho often do you create copies of your most important data (backup)	
Once a week	14 (14,9%)
Once a month	15 (16,0%)
Once in a few months	34 (36,2%)
Once a year	16 (17,0%)
I do not back up my data	15 (16,0%)

Do you use cloud platform to back up your important data		
No	31 (33 %)	
Yes	63 (67%)	
Please describe how you react if your web browser prompts a warning message		
I think that the warnings are serious and do not proceed with further activities	36 (38,3%)	
I carefully proceed with the activity	46 (48,9%)	
I ignore the warnings since these are mostly false alarms and I proceed to thedesired content	12 (12,8%)	
Application		
I always get informed in detail about the application I am about to install on my	46 (48,9%)	
device	25 (26,6%)	
I just briefly get informed about the application I am about to install on my device	18 (19,1%)	
I just install the application I need, without spending time getting informed about itI don't think about it because my cell phone is protected by antivirus app	5 (5,3%)	
	No n(%)	**Yes n(%)**
Has your account ever been hacked and has anyone ever accessed yourpersonal information	81 (86,2%)	13 (13,8%)
Have you ever been a victim of a money transfer fraud or scam on theInternet	86 (91,5%)	8 (8,5%)
Have you ever replied to an e-mail and revealed your personal dataabout your PIN code, bank account number, ID number	93 (98,9%)	1 (1,1%)

On the contrary, they believed they have become more aware of online risks (44.7%), learned how to use the internet in a more balanced way (42.6%), developed a greater understanding of their behaviors online (47.9%), and became more able to overcome problems experienced online (50.9%). No differences in terms of sex, age, and course of study have been found.

3.2. Stress and Resilience

The mean level of perceived stress reported by our students is 21.53 (SD=6.92), with a significant difference between males (M=19.6; SD=7.64) and females (M=22; SD=6.01; t=2.389(92), *p*=.019). Comparing our sample with the Italian normative one, we found significant differences between them. According to sex and age, our students perceived higher stress levels than the general Italian population (Table 4).

The main results showed that the youngest students and students attending Bachelor's courses reported lower levels of resilience than older students or students attending Master's and PhD courses. In addition, according to the t-test analysis, male students perceived higher levels of resilience (on the Brief resilience Scale) than female students (Table 5).

Table 3. *Negative Online Experiences*

Have you experienced various unpleasant or violent online content, and whether you watch similar content or read messages about such content?	**Mean (SD)**
I have been insulted or called names on social networks or other online communication channels before	0.54 (.94)
It has happened before that someone spread rumors about me on social networks	0.48 (.90)
I have been threatened on social networks, through e-mails, and other similar online ways of communication	0.28 (.72)
Someone has posted embarrassing photos or video content of me online	0.28 (.78)
I have been blocked/ignored by others on social networks, in chat messages, or group text messages	0.81 (1.03)
It often happens that I read certain content or see video clips/footage which show another person being a target of aggressive attacks or being insulted, etc	1.80 (1.24)
Do you make an effort to avoid online content that you perceive as uncomfortable, for example aggressive, sad or scary content?	1.96 (1.03)
After an online negative experience, the students...	**N (%)**
Blocked people (including 'unfriending')	72 (76.6%)
Increased my privacy settings	42 (44.7%)
Set up my account so that it does not automatically include my location on my posts	20 (21.3%)
Deleted comments that I had made	9 (9.6%)
Changed my filter preferences	13 (13.8%)
Deleted comments that others had made on my profile	13 (13.8%)
Removed my name from photos that I had been tagged	19 (20.2%)
Reported someone to the social media company or another organization	48 (51.1%)
Reported someone to my friends	14 (14.9%)
Reported someone to my parents	6 (6.4%)
None of these	7 (7.4%)

In relation to previous negative online experiences...	**M (SD)**
I did not feel good about myself	1.15 (1.59)
I felt angry, afraid, helpless, powerless	1.35 (1.67)
I felt left out/I lost some of my friends	.83 (1.41)
My reputation was damaged	.66 (1.33)
I didn't feel close to my family and/or friends	.51 (1.08)
I became more aware of online risks	2.62 (1.89)
I became more aware of who my real friends are	2.16 (1.95)
I learnt to use the internet in a more balanced way	2.60 (1.76)
I developed a greater understanding of my own behavior online	2.68 (1.88)
I became more able to overcome problems that I experienced online	2.85 (1.78)

Table 4. *Stress*

	M (SD)	**Normative Italian Sample M (SD)**	**z-test**
Total	21.53 (6.92)		
Sex (n)			
Female (54)	22 (6.01)	16.3 (5.5)	Z=7.35; *p* <.000; d=1.00
Male (40)	19.6 (7.64)	15.2 (6.1)	Z=5.27; *p* <.000; d=.83
Age (n)			
≤30 (56)	23.00 (7.13)	15.9 (6.3)	Z=8.73; *p* <.000; d=1.16
31-40 (23)	19.56 (7.42)	15.4 (5.4)	Z=4.79; *p* <.000; d=1.00
41-50 (12)	18.75 (3.38)	14.4 (6.4)	Z=4.79; *p* <.000; d=1.00
≥51 (3)	20.33 (1.52)	16.7 (5.4)	Z=1.04; *p* = .298; d=.600

Bivariate correlations performed to explore possible associations between students' perceived stress and resilience showed a negative relationship between variables (Table 6): in our sample higher levels of resilience resulted associated with lower levels of perceived stress.

4. DISCUSSIONS AND CONCLUSIONS

The results of this study bring out interesting aspects about the digital resilience and psychological wellbeing of Italian higher education students. First of all, our students reported high levels of digital resilience. These data are in line with previous studies from other countries. For example, Erin and colleagues [3] found that university students in Australia and Asia showed good abilities in facing problems around online learning during the Covid-19 pandemic through perseverance and collaboration and most of them felt to be extremely confident or confident in using digital technology.

Table 5. *Resilience*

	M (SD)	**t-tes/ANOVA**
KOP-26 Personal competencies	37.36 (4.79)	
Family Relations	46.54 (7.97)	
Age (n)		
≤30 (56)	44.75(8.92)	F=2.823, *p*=.043 Post-hoc LSD ≤30 Vs 31-40
31-40 (23)	49.91(5.45)	
41-50 (12)	47.33(5.19)	
≥51 (3)	51(6.02)	
Course of Study (n)		
Bachelor (27)	43.11 (9.17)	F=3.721 *p*=.028 Post-hoc LSD: Bachelor vs Master Bachelor vs PhD
Master (46)	47.84 (7.46)	
PhD (21)	48.09 (6.20)	
Social competencies	20.84 (4.77)	
Age (n)		
≤30 (56)	19.77(4.85)	F=3.079,*p*=.031 Post-hoc LSD: ≤30 Vs ≥51
31-40 (23)	21.91(4.88)	
41-50 (12)	22.58(2.87)	
≥51 (3)	25.67(2.52)	
Total	104.74 (14.87)	
Age (n)		
≤30 (56)	101.16(15.75)	F=3.225, *p*=.026 Post-hoc LSD: ≤30 Vs 31-40
31-40 (23)	110(12.86)	
41-50 (12)	108.17(9.34)	
≥51 (3)	117.67(12.74)	
BRIEF RESILIENCE SCALE	3.22 (.68)	
Sex (n)		
Male (40)	3.42 (0.75)	t(92) = -2,470, *p*=.015
Female (54)	3.08 (0.58)	
Course of Study (n)		
Bachelor (27)	3.06 (0.49)	F=3.851 *p* =.025 Post-hoc LSD: Bachelor Vs PhD Master Vs PhD
Master (46)	3.16 (0.74)	
PhD (21)	3.56 (0.66)	

Table 6. *Bivariate correlations between perceived stress and resilience*

	KOP_TOT	**Brief Resilience Scale**
Perceived Stress	-,402**	-,458**

Note. **. Correlation is significant at the 0.01 level (2-tailed).

Specifically, our students reported being able to recognize the risks or threats online and to make informed decisions about the digital environment that they are in [7-9]. In addition to this, they seemed to know what to do to seek help, considering pros and cons and using critical thinking, even during challenging situations [8,10]. Finally, with regard to negative online experiences, they declared to have learned knowledge and skills from their past experiences and to be able to adapt their future choices where possible [10]. According to literature, these are all main attributes of a good level of digital resilience [1].

Concerning psychological wellbeing, our students reported higher levels of distress than the Italian normative sample. In line with previous research [12,17], after the Covid-19 pandemic, the frequency of distress in university students increased. Especially in Italy, one of the countries most affected by the pandemic, the teaching methods that changed suddenly and the social distancing with professors and classmates have contributed to the increase in students' perceived stress. However, despite this red flag that universities should take into account to promote students' wellbeing [3], our students reported good levels of resilience. Approximately 63 percent of them, indeed, acknowledged that they bounce back quickly after hard times. As previous studies demonstrated, psychological resilience plays an important role in reducing negative feelings while facing difficult situations in higher educational settings [3, 18], such as study fatigue and stress [19].

Considering the results from the current study, and in line with previous studies [1,3], we may speculate that despite the higher perceived stress levels of our students, they were able to adjust to the changes that occurred in higher educational environments imposed by the Covid-19 pandemic, showing good levels of digital and psychological resilience. According to literature, it may be that their knowledge and experience with digital technology could have fostered their resilience, helping them maintain good academic performances and psychosocial adjustment [3, 20].

In conclusion, the results that emerged from our explorative study could usually inform interventions aimed at promoting awareness of the role of digital resilience in education settings as a protective factor for students' learning outcomes and psychosocial adjustment.

The current study presents several limitations that call for careful interpretation of the results while suggesting new perspectives for further research. First, the sample size precluded us from conducting more sophisticated analyses such as the evaluation of predictive effects. Future research with a sample large enough to test a causal model may bring to light a far more complex picture of the relationship between digital resilience, stress and psychological resilience. Furthermore, our study was cross-sectional in nature, limiting the strength of the inferences that may be drawn from our findings. Finally, future studies should explore the role of other variables in promoting digital resilience, and consequently, students' psychosocial adjustment, such as institutional and interpersonal perceived support.

Despite these limitations and to the best of our knowledge, this is the first study investigating digital resilience skills in Italian higher education students.

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Perceived stress, cyber and psychological resilience among Polish students – preliminary results

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Abstract: *One of the many efforts by governments to decrease disease during COVID-19 pandemic was reducing social contact and distance learning. In the long run, these decisions had ramifications beyond the risk of contracting the virus. Young people studying at universities have been deprived of contacts with their peers and forced to efficiently use technology for the purpose of acquiring knowledge. It required the ability to maintain or regain mental health despite experiencing difficulties that is called "resilience". The main aim of this paper is to present the results of quantitative analysis of the perceived stress, cyber and psychological resilience of Polish students. The analyses show that majority of students use digital devices in an informed and safe manner while most of them presented high levels of stress and rather low or medium resilience, which may raise questions about the positive adaptation of students to remote learning and coping with pandemic situations in general.*

Keywords: *cyber resilience; perceived stress; psychological resilience; students; Poland*

1. INTRODUCTION

The COVID-19 pandemic not only results in a global deterioration of physical health, but also poses a serious threat to mental health [1,2]. In order to limit the spread of a highly contagious disease, millions of people around the world have been forced to socially and physically distance themselves. Closing schools to limit face-to-face learning and teaching has a huge impact on students around the world, seriously affecting their daily functioning, disrupting the normal course of psychosocial development, resulting for example fear of year loss [3]. When faced with remote teaching, both students and lecturers face numerous technical and psychological challenges and difficulties, which had been highlighted even before the pandemic began [4]. Although online learning is one of the promising alternatives to traditional teaching and can allow the development of many digital skills, many students view it negatively [3]. Poor impacts of remote learning can result from technological, personal, families, institutional and communities obstacles [5,6].

A concept that helps to address the question of why some students do well under the conditions of the pandemic and the digitalisation forced by it, while others develop negative effects is resilience. The term is generally considered to refer to positive adaptation as well as the ability to maintain or regain mental health despite experiencing difficulties [7].

As everyday activity of modern man has moved into cyberspace (during the pandemic it was mainly conducted online in many areas), the term of "resilience" is referring to psychological as well as digital skills. Initially cyber resilience was related to information systems in conjunction with risk management processes and was understood as the ability to adapt to changing conditions and prepare for, withstand, and rapidly recover from disruption [8]. Thereafter, the nature of this term was shifted to the man. Pointing out human skills it includes many different behaviours to protect people and their organization from computer security threats [9].

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Those observations and reflections prompted the researchers from three countries – Serbia, Italy and Poland – to take action addressing the problem of the growing need for psycho-social support in times of crisis by enhancing digital and psychological resilience through peer networking in the online environment. They have created the project that aims to build capacities, readiness and procedures to empower students to enhance their digital and psychological resilience. One of the first steps in that direction was to identify and analyse students' psycho-social needs and difficulties in the distance education environment in times of crises, as well as students' perception of university support for their psychological resilience and wellbeing. For those purposes, the project team prepared the questionnaire consisting of questions and statements on digital and psychological resilience, and conducted the survey in three countries. In this chapter, we present an excerpt from the research results concerning the cyber and psychological resilience as well as the perceived stress, obtained on the Polish students studying at Kazimierz Wielki University.

The main aim of this paper is to analyse activity of students in cyberspace in the context of their self-protection and to present the results of quantitative analysis of the perceived stress, psychological resilience of young people measured by original questionnaire as well as three scales: Perceived Stress Scale, KOP-26 and Brief Resilience Scale.

2. MATERIALS AND METHODS

2.1. Participants and procedure

The survey was conducted in June 2022 among Polish students studying at Kazimierz Wielki University (Bydgoszcz, Poland). The sample consisted of 311 students (194 females, 62) from Bachelor (77%) and Master (23%), aged 18-52 years (average age 22,97y ± 4,49). Most of the participants were full-time students (86%) and studied outside their hometown (67%).

2.2. Methods

Perceived stress

The Perceived Stress Scale (PSS-10) [10] was used to evaluate the intensity of perceived stress during the previous month. The responses for 10 items are given on a five-point Likert-type scale. General result is calculated after reversing positive items' scores and then summing up all scores. The total range from 0 (no stress) to 40 points (extreme stress). The reliability of the Polish version was α=0.86 [11]. In our study it was 0.85.

Cyber resilience

There is no single authoritative definition for cyber resilience, also the scale of measuring this ability does not exist. Therefore, the project team developed its own set of cyber resilience theorems based on a literature review. In the publications devoted to this topic we can find some good practices or cyber hygiene behaviour, such as using strong passwords and responding adequately to incidents, that help to become more cyber resilient [12]. In others, there are presented and analysed the tips for protecting users in cyberspace and building digital wellbeing [13]. In our survey, we have created the section dealing with statements and questions related to cyber-resilience understanding as the ability to continuously deliver the intended outcome despite adverse cyber events [14]. The section consisted of 12 questions and statements referring to using and managing passwords to network accounts, privacy control, using antivirus program, installing updates and new applications, making data backup, reacting on the warning messages and experience in danger situations online (like hacking or scam). For each question the respondents could choose one of the answers describing possible behaviour in particular situation.

Psychological resilience

Resilience was checked using two questionnaires: the KOP-26 [15] and Brief Resilience Scale [16] translated into Polish. The questionnaire KOP-26 include 26 items with five-point Likert-type scale. The sum of points for all statements determines the overall score. In addition, the questionnaire makes it possible to determine three aspects: Personal competences (9 items), Family relations (11 items) and Social competences (6 items). The reliability of the original version of questionnaire (Cronbach's alphas was 0.80-0.91) and in our study (0.86-0.94) was satisfying.

The Brief Resilience Scale [16] consists of six items. The answers are given on five-point Likert-type scale. Total score is calculated as a mean of the six items (after reversing three negative items). In original study Internal consistency was good (Cronbach's alpha ranging from 0.80–0.91).

2.3. Statistical analyses

Descriptive statistics in terms of means, standard deviations, frequencies and percentages have been provided for socio-demographic data. Item analysis (means, standard deviation, frequencies and percentages), total scores and scores for subscales (as means and standard deviations), and internal reliability (Cronbach's alpha) have been reported for each questionnaire.

For the Perceived Stress Scale, the results obtained were related to the norms for the Polish population, allowing three groups to be defined according to the level of stress (low, medium, high). Temporary norms for KOP-26 [15] allowed comparison for the averages obtained by the students in our survey.

3. RESULTS

3.1. Perceived stress

Considering the last month before the survey, most of the students (69%) declared high level of stress (Tab. 1). In our measurement, Cronbach's alpha for the PSS-10 was 0.85.

Table 1. *Results of PSS-10 scale*

Level of stress	n	%
High	214	68.81
Average	85	27.33
Low	12	3.86

3.2. Cyber resilience

To recognize the cyber resilience of the respondents, we have analysed the answers of the respondents on the questions referring to their activity in the cyberspace. In general, we can evaluate that the majority of studied students use digital devices in an informed and safe manner. 57% of respondents rather use strong passwords (13% for every system and 44% for most systems) and another 33% do so at important systems.

Regarding privacy control of social network accounts, 50% of students set privacy control of social network accounts, another 40% set it for some platforms and left it on default on other.

In the context of regular updates and viruses protection, above 64% use antivirus program installed on their computer and 76% regularly install updates to their device (computer, cell phone). Also 76% of respondents use a cloud platform to back up their important data (like Google Drive or One Drive).

When asking about the reaction on web browser prompting a warning message (such as "this site may not be safe", "this link is blacklisted", "this file may contain dangerous data"), 84% answered that they are careful when warning messages appear (48% think that the warnings are serious and do not proceed with further activities and 36% carefully proceed with the activity; only 16,4% ignore the warnings since these are mostly false alarms and I proceed to the desired content).

The students are not so careful when they install new applications but still majority of them get informed before installing – 27,6% always get informed in detail about the application they are about to install on their device and 44% just briefly get informed. 20% of them declare that they just install the application they need, without spending time getting informed about it.

Students' weakest points relate to relying primarily on their memory to store passwords (53%) and making backups less than once a month (72%). When managing passwords, most of them (53%) remember it; 18,4% keep the passwords on paper; 16,5% use password manager software; 7,4% keep the passwords in a secured file and 5% keep the passwords in a plain file. 30% of students do not back up their data and only 12% do it once a week.

For internet abusing we have asked three questions: Has your account ever been hacked, and has anyone ever accessed your personal information (through e-mail or social network account)? Have you ever been a victim of a money transfer fraud or scam on the Internet? Have you ever replied to an e-mail and revealed your personal data about your PIN code, bank account number, ID number etc.? In each of them the great majority of students did not recognize themselves as victims of such situations. Figure 1 illustrates the results of those answers.

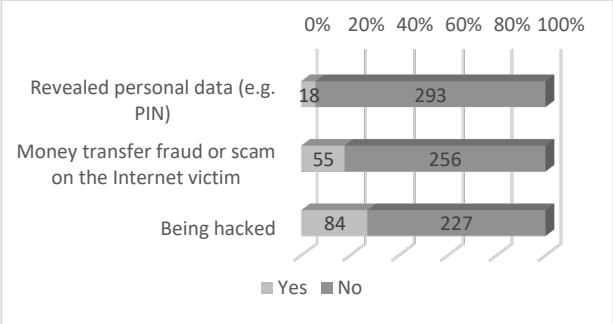

Figure 1. *Internet abuse.*

3.3. Psychological resilience

The obtained results of KOP-26 questionnaire (Tab. 2) were compared to the temporary norms for students given by the authors of the questionnaire [15]. All means for subscales take values for the 30th percentile, however the general score is slightly below this rate, which indicates that the students as a group are on the edge of low and medium resilience. In this study, the internal consistency coefficients (Cronbach's alpha) of the subscales and total was found to be between 0.86-0.94.

Table 2. *Results of KOP-26 questionnaire*

Resilience scale	M	SD	α
General result	94.25	19.64	0.94
Personal Competences	32.68	7.51	0.86
Family Relations	43.59	9.44	0.93
Social Competences	17.97	6.07	0.88

The mean of the Brief Resilience Scale was 2.88 ± 0.86 (range = 1–5). Cronbach's alpha for the BRS was 0.82. Comparing our results with means for the samples studied to validate the BRS by Smith et al. [16] we found significant differences between them ($p<0.001$). Our students declared lower resilience than the participants in prior studies [16].

4. CONCLUSION

The presented results of the analysis provide the knowledge about the perceived stress, cyber and psychological resilience of young people. During COVID-19 pandemic most of universities conducted e-learning or blended learning, requiring students to use cyberspace efficiently and reducing social contacts, which were limited in the period of a large number of infections. Recognition of their cyber and psychological resilience is one of the goals of the project leading to enhancing those skills through peer networking in the online environment in times of crises.

Regarding cyber resilience we may conclude that the majority of studied students use digital devices in an informed and safe manner. The most often frequently practiced activity in cyberspace is using passwords to network accounts, privacy control, using antivirus program, installing updates and reacting on the warning messages. Generally, they are not involved in danger online situation as well. Their weakest points relate to managing passwords and making backups.

Most students presented high levels of stress. It is worth considering to what extent the period of examinations/sessions in which the measurements were conducted influenced the results obtained.

It can also be concluded that the students characterise rather low or medium resilience, which may raise questions about the positive adaptation of students to remote learning and coping with pandemic situations in general.

Those conclusions will be useful for development of training programs for providing horizontal (peer) support to students related to mental health and digital resilience, in an informed and confidential manner.

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University students' resilience and perceived difficulties during the Covid-19 pandemic: a pilot study in Serbia

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Abstract: *Attending university is a stressful life period due to various factors and since the beginning of 2020 coping with the pandemic in many different aspects of life has been an additional challenge for students. Research on resilience, a personality characteristic that enables coping with different stressors successfully, is on the rise. Therefore, the main goal of this paper is to examine the resilience of university students as well as to gain insights into students' perceptions of difficulties they experienced during the pandemic period. The sample comprised of 180 university students from 18 to 49 years old (M=22.82, SD=4.72), from different faculties of the University of Kragujevac, Serbia. Female students constituted a majority in this sample with 74.4%, and 80% of participants were bachelor students. The results show that students currently display a medium level of stress and resilience, with female students reporting higher levels of perceived stress (t(178)=2.42, p<0.01), whereas male students reported higher levels of resilience (t(178)=2.10, p<0.05). The correlation between resilience and perceived stress was negative and strong (r=-0.51, p<0.001). Students did not report high levels of experienced obstacles during the pandemic, and they were troubled the most by their emotions and general mood, studying and preparing for exams, and communicating and hanging out with friends.*

Keywords: *university students; psychological resilience; perceived stress; Covid-19.*

1. INTRODUCTION

The health, well-being and employability of university students are key considerations within higher education and in response, interest in student resilience is on the rise [1]. Attending university is usually a stressful period in students' lives due to various of reasons. Since the beginning of 2020 when COVID-19 has been declared as a global pandemic [2], coping with pandemic can be added to that list of challenges. The COVID-19 brought about a lot of challenges for education process and all parties involved, and particular attention was given to the educational process itself, usage of information technology in teaching and learning, and the way in which students were coping [3]. Some of the studies on COVID-19 effects on mental health provide suggestions for improvement of protective factors, one of which being resilience [4]. Resilience, a personality characteristic that moderates the negative effects of stress and promotes adaptation, has been associated with increased psychological well-being [5]. For this reason, it is important to study the ways in which this characteristic is connected with stressful reactions in student population.

In this paper insights on university students' resilience will be analyzed through previous research review, and empirical findings on resilience and perceived difficulties during Covid-19 pandemic of students at University of Kragujevac will be presented.

2. RESILIENCE AND STUDENT WELLBEING DURING COVID-19 PANDEMIC

2.1. Psychological resilience and student well-being

There are diverse definitions of resilience one of which describes resilience as a set of traits, an outcome, or a dynamic process that involves exposure to stress or adversity, followed by successful adaptation [5]. One of the best-known definitions describes resilience as an "ability to cope

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with difficulties and recover from stress" [6]. A resilient person is ready for positive adaptation and functioning despite prolonged exposure to stressors and disadvantages [7]. Hence resilience is "one's ability to manage stressors and maintain adaptive functioning across all domains of life" [7].

Globally, stress is a well-recognized feature of the life of undergraduate students [8]. Attending university is a particularly stressful time for students due to unique emergent stressors such as changes of the environment, loss or diminishment of social support networks, academic pressures, development of peer relationships, and financial management [5]. Resilience and stress go hand-in-hand and managing different stressors successfully becomes the fingerprint of resilience. The intertwined relation between stress and resilience is best described in this quote: "*Resilience is nurtured, developed, and mobilized in times of stress"* [9].

Although some of the first approaches conceived resilience as a personal trait, recent studies show that resilience is more of a process than a personality trait and that the dynamic and that developmental process involves skills that can be learned [10].

Previous research indicates that a successful adjustment to university is not only related to resilience, but is also the result of modifiable psycho-social factors including peer connectedness, feelings of belonging to the university and perceived social support [11].

2.2. Students' coping during the COVID-19 pandemic

There are numerous studies on students' stress and coping during the COVID-19 pandemic. The ongoing COVID-19 pandemic can be characterized as a universal and chronic stressor affecting people worldwide and across all sections of society [12], students being one of the important populations affected by it.

In a study that investigated stress, anxiety, depression and coping strategies during the COVID-19 pandemic, it was determined that mental health problems were particularly present in participants who were 20-30 years old, single, and university educated [13]; and it appears that besides the general concern regarding COVID-19, these groups were worried about their career and job prospects. A longitudinal cohort study was conducted in the UK, in which the participants (university students) completed an online survey twice before the pandemic, and twice during the UK ''lockdown''. The findings showed that the pandemic had a negative impact on the university students' mental health [14]. During the "lockdown" mental well-being and physical activity of the UK students decreased, while the perceived stress and the time spent sedentarily increased. A positive association was found between the perceived stress and sedentary behaviour.

Jordan students were also suffering from several challenges during the lockdown, mainly the feeling of anxiety, not having a device to attend the online classes, not having a separate room to study at home, and Internet connectivity issues [15]. The vast majority of the surveyed students have never attended online courses before the pandemic and almost half of the surveyed students have spent less time studying than the time spent studying before the pandemic.

Research from Indonesia reveals some insights into the advantages and constraints of online learning that their students perceived during the early stages of the pandemic [16]: comfortable educational environment, time utilization and smooth interaction being identified as the main advantage, while the most frequent complaint was network instability, unilateral interaction and reduced concentration. Despite some very positive online learning experiences, most students in Ireland still prefer in-class learning and feel that the social aspect and the learning benefits from face-to-face interaction with instructors and peers are not fully replicable in the online learning environment [17].

In research on stress and academic functioning of almost a thousand Croatian students [18], four groups of stress sources have been identified: the consequences of isolation represent the strongest stress source, followed by academic stress, the possibility of infection, and family sources of stress. Females experience all sources of stress more intensely than males, and students who changed their residence experience family problems and the consequences of isolation more stressfully than students who live continuously in their families [18].

Research on university students' challenges during the pandemic in Serbia, which was more oriented towards the online learning process, provides some significant findings as well [19]. There are reports of motivation difficulties, with the majority of students reporting a dip in motivation to learn at the beginning of the pandemic in comparison to non-pandemic circumstances [19]. Other research concludes that the effects of online learning are mostly positive, emphasizing that students perceive that the biggest advantage of online teaching is saving time and money, while the biggest disadvantage was a lack of practical work and direct communication [20]. In addition, distance learning is most stressful to those students who think that this type of learning is going to reflect negatively on their exam passing rate and enrollment in the following academic year [20].

In researching stress, anxiety and depression levels of University of Belgrade students, the following data emerged [21]: the results showed that anxiety

and stress were more common in female respondents, while depression was more common in male respondents; the respondents from undergraduate academic studies are more prone to anxious, depressive and stressful manifestation than students of master studies, while depression and stress are significantly present in respondents from doctoral studies than respondents from undergraduate and master studies; students from the field of Social Sciences and Humanities are more prone to anxious manifestation, while depression and stress are approximately equally present in all education areas.

3. RESEARCH

The main goal of this paper is to examine the resilience of university students in Serbia as well as to gain insights into students' perceptions of difficulties they experienced during the pandemic period.

Research question 1: What is the level of resilience and perceived stress among students of the University of Kragujevac?

Research question 2: Is there a correlation between resilience and perceived stress among students of the University of Kragujevac?

Research question 3: Does resilience and perceived stress levels vary regarding socio-demographic characteristics such as sex, age, level of study, study field and studying away from home?

Research question 4: In which area of life did students struggle the most during the pandemic?

Data was collected in June 2022 through an online Google forms questionnaire as a part of wider research on the digital and psychological resilience of the students at the University of Kragujevac within the Erasmus+ project "Enhancing digital and psychological resilience through peer networking in the online environment in times of crises". Informed consent was obtained from all students included in the study and their anonymity was preserved.

The research instrument presented in this paper consists of two psychological scales (Brief Resilience Scale and Perceived Stress Scale), data on participants' sex, age, the level of study, the field of study, etc. and questions on psychological needs or obstacles that students may have experienced, especially during the pandemic.

- BRS – The Brief Resilience Scale [6] was developed to assess the construct of resilience and it consists of six items with a five-point scale (from 1 - low resilience to 5 - high resilience). The metric characteristics of the BRS are confirmed in different populations and different languages [22-24]. In our study, the scale showed satisfactory internal consistency (α=0.80). The level of resilience can be classified into three categories: low resilience 1.00-2.99; medium resilience 3.00-4.30; high resilience 4.31-5.00 [25].
- PSS – Perceived Stress Scale [26] is a self-reported measure of the degree to which situations in an individual's life are appraised as stressful [27]. It consists of 10 items with five-point scale (from 1 = never to 5 = very often). A higher score indicates higher stress. The PSS-10 has demonstrated adequate metric characteristics that were also evaluated for different populations and different languages [27]. In our study, the Cronbach alpha was 0.72.

Participants/sample: The sample comprised of 180 university students from 18 to 49 years old (M=22.82, SD=4.72), from different faculties of the University of Kragujevac, Serbia. 80% of participants are bachelor's students, 11% master's and 9% PhD students. Female students constituted a majority in this sample with 74.4%. The majority of the participants study in the field of social sciences and humanities (37%), followed by medical disciplines (25%) IT (22%), engineering, natural sciences and technology (15%). 38.3% of participants study in their hometown, while 61.7% study in other cities and towns outside of their hometown.

Statistical analyses included basic descriptive statistical analyses, Pearson's correlation coefficient, t-test and ANOVA analyses. SPSS 21 was used for the statistical analyses.

4. RESULTS AND DISCUSSION

The mean level of perceived stress reported by our students is 21.18 (SD=5.99), and the scores did not significantly deviate from the normal distribution (Table 1). This finding suggests that overall students currently display a medium level of stress (distress) and it calls for further research. Opposite of what was expected considering the timing of data collection (June is traditionally a month of exams in Serbia), that did not influence the levels of stress perception to go higher to a greater extent.

The average score on the Brief Resilience scale indicates a medium resilience level in students (Table 1).

Table 1. *University students' resilience and perceived stress*

	M	**SD**	**Sk**	**Ku**
Perceived Stress Scale	21.18	5.986	-0.02	-0.15
Brief Resilience Scale	3.02	0.748	0.18	-0.27

Sk – skewness, Ku - kurtosis

As expected, the correlation between resilience and perceived stress was negative and strong (r=-0.51, p<0.001), meaning that higher resilience is associated with a decrease in stress perception.

This is in accordance with other research that also confirmed the correlation between resilience and perceived stress [28-30].

In comparing how different subgroups of the participants perceive stress and their resilience ANOVA and t-test were conducted. Female students reported higher levels of perceived stress (M_f=21.72, M_m=19.29, t(178)=2.42, p<0.01), and male students higher levels of resilience (M_f=2.95, M_m=3.21, t(178)=2.10, p<0.05). Other demographic features neither showed significant differences nor correlation with scores on these two scales.

These findings are in accordance with previous research (both during the pandemics and before) that found statistically significant differences in levels of resilience based on students' gender, with male students showing higher resilience levels than did female students [28,31]. Moreover, the majority of these studies did not find differences in relation to other demographic characteristics [28,32].

Lastly, students were asked to give an overall assessment of the potential difficulties they've experienced since the beginning of the pandemic (Table 2). In contrast to BRS and PSS, where they responded by assessing their current state, this following group of questions refers to an integral assessment of students' difficulties during the pandemic period.

Table 2. *University students' experienced obstacles during the pandemic*

	M	SD	Sk	Ku
Attending courses	1.82	1.379	0.14	-1.18
Studying and exam preparation	2.04	1.365	-0.07	-1.20
Communication and relationships with lecturers	1.77	1.341	0.13	-1.24
Communication and relationships with colleagues	1.69	1.346	0.30	-1.06
Communication and hanging out with friends	1.94	1.456	0.07	-1.34
Communication and relationships with family members	1.28	1.414	0.71	-0.85
Love relationship with partner	1.17	1.380	0.82	-0.72
Emotions and general mood	2.16	1.369	-0.10	-1.18
Physical health	1.76	1.331	0.19	-1.13

Students did not report high levels of experienced obstacles during the pandemic, most of their assessments are medium to low (mean values are between 2 and 1, on a 0-4 scale). Students were troubled the most by their emotions and general mood (M=2.16), studying and preparing for exams (M=2.04) and communicating and hanging out with friends (M=1.94). They report the least difficulties in communication and relationships with family members (M=1.28) and in romantic relationships (M=1.17). Concerns about attending courses, communication and relationships with colleagues and their physical health issues were also low. Younger students reported more difficulties with attending courses (r=-0.22, p<0.01), studying and exam preparation (r=-0.16, p<0.05). Female students reported more difficulties with emotions and general mood than males (t(177)=-2.92, p<0.01).

5. CONCLUSION

This study showed that in mid-2022 students of the University of Kragujevac displayed medium levels of resilience and perceived stress, and they did not report high levels of experienced obstacles during a pandemic. After more than two years of life in the pandemic circumstances' and with the current situation in Serbia regarding the pandemic being under control, it is somewhat not surprising to have these findings. However, this conclusion is not too informative for future practical recommendations. Making the student sample more representative and also tracking levels of perceived stress and resilience through longitudinal research could provide insights into stress and resilience fluctuations within the student population. Moreover, research on retrospective reflection of coping in different stages of pandemic and what contributed to their overall adaptation in a given situation or time period, could provide relevant data for understanding protective factors and risk factors in different stages of pandemic/crises situation.

Finally, some specific gender differences in stress perception and resilience levels, as well as age differences in perceived difficulties during the pandemic, call for further research validation on a more representative student sample. If confirmed, these findings could serve as a basis for guidelines in creating some practical support or training programs.

In terms of study limitations, we should emphasize that the research was conducted using self-evaluation questionnaires which somewhat limit the reliability of the obtained data. Moreover, it is a cross-sectional study, and, some of our results are retrospective in nature.

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University students' well-being during emergency remote teaching: reflections from the viewpoint of the Self-determination theory

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Abstract: *The aim of this paper is to provide an overview of research findings on different qualities of emergency remote teaching (ERT) and interpret their implications for student well-being from the perspective of the Self-determination theory (SDT). The analysis of research findings suggests that students' well-being and success in online learning were compromised, and that the teaching/learning practice during ERT could not provide adequate support to students' basic needs for autonomy, competence, and relatedness. The observation that student well-being was not a priority while implementing ERT was not surprising for several reasons: the primary objective of ERT was to ensure the continuation of education; the switch from regular classroom settings to an online environment was rapid and hasty; teachers were faced with numerous challenges while rapidly adapting to new conditions and ways of working, communication and exchange, new tools and resources, and they lacked competencies and experience in teaching with digital technologies.*

Keywords: *student well-being; Self-determination theory; emergency remote teaching*

1. INTRODUCTION

It's been more than two years since the COVID-19 breakout, and we still talk about the consequences of the pandemic and the shift towards living, working, teaching and learning in a digital environment. After many published papers on COVID-19 experiences and responses, a new kind of research that reaches beyond the pandemic has emerged. In this new kind of research, the pandemic experience is transformed from an object of research to an intrinsic part of the new theories, approaches, and research methodologies [1], along with the lessons learned, recommendations for accepting the "new normal" and the transformation of the "grey areas" in education.

We have all witnessed or experienced the transformation of education due to the rapid spread of the pandemic. This was well documented by UNESCO [2] who thoroughly monitored and reported on the closure of educational institutions. Instead of just closing educational institutions, the pandemic triggered a global experimentation with remote teaching [3]. In order to ensure the continuation of teaching and learning [4-6], the higher education institutions were transformed by switching their teaching/learning practice from the traditional classroom setting to the online environment [7, 8].

This transformation of higher education was rapid and hasty and resulted in what is now often referred to as emergency online education [8] or emergency remote teaching [9]. Emergency remote teaching (ERT) represents a temporary shift in the delivery of teaching to an alternative mode of delivery, caused by crisis circumstances (like pandemics, wars, or natural disasters) [9]. It usually involves the use of fully remote teaching solutions for education which was primarily intended to be delivered face-to-face or as blended in regular circumstances. The main characteristic of ERT is that it is planned and executed rapidly, including urgent redesigns of courses originally developed for the traditional classroom setting. The main objective of ERT was to ensure the continuation of education by providing temporary and remote access to teaching and teaching support, and not to recreate a solid education system.

This "new normal" led teachers and students in an "unfamiliar terrain" [10], presenting them with a challenge to adapt to new conditions and ways of working, communication and exchange, and new tools and resources. Teachers had to be adaptable, flexible and creative enough to improvise and innovate on the spot and rapidly switch their regular teaching practice to an online environment. They were faced with numerous challenges from redesigning courses originally conceived for

teaching in traditional classrooms, to adapting teaching and learning materials and activities, and providing students with support for learning in a digital environment.

All these challenges, combined with the lack of competencies and experience in teaching with digital technologies led to the transmissive nature of the teaching practice during the pandemic, so that motivation and students' engagement, as well as their interaction with the teacher and other students, did not reach the desired quality [11]. This opened the question if, in rushing to implement ERT, the student well-being was disregarded.

In this paper, we focus on university students' well-being during ERT. We aim to provide an overview of research findings on different qualities of ERT and interpret their implications for student well-being from the perspective of the *Self-determination theory* (SDT) as a macro-theory of human motivation which deals with the factors that either facilitate or hinder the assimilative and growth-oriented processes in people [12]. According to SDT, fulfilment of the basic psychological needs – needs for competence, autonomy, and relatedness – represents the core condition for personal growth, social development, and psychological well-being [13].

2. WHAT IS STUDENT WELL-BEING AND WHY IS IT IMPORTANT?

Well-being is one of those concepts that is understood in different ways and that has no single definition as there is no consensus about it among scholars from various fields that study well-being, such as: health, psychology, education, social care, economy etc. The most cited first definition in many academic papers is the one from the Oxford English Dictionary, where well-being is defined as a state of being comfortable, healthy, or happy. Even though this definition is often qualified as simplistic, most of the definitions of well-being indeed refer to: the presence of positive emotions (e.g., contentment, happiness), absence of negative emotions and psychological states (such as depression, anxiety), satisfaction with life, fulfilment, positive functioning [14-17], self-esteem, self-determination, resilience, quality of life, good mood, good mental health, and healthy lifestyle [14, 18-20]. In general, common modern-day definitions of well-being focus on a state of balance that can be affected by life events and challenges. Therefore, well-being is "when individuals have the psychological, social and physical resources they need to meet a particular psychological, social and/or physical challenge" [21]. With that in mind, we could state that student well-being encompasses positive emotions and individual's inner capacity to cope with the challenges of day-to-day academic life [22].

Studies show that students with low levels of well-being are more likely to suffer from stress, depression, and anxiety [23, 24]. On the other hand, several meta-analyses show that students who have a greater sense of well-being tend to have higher motivation, increased self-confidence, higher levels of engagement and academic achievement [23, 25-27]. In that light, we could expect that universities that show dedication to student well-being will be able to prevent drop-out and have higher graduation rates [28, 29].

Studies on university students' well-being during the Covid-19 pandemic in many countries, such as Australia, Brazil, China, Germany, Malaysia, Mexico, Romania, Spain, Switzerland etc., found that many students showed signs of depression and anxiety [18, 30-45]. This was likely caused not only by concerns related to health and economic issues, but also by reduced social interactions, disruptions in teaching/learning process, and potential effects that those disruptions and pandemic in general will have on their educational outcomes and opportunities in the labour market [31, 34, 37, 38, 41, 42]. For that matter, it could be valuable to reflect on student well-wellbeing during the pandemic in the light of the quality of ERT.

3. THE QUALITY OF THE EMERGENCY REMOTE TEACHING AND STUDENT WELL-BEING

Studies show that both teachers and students were not fully satisfied with the quality of ERT [11, 46-49]. To our knowledge, there are no specific studies that link university students' sense of well-being during the pandemic to different qualities of ERT. Therefore, we will discuss findings from different studies with university teachers and students on the quality of ERT from the perspective of SDT and its implications for student motivation and well-being.

SDT anticipates three main types of motivation: amotivation, extrinsic motivation, and intrinsic motivation. When intrinsically motivated, people engage in activities that interest them, and they do so freely and driven by curiosity, pleasure or enjoyment of the task [50, 51]. At the other extreme, amotivation (non-regulation; a lack of motivation) results in action without real intent or absence of any action. In the middle is extrinsic motivation. Extrinsically motivated behaviours are instrumental in nature – people perform activities for the sake of rewards or to avoid punishment, to fulfil an obligation, etc. In SDT, it is argued that extrinsic motivation can be self-determined, i.e., there are different types of extrinsically motivated behaviours or regulatory styles, which differ in the extent to which they represent self-determined versus controlled responding – external, introjected, identified, and integrated form of regulation. The transition from external to

integrated regulation requires that values and goals become internalized (personally important) and integrated, i.e., fully assimilated into one's sense of self [50, 51]. These processes are facilitated by the fulfilment of three basic psychosocial needs: *competence*, *autonomy,* and *relatedness*. Therefore, in the next chapters we will discuss how were these students' needs supported during ERT.

3.1. Competence

A need for competence relates to the feeling of mastery, a sense that one can succeed and grow. For example, students' need for competence is satisfied when they feel able to meet the requirements and challenges of their studies. This need is best satisfied within well-structured environments that afford optimal challenges, positive feedback, and opportunities for growth [12].

In various studies on the qualities of ERT, students singled out the poor learning atmosphere as one of the main challenges [52], and reported that teaching methods were monotonous and not enough engaging [47, 48, 53, 54], that learning resources were poorly designed and unattractive [46-49], and that they were overloaded with learning contents and assignments [30, 54, 55]. Students also reported problems related to delayed feedback from teachers [52]. University teachers reported that teaching/learning activities during ERT were mostly of a transmissive nature, such as lectures via video conference calls, and that they were not satisfied with the quality of students' motivation and engagement, student-teacher interactions and interactions between students [11, 56]. Namely, as ERT came as a sudden change, many teachers lacked both competencies and time to plan and organize online teaching/learning in a more interactive manner. Therefore, from the perspective of SDT, we could argue that the described pedagogical practice during ERT could not support students' need to feel competent, and as a result, led to a drop in students' learning motivation, their lower participation during classes and, in turn, neither students nor their teachers were satisfied with the quality of online teaching/learning provided during the pandemic.

In addition, studies show that many students had technical issues related to internet speed and the use of different technologies and online services [30, 46, 47, 49, 52, 54, 55,], which amplified their insecurity in shifting towards learning in an online mode. We could argue that even when students have sound digital competencies, technical difficulties could diminish their sense of competence, especially if students do not have prior experience in online learning [56].

3.2. Autonomy

Autonomy refers to a sense of initiative and ownership in one's actions and it is supported by experiences of interest and value; and undermined by external control by rewards or punishments [12]. Teachers who support students' autonomy attempt to understand and be responsive to students' perspectives, provide a meaningful rationale for the tasks that need to be done, provide students with meaningful choices and tasks that are in line with their interests, and provide opportunities for students to take ownership of their work [51].

Results of the study that measured autonomy supportive teacher behaviour on a scale with items such as "I provide the students with choices and options", show that the teachers' support was the lowest for the basic need for autonomy [58]. This could mean that, during ERT, students' perspectives and interests were neglected, and that they were not enough provided with meaningful choices.

It is well-known that online learning favours self-regulated learners who are able to plan, organize, and monitor their learning on their own [59-61]. Accordingly, success in online learning settings has been associated with students' self-regulated learning (SRL) skills in many studies [60, 62]. Some studies focused on online learning during ERT also found that students with higher self-efficacy in self-regulation had lower study related stress during the pandemic [63] and that students with better self-organization skills were found to have better learning gains [64]. Another study found that relatedness was positively associated with SRL, which emphasizes the importance of supporting students' SRL via developing social connections if we want to boost learning gains and student satisfaction in online learning [65]. SRL was also found to be positively related to students' tranquillity, hope, gratitude, and joy, while it was negatively related to loneliness and disinterest [35]. One study found that digital competence preserved university students' psychological well-being by helping them to manage cognitive load and academic burnout, as well as increasing their engagement during ERT [61].

All these findings suggest that SRL was indeed an important asset during ERT. However, if we keep in mind that many students were not used to learning in an online environment and lacked digital and/or SRL skills needed to manage their way through ERT [66], we could argue that for many students needs for autonomy and competence were not supported enough during the pandemic and, thus, their well-being and success in online learning were challenged. Students were often left to their already existing capacities to cope with the challenges of day-to-day academic life.

3.3. Relatedness

Relatedness in the SDT refers to a sense of belonging and connection. It is facilitated by the

conveyance of respect and caring. People tend to internalize and accept as their own the values and practices of those to whom they (want to) feel connected, and from contexts in which they experience a sense of belonging [12].

Low levels of student-teacher and student-student interactions were the most mentioned shortcomings of ERT by both students [48, 53, 57] and university teachers [11, 57, 67]. In addition, studies show that, during ERT, students were spending less time studying together compared to the time before the pandemic [34]. Some studies focused on examining the perceptions of belonging in teachers and students during ERT. It was found that the sense of belonging is reduced in both teachers and students, who felt that being physically present on campus mattered in terms of belonging [67].

There are also studies that measured the teachers' supportive behaviour towards the basic needs for competence, relatedness, and autonomy, both from the teachers' and students' perspectives [58]. The results of this study show that teachers were relatively high in their need supportive behaviour, especially concerning the support of relatedness. The relatedness support was measured by self-reports on a scale with items such as "I encourage the students to work together". Students also reported that they felt supported by their teachers regarding their autonomy, competence, and relatedness during ERT. On the other hand, the supportive behaviour of teachers does not mean that students' need for relatedness was met, which was confirmed by some reports that much more interaction between students was expected than occurred [68].

In the light of SDT, we could interpret that students' need for relatedness was at risk the most during ERT, given that peer interactions and learning were not encouraged enough. This was supported by the study that examined if ERT could meet the basic students' learning needs, and found that online learning could meet the basic learning needs of autonomy and competence, but not relatedness [69] Therefore, it is understandable that many students decided to keep their cameras off and just consume the contents served by their teachers. We could argue that this had profound implications on how students perceived themselves as learners, but also on their group identity and cohesion. In such context, we could not expect that students would have positive emotions during learning, which is a core part of their well-being.

4. DISCUSSION AND RECOMMENDATIONS

Even though some studies acknowledged the teachers' supportive behaviour towards the basic needs for competence, relatedness, and autonomy, the analysis of research findings on different qualities of ERT shows that students' well-being and success in online learning were challenged. Research results suggest that the teaching/learning practice during ERT could not provide adequate support to students' basic needs for autonomy, competence, and relatedness, leaving students to their already existing capacities to cope with the challenges of online learning. This resulted in general dissatisfaction with the quality of online teaching/learning during the pandemic, a decrease in students' learning motivation, lower participation during classes and lower peer interactions and learning, which were not encouraged enough.

Therefore, we can provide a positive answer to the question opened in the introduction, if the student well-being was disregarded in rushing to implement ERT. However, this outcome was well expected, for several reasons. First, the primary objective of ERT was to ensure the continuation of education, and the switch from regular classroom settings to an online environment was rapid and hasty. Second, teachers were faced with numerous challenges while rapidly adapting to new conditions and ways of working, communication and exchange, and new tools and resources, all combined with the lack of competencies and experience in teaching with digital technologies. Taking all this into account, it is not surprising that student well-being was not a priority while implementing ERT.

The presented research findings can well be used for gathering recommendations for supporting student well-being in online teaching/learning. Improving the online teaching/learning experience is in line with the efforts to increase student motivation for learning, through the effective use of digital tools (*competence*), through *autonomy* in learning, and through active and interactive relationships between and among students and teachers (*relatedness*). In this process, the support that student receives from the teachers and the institution as a whole becomes important.

Interactions in the teaching/learning process are important. They help students learn, influence students' satisfaction and help students build their confidence in online academic life. That is why interactions should be the core for planning, designing and delivering teaching/learning in an online environment. Interactions in online teaching/learning should be direct, among students, and between students and teachers, with facial expressions and gestures. It is also important to create a sense of community and an online environment that emphasises the students' own contribution to the learning process.

Digital competence is essential for students to be successful in online learning, it empowers them to manage cognitive load, as well as their way through online learning experience. Participation in a digital learning environment which is well-structured with optimal challenges, positive feedback, and opportunities for growth leads to the improvement

of students' digital competence, and has benefits that go beyond subject matter learning objectives, and are critical for both personal and professional advancement following the demands of living and working in a digital world.

Along with that, different ways of expression and learning activities should be implemented in online teaching/learning, and as for learning materials and activities, they should be of proper difficulty levels that are congruent with students' cognitive levels, but also in line with students' interests. Teachers should be responsive to students' perspectives, and provide them with meaningful choices and opportunities for taking ownership and responsibility for their work. Teachers should also support SRL, by setting intermediate goals and giving timely feedback.

5. CONCLUSION

In our review of studies on different qualities of ERT, we found that students' well-being was not supported enough, given that there is no solid evidence that students' needs for autonomy, competence, and relatedness were fully met during online teaching/learning at universities. We could argue that, as continuation of education was the top priority in many countries, as well as keeping teachers and students healthy and safe, addressing psychosocial aspects of student well-being during ERT has been left out of focus. However, over time, it has become evident that both students and their teachers are not satisfied with the quality of online teaching/learning during the pandemic, and that there was a decrease in students' motivation and engagement. That is when questions related to student well-being started to rise.

Even though it might sound as a belated wisdom, the experience during ERT can provide many valuable lessons on how to support student well-being and successful online learning experience, given that many universities nowadays are still fully or partially organizing courses in an online mode. We should consider planning and delivering teaching/learning process that engages students and encourages interaction, students' agency, responsibility, flexibility, and choice. In addition, for a better quality of online learning experience, we would highlight the importance of using students' reactions and feedback for iteratively refining online teaching/learning practice.

Even though SDT was of great heuristic value for our review, further research on students' sense of well-being during ERT and on their perspective on teaching practices that support or hinder the fulfilment of their needs for autonomy, competence and relatedness are needed.

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Resilience of Higher Education Institutions in Serbia: A Student's Perspective

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Abstract: *The present study investigates the experiences of undergraduate students in pursuing their studies in the initial months of the COVID-19 pandemic. In this study, we use an exploratory descriptive approach through an online survey with a convenient sample of 467 undergraduate students. The results indicate that the students have experienced emergency remote education (ERE) as more demanding in comparison to the pre-pandemic face-to-face learning/teaching. Since the ERE has been largely dependent on the resources of learners and their families, it is important to highlight that 25.1% of students reported that none of the teachers showed interest in differences among students in their living and learning contexts, while 34.5% reported that none of the teachers individualized their teaching, accordingly. Recommendations are presented to build the resilience of higher education institutions in Serbia during future emergencies.*

Keywords: *resilience; higher education; COVID-19 pandemic; education in emergencies*

1. INTRODUCTION

In the face of disturbances, such as pandemics, natural disasters, wars, and social unrest, higher education (HE) has an important role to maintain academic quality and continuity. As Bartusevičienė et al. [1] emphasize, educational institutions have to be able to respond to a crisis and continue to provide uninterrupted services through adaptation and adjustment. In this context, resilience as a quality of being able to return quickly to a previously good condition after facing disruptions is becoming crucially important for HE institutions (HEIs).

One of such disturbances calling for resilient HEIs was the COVID-19 pandemic. The pandemic has imposed increased demands on HE and seriously shaken the established ways HEIs run their courses [2]. This process, emerging from a global context burdened with uncertainty and prosocial concerns and characterized by a rapid and unplanned shift towards remote education, is recognized in the literature as emergency remote education (ERE) [3]. Overview of the studies on the ERE shows that the main challenges are associated with lack of technical and material resources, lack of digital and pedagogical/learning skills, as well as lack of social interaction in learning/teaching process [4]. Consequently, the ERE is associated with increased stress, burnout and mental health problems for both teachers and learners [4].

The first recorded case of the coronavirus in Serbia occurred in early 2020. Following its rapid spread, the government announced restrictions with stringency increases as the COVID-19 virus spread. An expansion of government-imposed restrictions continued until May 2020, after which a first steps towards limited reopening were introduced. In the initial months of the pandemic, university classrooms and dorms were emptied. HEI's management have responded by moving academic and related activities online with a sense of urgency. Research indicates that for a majority of the HE teachers in Serbia online teaching was a novel task, i.e., they did not have the experience with online teaching prior to the ERE [5]. HE teachers have experienced a mismatch between available resources and support, and previous experiences with remote teaching practices and technologies, on the one hand, and demand for high quality online teaching/learning practices, on the other hand. However, how has the transition from in-class to remote education been experienced by HE students in Serbia remains under-researched.

1.1. Organizational Resilience

The concept of resilience regained attention following the COVID-19 pandemic. It has been used to describe individuals, organizations, and/or systems that are able to respond to and recover from threatening experiences with minimum disruption to their stability and functioning [6]. The authors focusing on a level of institution describe this feature as organizational resilience. If organizations are not sufficiently prepared to mitigate impacts and effectively respond to crises, it could have a negative impact on their members. For example, studies indicate the significant role for

the HEIs in providing resources to help students effectively cope with stress and mental health issues during the COVID-19 pandemic [7]. In the presence of adequate HE support, the effect of stress on development of psychological problems is reduced and may even be fully remedied.

Organizational resilience is defined as an organization's capability to anticipate possible risks, successfully cope with unexpected events, and learn and adapt to changing situations [8]. A crisis could trigger self-organizational process in organization and lead to organizational transformation. As Bento et al. [9] mentioned, the exploration of new possibilities is required for system and institution level adaptation. Often, innovation in teaching practices in HE is the outcome of emergent processes rather than planned design [9].

Based on the literature, organizational resilience is primarily built on knowledge, resource availability, social resources, and power-based relationships [1, 8]. More specifically, organizations with these attributes are likely to come out of crises more easily than those lacking in these factors [6].

The abovementioned suggests that resilience is not a one-time response to a specific event, but is rather an iterative process that requires pre- and post-event preparation, learning, and adaptation. Therefore, we would like to explore how have HE institutions in Serbia anticipated and coped during the pandemic. Moreover, we are interested to learn how HE institutions' adjustment and organizational transformation in the post-COVID era could be supported.

1.2. Aim of the Study

The COVID-19 pandemic could be considered a major disturbance, which will be part of the evolutionary history of educational institutions [8]. With a focus on the continuity and quality of HE during the COVID-19 pandemic, we aim to understand how the undergraduate students in Serbia have experienced the ERE, and to explore how sensitive HEIs have been to differences among students. We have considered important to approach the issue of HEIs' resilience from students' perspective, having in mind that the key indicators of organizational resilience could be recognized in students' experiences and outcomes.

Based on the findings, we will discuss how lessons learned from the experience of a sudden transition from face-to-face to online learning can be used to maintain academic continuity and build organizational resilience in the HE in Serbia.

2. METHOD

Due to the novelty of the phenomena, the study undertook an exploratory descriptive approach.

2.1. Participants

All study participants were HE students, actively enrolled in a study programme at universities throughout the Serbia. Of the participants who partook in the study, those who had successfully completed the survey were included in the dataset. The convenient sample included 467 undergraduate students enrolled at state universities in Belgrade (48.8%), Novi Sad (3.2%), Niš (6.0%), and Kragujevac (42.0%). In the present sample, 32.3% of the participants were in their first academic year, 22.5% were in their second year, 23.6% were in their third year, and 21.6% in their fourth year of undergraduate studies. Females represented a higher proportion (328; 70.2%) of the sample than males.

2.2. Data Collection

Across four state universities in Serbia, students were invited to complete the survey. The survey was disseminated online via Moodle survey tool during the first lockdown period – March to May 2020. Its' completion was in accordance with European guidelines on General Data Protection Regulation (GDPR). Participation in this study was voluntary and not part of a course requirement. Participants were required to give consent prior to proceeding.

The survey was designed to capture the wide range of experiences of higher education students during emergency remote education. The survey consisted of the following sections: demographic information, changes introduced in the learning process due to the COVID, experience of these changes in comparison to face-to-face learning and a role of HE teachers in the ERE. To examine the impact of COVID-19 on their learning experience, an initial open question asked students to compare their experiences with face-to-face and online learning.

2.3. Data Analysis

Descriptive statistical analysis of data was performed in order to generate an overview of the ERE experiences by students.

3. FINDINGS

The findings on the ERE from the students' perspective will be used to understand how have the HEIs in Serbia been anticipating and coping with the COVID-19 pandemic.

3.1. How was the ERE delivered?

Students were exposed to different modes of remote teaching during the ERE (Figure 1). The majority of students (376; 80.5%) reported that they had the opportunity to participate in all modes of remote teaching offered in the survey – recommendation of learning resources via email, publishing learning resources and additional learning materials on an online platform, providing

individualized instructions and consultations, and teaching using video conference platforms.

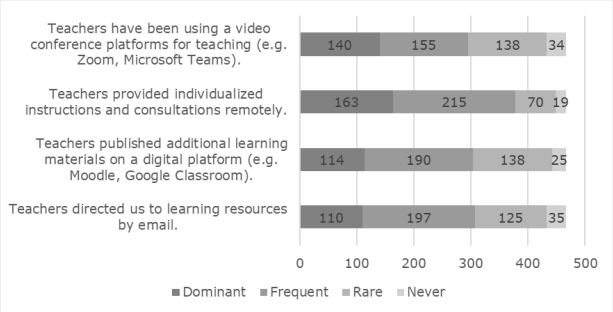

Figure 1. *Frequency of different modes of the ERE*.

Similar to the previous research [5], a significant number of students report that they were exposed to teacher-led unstructured learning activities, in which the main role of a teacher was to select and ensure relevant sources for learning. Pešikan et al. [4] interpret similar findings as a tendency of HE teachers to apply pre-COVID epistemological beliefs and practices to the COVID context, hindering in that way transformational process in HE.

Additionally, different modes of the ERE could indicate a sensitivity of HEIs to differences in students' living and learning contexts, teachers' competencies and resources, and teaching methodics of different subjects. However, it could also indicate lack of the common vision of the ERE goals within HEI, lack of coordination among HEI's staff and lack of support for these goals to become achieved at the level of HEI.

3.2. How have Students Experienced the ERE?

The students evaluated how demanding were different aspects of the learning in the ERE context in comparison to the face-to-face context. Fig. 2 shows that approximately 40% of students participating in the study, consistently recognize that the ERE context was more demanding regarding learning. The largest number of participants (46.4%) reported difficulties in ensuring optimal learning environment during this period. Namely, 48.5% participants that lived independently prior to the pandemic reported that they had to move back to the family homes.

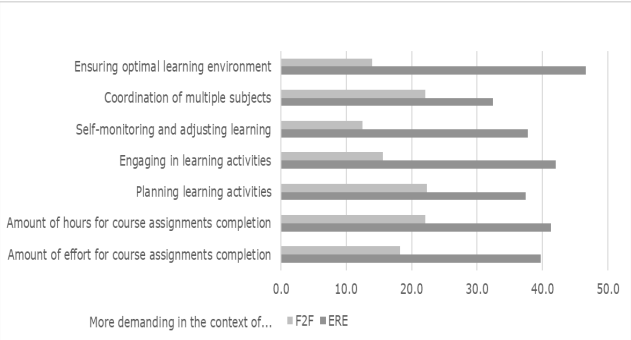

Figure 2. *Students' evaluation of learning in the ERE and face-to-face context*.

Moreover, the findings suggest that for a significant number of students (app. 40%) self-regulated skills, related to planning learning activities, managing time and tasks, self-monitoring and adjusting learning process, become even more important in distance learning than it was in traditional learning settings, which is aligned with previous studies. [10, 11]. All these changes in the context of the COVID-19 pandemic, had negative effect on students' capacity to regulate their motivation for learning: 20.2% of students retrospectively reported low motivation for learning prior to the pandemic, and this percentage increased to 48.4% during the ERE.

The findings warn that increased demand for self-regulation of students, could become a risk factor for students' learning motivation and performance, if it is coupled with the lack of HEIs' support.

3.3. How has the HE Teaching Adapted to the Changes in the Students' Lives and Learning?

A shift to a remote education introduced different considerations into planning process, such as having added uncertainties about available equipment and Internet access, learning about new types of technology and how to manage an online context, feelings of isolation and remoteness, all amidst personal circumstances and concerns about health and financial affairs [12]. The changes in the both living and learning context of students, required certain level of individualization of teaching and learning process. Therefore, it is important to highlight that the one quoter of participants in our study (25.1%) has no experience of teachers who showed interest in differences among students and their living/learning context, while 46.5% of students report that some teachers showed interest (Figure 3).

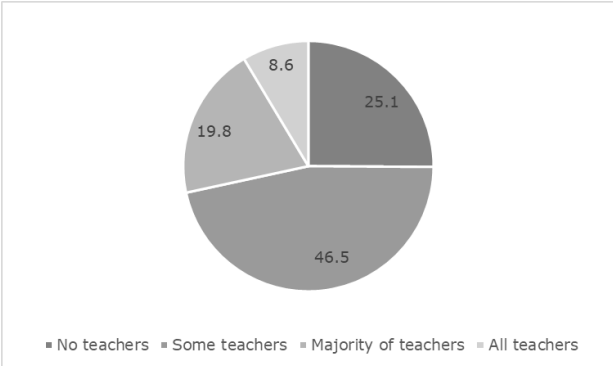

Figure 3. *Students' responses to the question "Teachers showed interest for differences among students and their living/learning context." (%)*

Beside acknowledging differences among students, HEIs and teaching staff were expected to make adjustments to the differences among students and

their living/learning context. One third of students (34.5%) report that none of the teachers adjusted teaching and learning to their individual strengths and needs, while 39.2% of students report that was the case for some teachers (Figure 4). In other words, only 7.9% of students reported that they were engaged in an individualized learning/teaching process, across the subjects.

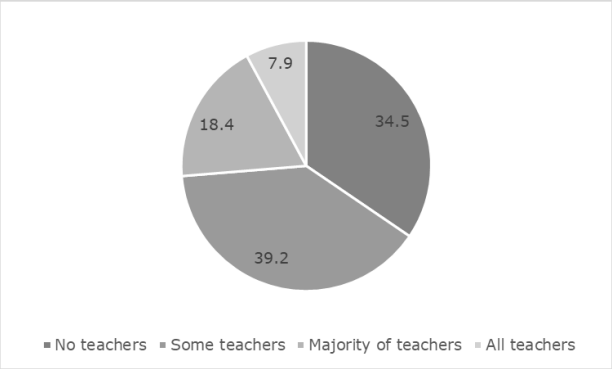

Figure 4. *Students' responses to the question "Teachers adjusted teaching and learning process to differences among students and their living/learning context." (%)*

4. DISCUSSION AND RECOMMENDATIONS

Resilient HEIs are capable to anticipate possible risks, successfully manage unexpected events, and adapt to changing situations [8]. Since our study took place during the first wave of the COVID-19 pandemic, we are interested in the ways HEIs in Serbia anticipated risks related to the ERE and how they have coped with it.

As Shaya et al. [6] described, anticipation in the context of a resilient organization is not limited to forecasting events (which may be impossible), but includes the concept of preparation: activities aimed at expanding knowledge and skills of staff, as well as improving availability and accessibility of scarce resources. The coping stage, on the other hand, is the process of devising and implementing solutions to a crisis [9]. This stage comprises accepting the evolving situation and the ability to seek a solution and put it into action [6]. Looking at our findings through the lens of organizational resilience is not resulting in an optimistic view.

The study shows that although the pandemic has imposed changes in different aspects of the learning process (e.g., learning environment, learning resources, learning activities), these were not commonly taken into account by HE teachers and institutions, highlighting the need for enacting pedagogy of care. A care approach to education pushes educators to recognize and address the diversity of students' experiences and vulnerabilities, allowing them to be more receptive not only to the assumed needs of students but also their individual needs [13]. This becomes particularly important in the context of emergency, since the usefulness of the existing support systems and established practices and habits is at risk.

The findings suggest that students have experienced the ERE as more demanding in comparison to face-to-face learning/teaching, indicating insufficient support from the HEIs in the process of transition from the 'normal' to the 'new normal'. While Covid-19 restrictions continue to demand online learning, student wellbeing, motivation for learning, and learning outcomes may be enhanced by increasing the availability of HE support services. Moreover, HEIs should aim for increasing knowledge on the pedagogical and psychological aspects of the ERE among the staff, providing resources relevant for participation in the ERE, support development of effective social network within institution, and challenging rigid and established roles and ways of knowledge construction [6].

In order to mitigate the COVID imposed challenges while also building a more resilient system that can withstand future crises, countries across the Europe have started developing national recovery and resilience plans, which include education as one of the target sectors [14].

In the case of Serbia, the first step would be to take a look back at educational experiences of different stakeholders during the pandemic. Reflection on the ERE experiences could help identifying knowledge gaps, limited resources, rigid structures of the educational systems, and underdeveloped parts of the social network. At the same time, it could help identifying innovative practices emerging from the ERE and potential resources for HE development.

Engagement of wide range of stakeholders, with the particular emphasis on students' engagement, is not important just at the data collection and systematization stage, but throughout the decision-making process related to the future interventions, its' implementation and monitoring. Stakeholder involvement provides an opportunity to deepen mutual understanding about the issues at hand, explore and integrate ideas together, generate new options and solutions that may not have been considered individually and ensure the long-term commitment to achieve mutual goals [15]. All of these issues are becoming increasingly important in the context of emergency, helping to avoid confusion regarding division of responsibilities, ineffective use of scarce resources and adverse outcomes at level of individuals, organizations and systems.

Designing recovery and resilience plan is a step towards (a) developing joint vision of short-term and long-term goals; (b) selecting relevant and effective measures in the light of available resources; (c) mapping roles and responsibilities of HEIs, the Ministry of Education and the

Government of Serbia; (d) monitoring progress in the process of education recovery. Moreover, it could be a step towards the intentional and planned long-term transformation of HE towards more resilient and more innovative HEIs.

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University Teachers' Resilience

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Abstract: *This research focuses on resilience and perceived stress as important components of university teachers' well-being. Resilience is generally conceptualized as a process and an outcome of successfully adapting to difficult / challenging life experiences and perceived stress as individual feelings or thoughts about the level of stress a person is experiencing at a given time period. In the context of the teaching profession and the current pandemic circumstances, we investigated university teachers' resilience and perceived stress. The Brief Resilience Scale and Perceived Stress Scale in digital format as Google Forms surveys are used in this study. The sample consisted of 100 university teaching staff (university teachers and university teaching assistants). The results show that the resilience of the university teaching staff is at a medium-high level. Perceived stress is low. The correlation between resilience and perceived stress of university teaching staff is negative and relatively high. University teaching assistants perceive more stressful situations and stress feelings than university teachers. There are no differences in resilience and perceived stress between university teaching staff from different educational and research fields. This study introduces new research topics and considerations in the contexts of teacher education and university activities aimed at enhancing university teaching staff resilience, stress management, and well-being.*

Keywords: *psychological resilience; perceived stress; teacher resilience; university teachers.*

1. INTRODUCTION

Educational policy in the last two decades has been based on the competency paradigm. Fostering the generic/transversal competencies is the focus of students' development. However, the question is what has happened with teachers' generic competencies and what is the impact of teachers' competencies in supporting the development of the same students' competencies? Some of the researchers ask the question: "Can the teacher teach what he/shehas notdeveloped in himself/herself?" [1]. Teachers' resilience is one of the competencies in focus, the same as conceptions and models of cultivating teachers' resilience [2]. At the end of the second decade of the XXI century, researchers recognized "the ability to maintain wellbeing and respond resiliently to professional challenges as a valuable teacher's capacity" [3]. At the same time, some researchers [4] emphasized teacher resilience as a necessary condition for their teaching effectiveness. Resilient teachers make an impact on students' academic resilience [5].

Positive psychology suggests that resilience and satisfaction of basic psychological needs contribute to predicting teachers' quality of teaching and professional engagement, and the optimal personal and professional development. Reflection of the teachers' psychological resilience on the students' community is important to resilient educational community development and to reduce students' stress [6]. Furthermore, we will consider resilient teachers as a supportive environment for the development of resilient students.

2. CONCEPTUALIZATION OF THE RESILIENCE

The construct of resilience is "dynamic, complex in nature, and conceptualized as multidimensional" [3, p. 2]. Some definitions of resilience are considered:

- resilience is "the capacity to overcome personal vulnerabilities and environmental stressors, to be able to bounce back in the face of potential risks, and to maintain well-being" [7, p. 189];
- resilience is "using energy productively to achieve school goals in the face of adverse conditions" [7, p. 189];
- resilience is the "capacity to continue to bounce back, to recover strengths or spirit quickly and efficiently in face of adversity" [7, p. 189];
- resilience is "a mode of interacting with events in the environment that is activated and nurtured in times of stress" [8, p. 58];
- resilience is "the capacity to "overcome odds" and demonstrate the personal strengths needed to cope with hardship or adversity [9, p. 43].

Although the definitions of resilience are diverse, most people consider resilience as the ability to bounce back from an adverse event or set of circumstances [10].

Although the first approaches to the conception of resilience conceived resilience as a personal trait, later research confirmed that human resilience is

an attribute that can be developed. Nowadays, researchers with an educational orientation think that "resilience is one's ability to manage stressors and maintain adaptive functioning across all domains of life" [11, p. 263].

Different models of resilience explain the connection between resilience and risk and stress situation [9]. In accordance with the compensatory model, resilience is a factor that neutralizes exposure to risk. The challenge model suggests that the stress factor is a potential enhancer of successful adaptation, and prepares the person for the following challenges. In accordance with the protective factor model, the interaction between protection and risk factors reduces the probability of a negative outcome and moderates the effect of exposure to risk.

Tait described a resilient person stating that a "person who demonstrates resilience is able to regulate his or her emotions and interact more effectively in social environments. Resilience is nurtured, developed, and mobilized in times of stress" [8, p. 72]. Stress is a part of everyday life, but people's perceptions of stress, especially distress, differ, as do how their perceptions of stress trigger their distress responses and how they influence the establishment and maintenance of resilience.

Some of the indicators of resilience are the following: able to show positive adaptation in the face of adversity; able to rebound; flexible; able to make and maintain supportive relationships; reflective; has problem-solving skills; able to plan; seeks to help; able to act independently; has goals; persistent; takes risks; optimistic; able to regulate his or her emotions and interact more effectively in social environments [8, p. 61, 72] and has a higher sense of control and internal locus of control [12]. A resilient person is ready for positive adaptation and "functioning despite prolonged exposure to stressors and disadvantages" [11]. Resilient people are aware of situations, their own emotional reactions, and the behavior of those around them [12]. Resilience behaviour involves the ability to recover and rebound from challenges and setbacks and to understand that life is full of challenges [12].

The most comprehensive definition and the most widely accepted in the expert professional community is the following statement of psychological resilience, according to the APA Dictionary [13]: "Resilience is the process and outcome of successfully adapting to difficult or challenging life experiences, especially through mental, emotional, and behavioral flexibility and adjustment to external and internal demands.

A number of factors contribute to how well people adapt to adversities, predominant among them:

- the ways in which individuals view and engage with the world;
- the availability and quality of social resources;
- specific coping strategies.

Psychological research demonstrates that the resources and skills associated with more positive adaptation (i.e., greater resilience) can be cultivated and practised" [10].

According to Brunetti (cited in [7, p. 8], teachers' resilience is "the quality that enables teachers to maintain their commitment to teaching and their teaching practices despite challenging conditions and recurring setbacks."

3. THE TEACHERS' RESILIENCE

"To teach, and to teach at one's best over time, has always required resilience" [4].

Maria Assunção Flores [14] concluded that "over the last fifteen years or so, resilience has emerged as a field of research, not only in countries that experience high rates of attrition, but also in contexts in which the teaching profession has gone through policy and social changing circumstances affecting its social and economic status [14. P. 169].

What is the role of resilience in teacher effectiveness? Gu & Day investigated this topic 15 years ago. They considered teaching as an emotional practice. And they understood teachers' resilience as a "multidimensional, socially constructed concept that is relative, dynamic, and developmental" [4]. The main findings are the following: "Teachers' capacity to manage such interactions is a sophisticated process which contributes strongly to the relative strength of their resilience."

Maria Platsidou and Athena Daniilidou [15] considered teachers' resilience processes, their adaptive behaviour, the feeling of well-being, and the meaning of life. The research "emphasized the important role of the presence of meaning in strengthening resilient responses; also, searching for meaning, when combined with a high sense of meaning, relates to better use of the resilience protective factors and resources."

The other researchers confirmed an important connection between the teachers' resilience with self-confidence [16], the highest level of well-being and job satisfactithe on, lowest level of burnothe ut, highest level of self-esteem, self-care, emotional intelligence and optimism, emotional intelligence [10], absence of mobbing [17], level of happiness [18], less depression, anxiety, and stress [19]; emotional intelligence (awareness of own emotions and others' emotions, expressiveness of own emotions effectively and controlling them, forming strong empathetic relationships with people). Although the concept of teacher resilience and teacher well-being are intertwining in the research and in the teacher's professional experience and doing, it is necessary to differentiate them [3]. Teachers' well-being is a

positive emotional state, which is the result of harmony between the sum of specific environmental factors on the one hand, and the personal needs and expectations of teachers on the other hand [9, p. 44].

Current research emphasizes that both individual and environmental factors are important for teacher resilience. There are some conceptions integrated as the "theory of teachers' resilience". In the comparison with the theory, Drew & Sosnowski [20] recognized that: resilient teachers are looking for support in their school communities; they embrace non-expected negative experiences as the useful experienced learning; they use relationships with teaching staff (teaching colleagues), students, and school principals to endure challenges and overcome stressful situations.

What contributes to the teacher's resilience? One of the issues considered the concept of "lived in resilience" (Fig. 1; [11]), and the other emphasized the importance of resilient culture, school resilient culture. etc.

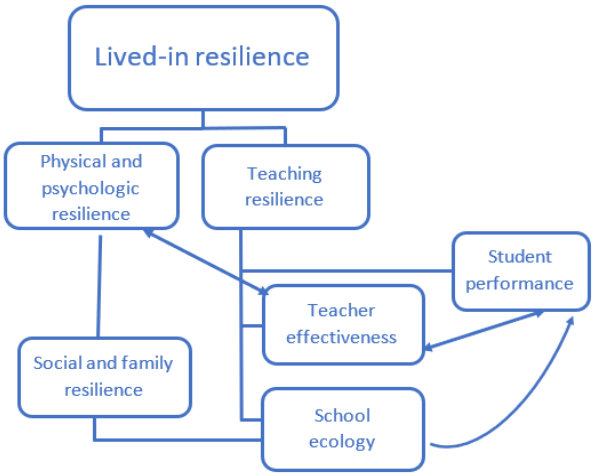

Figure 1. Resilience living framework for teachers (adapted according to [11, p. 272]

Teacher resilience "fluctuate[s] as a result of the influences of the personal, relational and organizational settings in which they work" [21, p. 1304]. Research on the resilience of teachers at different educational levels (from pre-primary education to higher education) considered the specificities of their resilience.

Relevant research of the resilience of teachers in different educational levels (from pre-primary education to higher education) considered the specificities of their resilience.

In the research on the protective factors associated with resiliency among teachers in elementary special education in Jakarta, two protective factors were discovered: self-compassion and self-esteem, which contribute 33.1% to resilience in the elementary special education [22].

Analysis of the data about associations among preschool teachers' positive emotions, negative emotions, psychological resilience, and work stress, realized with Taiwan preschool teachers [23] obtained the following conclusions: positive emotions raise preschool teachers' psychological resilience; negative emotions lower preschool teachers' psychological resilience; positive emotions lower preschool teachers' work stress; negative emotions increase preschool teachers' work stress, and positive emotions lower preschool teachers' work stress.

The research on teachers' resilience, teacher perceived stress, self-efficacy, and burnout of Greek primary school teachers confirmed associations between these variables and emphasized the importance of teachers' self-efficacy to predict their resilience as well as their burnout and stress, and that resilience predicts burnout and stress resilience [24].

In the research on resilience and occupational well-being of secondary education teachers in Greece, "teachers' resilience mean was found to be above average and at higher levels than it was reported in other recent research projects'' [9].

One of the research studies on university teachers' resilience, including stress, anguish, and anxiety as a consequence of the COVID-19 pandemic, realized in Latin America [25], showed that the stress of university teachers is high, anxiety is high too, resilience was manifested at a medium-high level, the emotional state of most participants is low, and their resilience response is medium-high.

According to the current approaches and social-ecological approach to resilience, resilience is a process which operates across the individual and their environment. University teaching staff and university students constitute a joint academic community and environment for their growth as individuals and as professionals.

Why is the university teaching staff important in the context of resilient educational settings? Why is the focus of this research on the university teaching staff?

What we know so far from various research is that in order for the teacher to direct a certain behavior, in this case, resilient behavior, it is necessary to develop and manifest the characteristics that should be promoted. Educational, research, management, and work settings at the university make university teachers' profession different from the other teaching professions. The profession of university teachers is also delicate in its dual nature: university teachers are expected to be both teachers and researchers and to meet the criteria of quality university teaching and the criteria of quality scientific production. In addition to all this being related to overall teacher resilience, the current working and living conditions are gravely modified by the pandemic in a time of social crisis, and in that context, teachers' resilience becomes of great importance.

4. RESEARCH METHODOLOGY

What is the incentive for this research? Resilience is mobilized in times of stress. Although the teaching profession is one of the more stressful professions, the direct incentive for this empirical research is the research on the digital and psychological resilience of the students at the University of Kragujevac developed as a part of the project "Enhancing digital and psychological resilience through peer networking in the online environment in times of crises" (DigiPsyRes [26]).

The main problem investigated in this empirical research is the university teaching staff's resilience and its correlation with perceived stress. The following research questions were selected:

- Are university teachers resilient?
- What are the differences between teaching university staff from different educational fields?
- Are there differences in the resilience and perceived stress between different universities' educational settings or school cultures?

The goals of the research are: to explore the basic level of university teachers' resilience, to define and recognize their perception of stress, and to explore correlations between resilience and perceived stress.

Research variables:

- Resilience is "the process and outcome of successfully adapting to difficult or challenging life experiences, especially through mental, emotional, and behavioral flexibility and adjustment to external and internal demands" (APA Dictionary [13]). It was measured by the Brief Resilience Scale.
- Perceived stress "is the feelings or thoughts that an individual has about how much stress they are under at a given point in time or over a given time period". Perceived stress is "a subjective belief about the possibility to control and predict one's life, the frequency of coping with a variety of stressful events, as well as the belief in one's ability to cope with problems" [27, p. 204]. It was measured by the Perceived Stress Scale.
- University staff positions: university teachers (full professors, associate professors, assistant professors, professors of applied studies, lecturers), and university teaching assistants (teaching assistants and similar).
- The field of teaching: university staff in the field of social sciences and humanities; university staff in the field of technology and engineering; university staff of science and mathematics; university staff of the arts; university staff of the biomedical sciences (according to the classification of the HEIs/university educational fields in Serbia).
- University teaching experience: first five years; six and fifteen years; sixteen to twenty-five years; and more than twenty-five years.

Hypothesis:

- The resilience of the university teaching staff is high.
- Their perception of the stress – perceived stress is low.
- The correlation between resilience and perceived stress is negative.
- There are some differences in resilience and perceived stress between university teachers of different educational fields.
- There are certaing differences in resilience and perceived stress between university teachers and university teaching assistants.

The research is based on an exploratory quantitative approach.

Survey polling is used to collect data. The survey was developed using Google Forms. The research instrument (Google questionnaire) consists of two psychological scales (Brief Resilience Scale and Perceived Stress Scale) and general questions.

- BRS – The Brief Resilience Scale was created to assess the perceived ability to bounce back or recover from stress. The instrument was developed by Smith, Dalen, Wiggins, Tooley, Christopher and Bernard [28]. The scale was developed to assess a unitary construct of resilience (one-dimensional or monofactorial scale), including both positively and negatively worded items. It consists of six items (table 2). The respondent takes a response on the five-point scale (from 1 – low resilience to 5 – high resilience).

  The metric characteristics of the BRS are confirmed for different populations and different languages: Cronbach's alfa is between 0.71 and 0.83 [29, 30, 31, 32, 33]. Range of the resilience categories: low resilience 1.00-2.99; medium resilience 3.00-4.30; high resilience 4.31-5.00 [34]. It is not a specific instrument to measure a specific dimension of teacher resilience, but it is an instrument to measure the general concept of resilience.

  Example of items: *I have a hard time making it through stressful events.*

- PSS – Perceived Stress Scale is a self-reported measure designed to deal with the degree to which situations in an individual's life are appraised as stressful [34]. The instrument was developed by Cohen, Kamarck, and Mermelstein [35]. The 10-item scale is used in the research. The respondent takes a response on a five-point scale (from 1=never to 5=very often). A higher score indicates higher stress.

The PSS-10 has demonstrated adequate reliability coefficients; Cronbach's alpha ranges from 0.75 to 0.91 (cited in [34, p. 108]. The perceived stress scale (PSS-10) reliability and validity were evaluated for different populations and different languages [34].

Example of items: *In the last few months, how often have you found that you could not cope with all the things that you had to do?*

Participants: The sample consists of 100 members of the university teaching staff: 71 university teachers and 29 university teaching assistants from the universities in Serbia: University of Kragujevac, University of Niš and other universities (Tab. 1).

Table 1. *Structure of the participants*

Variables	Subgroups	N/%
Gender	Female	68
	Male	31
	No answer	1
University teaching experience	More than 25 years	16
	16 to 25 years	21
	6 to 15 years	43
	Less than 5 years	20
Teaching/research domains	Social sciences and Humanities	79
	Engineering and technology	18
	Science (nature) and Mathematics	3
Type of university teaching engagements	University teachers	71
	University teaching assistants	29

Research procedure: data were collected between May and June 2022 using Google Forms polling. University teaching staff was informed by an e-mail about the general aim of the research, anonymity of their answers and voluntary participation. Questionnaire completion demands a maximum of 10 minutes.

Descriptive statistical analysis, correlation analysis and ANOVA were used to generate an overview of the university teaching staff resilience and stress perception.

5. RESULTS AND DISCUSSION

The focus of the research on the resilience of university teaching staff and their perceived stress is a descriptive and comparative analysis of these variables.

5.1. Descriptive and correlation analysis

The resilience of the university teaching staff is at a medium-high level (Mbrs=3.06), and perceived stress is low (Mpss=1.86) (Tab. 2, on the next page). The university teaching staff resilience mean was found to be above average and at higher levels than that reported in other comparative research of resilience measured by BRS [9].

Perceived stress among university teaching staff is low. The low scores on the scale imply that most university teaching staff have decreased levels of stress (distress).

In accordance with research organizations, the first two hypotheses on the level of university teaching staff resilience and stress perception are confirmed.

As expected, the correlation between resilience and perceived stress is negative ($r=-0.54$, $p<0.001$): increasing resilience is associated with a decrease in stress perception. In accordance with the theoretical conceptualizations and empirical research, the essence of resilient behaviour is to better cope with stress and overcome stress. The other research confirmed the correlation between resilience and perceived stress too: participants with low resilience showed higher scores in perceived stress level ($r=-0.$, $p<0.001$) [36]; in the other research, the relationship between these variables is statistically significant ($r=-0.38$; $p\leq0.001$) [37].

The research publications on resilience provide a variety of individual and contextual risk and protective factors. Price et al. [38] confirmed that personal factors, such as strong self-efficacy, high motivation, moral purpose, flexibility, and sense of humour, as well as contextual factors, such as an effective administrative team and supportive peers, have been suggested as some of the most powerful characteristics that distinguish resilient teachers. Most of these factors (both personal and contextual) are recognized in the university teaching staff work settings.

Table 2. *University teaching staff's resilience and perceived stress – scores on BRS and PSS*

	Minimum	Maximum	M	SD	Kurtosis	Skewnes
Resilience: BRS (Sum/6)	1.50	4.67	3.06	0.74	-0,517	-0.108
Perceived stress: PSS. (Sum/10)	0.90	3.50	1.86	0.59	0.167	0,749

Compliant with the conceptualization of resilience as "the capacity to overcome odds and demonstrate the personal strengths needed to cope with hardship or adversity" [9, p. 43]) , perhaps the university teaching staff has conditions for strengthening personal capacities, especially self-

efficacy, through their professional engagement. Personal and environmental characteristics (interaction in the triangle of university teacher–students–colleagues is one of the most important) are proposed to function as protective factors that mitigate the negative impact of stressful events, situations or conditions.

In the comparison with the research on resilience and stress of academic medical staff in Serbia [39], there are some similarities and some differences.

The results of both studies on the resilience of academic staff are similar: in our research Mbrs=3.06; in cited research Mbrs=3.42, with similar standard deviations in both studies.

At the other study of resilience as moderator factor of the association between burnout and subjective well-being among medical workers at the time of the pandemic, the results confirmed that resilience reduces the negative connection between burnout and subjective well-being [40].

Perceived stress (measured by PSS) in our study is lower than the measured perception of stress in cited research, which is higher: in our research Mpss=1.86, in cited research Mpss=3.17. The participants of these studies differ: university teaching staff from different educational and research fields and medical academic staff.

In the research on teachers' perceived stress and experience in online teaching during the early phase of the COVID-19 pandemic [27], the score of the school teachers on PSS is similar (Mpss=17.92/10=1.79) to the score of university teaching staff in our study.

One of the reasons for differences in perceived stress may be the time of the research: the cited study [40], was conducted at the start of the pandemic and dealt with medical academic staff, whereas our study was conducted two years later in different health and work settings and with university teaching staff from various professions.

5.2. Comparison of the subgroups

Based on differences between some teacher groups and sub-populations [7], the differences between university teachers and university teaching assistants, then university teaching staff with different teaching experiences and university staff gender are assumed in this research.

Two main subgroups of the participants in the research – university teachers and university teaching assistants – have different perceptions of stress (Tab. 3). It is a statistically significant difference ($p<0.05$).

University teachers are more resilient than university teaching assistants. However, the results are not independent of the age of the participants, which is the topic for the following research. Most university teachers are older than 35 years, and most of the university teaching assistants are younger than 35 years.

Table 3. *Different teaching status and resilience and perceived stress – scores on BRS and PSS*

Variables	University teachers	Teaching assistant	**F**	
	M	**M**	**F**	**sig**
Resilience (BRS)	3,15	2.84	3.806	0.054
Perceived stress (PSS)	1.77	2.09	6.479	0.012*
N	71	29		*p<0.05

Data analysis showed that there are no differences between the other subgroups of university teaching staff:

- University teaching staff with different teaching experiences (years of university teaching experience) do not differ in the level o resilience (F=0.767, p=0.516) and perceived stress (F=1.426, p=0.242).
- Different research and educational fields of teaching are not reflected in their resilience (F=0.009, p=0.991) and perceived stress (F=0,129, p=0.880).
- There are no gender differences in resilience (F=0.125, p=0.833) and perceived stress (F=0.435, p=0.648) in the group of university teaching staff.

These findings may be a consequence of the similar educational contexts — university educational settings – where all of them work.

6. CONCLUSION

The university teaching staff's resilience is at a medium-high level, and their perceived stress is low. As expected, their resilience is negatively associated with perceived stress.

The type of the sample (it is not a representative sample), using procedures for data collection (Google forms and online surveys are not reliable procedures), and the number of items in both scales are the limitations of this research

What is the next step in the analysis of university teachers' resilience? Based on the confirmation that the university teaching staff, especially university teachers, have moderately high resilience and low perceived stress, research on the supportive factors for strong resilience and overcoming stress of the highly educated professionals suggests the following steps — to recognize factors of high resiliency and to use these findings and positive practice for empowering university staff continually.

This study introduces new research topics and considerations in the contexts of teacher education and university activities aimed at enhancing university teaching staff resilience, stress management, and well-being.

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From Collaboration to Solutions: Encouraging Collaborative Problem Solving through School Practice

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Abstract: *The aim of this paper is to present a viable, psychologically based framework designed for systematical promotion of the adolescents' capacities for collaborative problem solving and possibilities for their cultivation through everyday school practice. Specifically, a model for designing teacher-training programs is proposed, wherein several elements of effective collaborative problem solving are drawn together.*

Keywords: *problem solving; cooperation; peers; socio/emotional competencies; intervention study.*

1. INTRODUCTION

The contemporary, although not new, orientation of education policy in Serbia towards competence-based education affirmed the constructivist approach to learning, through peer cooperation, exchange and reflection, that is, collaborative formulation of solutions and conclusions. In the competence-based education, the student is expected to be active, to have a developed sense of cooperation and to be able to present and explain his/her point of view. In the same time, the teacher is expected to be sensitive to these competencies and to support them with appropriate work methods. The main goal of the project "The PEER model of collaborative problem solving: Developing young people's capacities for constructive interaction and teamwork" is to develop a teacher training program for the implementation of teaching oriented towards cooperative problem solving and building the capacity of young people for constructive interaction, as well as to monitor its implementation and ensure the positive effects of such work.

2. CONCEPT AND METHODOLOGY

As the current and rich research evidence clearly shows, collaborative problem solving (CPS) is the principal way of dealing with scientific and civic issues in the contemporary world. It is generally known that joint work to solve problems is more creative, effective and productive than individual work. In addition, working together is the only way to approach complex, socially relevant problems, which require a consideration of multiple sides and factors, and often call for an interdisciplinary perspective [1, 2, 3]. Consequently, the need to develop young people's problem-solving skills and prepare them to work effectively in teams within their future professional and social environments has also been specified as a major educational goal, which is already case with the educational system in Serbia [4, 5].

As Piaget originally proposed (1941/1999, 1950/1999, 1960/1999), the peer interaction can spur the development of cognitive and other competencies, such as socio-emotional ones, through the process of coordination of multiple perspectives and consequent decentration from one's original point of view [6]. According to this point of view, we can see CPS in peer groups as a method of learning that allows individual group members to arrive at a deeper understanding of the problem at hand and the ways it may be soled.

The above benefits of peer interaction and CPS are contingent upon certain conditions. For example, participants should be able to share different perspectives openly and resolve socio-cognitive conflict constructively [7, 8].

As the empirical evidence shows, it is possible to teach young students the language and social skills

that can help them become more productive participants in CPS. As demonstrated primarily through the continuous efforts of Mercer and his research group [9], through specifically designed educational programs students can learn how to think together, while also benefiting in terms of their individual competencies, i.e., achieving better school grades. In addition, students could be taught to communicate effectively and respectfully, to suspend their own values, beliefs and judgement when interacting with others and to take an active part in conflict management and resolution [10].

Finally, adolescence is arguably the optimal period to systematically support the competencies and capacities relevant for constructive peer interaction and CPS. This is, for one, because adolescents possess the necessary cognitive and socio-emotional prerequisites to grasp and consider different views for the sake of argument, but, moreover, they are strongly orientated towards and seek the company of peers [11]. Lastly, high school students are one step away from entering higher education and the world of work, where teamwork is crucial and associated with higher engagement.

2.1. Methodology

The Project will employ a mixed-methods approach. First phase' objective is to develop a PEER model-based training for adolescents based on data about individual and group-level factors of (un)productive peer interaction; personal themes through which these factors appear in CPS; and adolescents' past experiences with and attitudes towards CPS. Data will be collected through two qualitative studies, using individual interviews with participants and observations of their spontaneous behavior during CPS.

The objective of the second phase is to implement the PEER model of training during teaching/learning process and test it in two intervention studies. The first study will examine the training's effects on two group-level variables: quality of interaction during CPS; and quality of the solution to the presented real-world (complex) problems. In addition, we will use the data from this study to make final adjustments to the PEER model-based training. The second intervention study will test the effects of the final version of the training on two individual level variables: scientific and civic problem-solving competencies; and participants' subjective experience of CPS. Both intervention studies will use an experimental design with repeated measures (pretest - training -posttest). The experimental group will receive the PEER model-based training and have the opportunity to practice CPS in triads with an experienced instructor providing scaffolding and digital media as resources The control group will also be engaged in CPS, but will not receive any training or scaffolding.

2.2. The PEER intervention model

Proposed model for designing teacher-training programs focuses on several elements of effective collaborative problem solving. First, the model refers to the role of personality differences (the "P" element) in joint peer activities and highlights the need to teach young people to appreciate and benefit from the participation of different personalities in CPS. The model's second element points to the necessity to introduce adolescents to the rules and values of exchanging ideas in dialogue (the first "E" of the acronym), so as to raise the quality of their interactions and prevent these from turning into persuasion and conflict, or ending in disengagement and withdrawal. Third, the model assumes that–to be able to respect each other's different personalities and follow the rules of constructive dialogue–young people also need to develop their emotional intelligence (the second "E" of the acronym) and socioemotional competencies more generally. Finally, the PEER model proposes that effective CPS also depends on the availability of external resources (the "R" element), such as scaffolding provided by an experienced instructor and digital media.

Compiling these four elements, the described model not only provides an original synthesis of available knowledge on the psychological factors contributing to CPS, but will serve as the groundwork for developing an evidence-based CPS training program.

3. CONCLUSION

Competencies such as collaborative problem solving, critical thinking, ability to examine issues of global and local significance, ability to understand the perspectives of others and to evaluate actions and consequences are of the critical importance for the young people. Education systems that embrace the need for such competences are likely to be the ones that equip students to live in an interconnected and diverse world and to benefit from it [10].

The above described implementation of the PEER model should yield major insights into the possibility of developing adolescents' capacities for collaborative problem solving and using it to promote their individual competencies. The best place to implement an intervention study based on this model is the regular educational process because school is the only socialization agent that has the possibility of systematic and comprehensive influence on young people.

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Developing young people's capacities for constructive interaction and teamwork – PEERSolvers.

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Appendix A:

Symposium "Technics and Informatics in Education: School Teachers for Teachers"

Notes:

9th International scientific conference
Technics and Informatics in Education – TIE 2022
16-18 September 2022

Symposium: *Nastavnici za nastavnike*
Stručni rad
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Inovativni pristupi nastavi matematike primenom znanja stečenih u okviru informatike i računarstva

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Rezime: *Kontinuirani progres u oblasti informacionih i komunikacionih tehnologija (IKT), ima neminovan uticaj na sve sfere života, pa samim tim i na nastavni proces. Sadržaji sa kojima se učenici upoznaju u okviru informatike i računarstva mogu se primeniti u gotovo svim nastavnim predmetima. Njihova primena u matematici ima višestruki pozitivan uticaj kako na motivaciju učenika, povećanje efikasnosti nastavnog procesa, racionalno korišćenje vremena na časovima, razvoj opštih međupredmetnih kompetencija, kao i ključnih kompetencija za celoživotno učenje. U cilju isticanja veze između nastavnih predmeta i osposobljavanja učenika da primenjuju stečena znanja na konkretnim primerima, predmetni nastavnici često osmišljavaju zajedničke časove ili projekte. U radu su prikazani neke od uspešno realizovanih aktivnosti koje predstavljaju korelaciju tri nastavna predmeta: informatike i računarstva, tehnike i tehnologije i matematike.*

Ključne reči: *inovativna nastava; IKT; međupredmetna korelacija; međupredmetne kompetencije*

Innovative approach to teaching mathematics by applying the knowledge acquired in Informatics and computing

Abstract: *Continuous progress in the field of Information and communications technology (ICT) has an inevitable impact on all spheres of life, and therefore also on the teaching process. The content that students are introduced to in Informatics and computing can be applied in almost all subjects. Their application in mathematics has a multiple positive impact on student motivation, increasing the efficiency of the teaching process, rational use of time in classes, development of general cross-curricular competencies, as well as key competencies for lifelong learning. In order to emphasize the connection between teaching subjects and enable students to apply the acquired knowledge on concrete examples, subject teachers often design joint lessons or projects. The paper presents some of the successfully implemented activities that show the correlation of three teaching subjects: Informatics and computing, technique and technology, and mathematics.*

Keywords: *innovative teaching; ICT; cross-curricular correlation; cross-curricular competences*

1. Uvod

Za razliku od tradicionalne nastave kada je u središtu pažnje bio nastavni sadržaj i znanja koja su učenici trebali da usvoje, savremena nastava je okrenuta ka razvijanju kompetencija za nove i promenjene poslove , kao i kompetencije za celoživotno učenje, prihvatanje i prilagođavanje promenama.

„Imajući u vidu da je u savremenoj nastavi prisutan širok krug izvora znanja za koja se koriste određena tehnička pomagala, povećava se kvantitet znanja, a primenom obrazovne tehnologije, povećava se kvalitet znanja" [1].

Upravo te promene imaju sa jedne strane kao uzrok, a sa druge kao posledicu neizostavnu primenu informacionih i komunikacionih tehnologija (IKT) u nastavi. Prednost savremene nastave uz upotrebu IKT-a je i taj što se nastavni sadržaji koji se obrađuju mogu prilagoditi različitim nivoima znanja učenika, nastava se lakše može individualizovati.

Osnovni cilj individualizacije je naučiti učenike učenju, formirati kod njih pozitivnu motivaciju za

učenje i osloboditi potencijalne sposobnosti svakog učenika [2].

Promene obrazovnog procesa u celini moraju biti ispraćene i u odnosu učenika i nastavnika, kao i promeni njihovih uloga. Kako bi mogli da razvijaju određene kompetencije učenika, nastavnici moraju i sami da se prilagode konceptu celoživotnog učenja kao i uslovima informatičkog društva.

Vlada Republike Srbije, Ministarstvo prosvete nauke i tehnološkog razvoja i Zavod za unapređivanje obrazovanja i vaspitanja (ZUOV) sistemski rade na promovisanju digitalnih kompetencija koje spadaju u niz ključnih kompetencija potrebnih za kvalitetan život i rad svih građana.

Sa druge strane, jedan od osnovnih pravaca promene u današnjoj nastavi predstavlja primenu novih interaktivnih metoda učenja i poučavanja. Interaktivno učenje, podrazumeva učenje kao socijalni proces, interakciju između učenika i nastavnika, učenika međusobno, interakciju sa roditeljima,... Osnovna svrha interaktivnog modela je prenošenje akcije sa nastavnika na učenika, usmeravanje učenika da zajednički uče, da zajednički rade na ishodima i sadržajima učenja kao i da primenjuju i vrednuju naučeno. Primena interaktivnog modela kod učenika razvija međupredmetne kompetencije i osposobljava ih da uspešno implementiraju koncept celoživotnog učenja. Primenom pomenutog modela učenici pokazuju značajno višu motivaciju za rad, akcenat je na samom procesu i načinu učenja, kao i na povezivanju znanja unutar predmeta, ali i među predmetima. Još neke od dobrobiti ovog modela su te što se učenici uče preuzimanju odgovornosti i usaglašavanju stavova, formiraju kritičko mišljenje, osposobljavaju se za donošenje zaključaka i pravilno rasuđivanje, uče se modernoj komunikaciji koristeći medije i različite izvore znanja.

Holistička paradigma vaspitanje i obrazovanje vidi kao neodvojive procese koji su međusobno isprepletani i uslovljeni te ih je nemoguće razdvajati. Bitno je da vaspitanje i obrazovanje ne izgube vezu sa stvarnošću, što se može dogoditi ukoliko ih posmatramo samostalno i razdvajamo u različite discipline. „Ako holističku paradigmu primenimo u nastavnom procesu, jasno je da u tom obliku ona predstavlja korelaciju sadržaja unutar i među predmetima" [3]. Integrisanje znanja iz različitih naučnih disciplina, odnosno iz različitih nastavnih predmeta, omogućava učenicima izgradnju celovite slike o izučavanom sadržaju i omogućavaju primenu naučenih sadržaja u svakodnevnom životu. Tačnije rečeno, učenici povezivanjem znanja uočavaju pravi smisao naučenih sadržaja. Interdisciplinarni pristup nastavi i ostvarivanje korelacije među predmetima podrazumeva dodatni angažman i kontinuiranu saradnju kako kod učenika, tako i kod nastavnika, ali i uključivanje roditelja i lokalne zajednice u obrazovni proces.

U radu je dat pregled alata, obrazovnih softvera i uređaja sa kojima se učenici upoznaju na časovima informatike i računarstva i časovima tehnike i tehnologije, a koji su pogodni za unapređivanje nastave matematike. Nakon ovog pregleda, na konkretnim primerima časova realizovanih u OŠ „20. oktobar" u Vrbasu, opisano je povezivanje sadržaja iz navedenih nastavnih predmeta.

2. METODOLOGIJA ISTRAŽIVANJA

Predmet istraživanja ovog rada je način implemantacije sadržaja nastavnih predmeta informatike i računarstva i tehnike i tehnologije u cilju postizanja kvalitetnije i efikasnije nastave matematike i povećanja motivacije kod učenika.

Glavni cilj rada je osmišljavanje inovativnog pristupa nastavi matematike korišćenjem znanja stečenih u okviru nastave informatike i računarstva, a u cilju poboljšanja kvaliteta i efikasnosti nastave matematike i povećanja motivacije kod učenika. Pored navedenog glavnog cilja rad se bavi i pregledom ranijih istraživanja kao i iskustva stečenog u radu sa učenicima radi ukazivanja na značaj međupredmetnog povezivanja matematike i informatike i računarstva koje je od neprocenjive koristi kako učenicima tako i njihovim nastavnicima. Osim navedenog, težnja autora je da opisanim praktičnim primerima daju ideju i podršku ostalim kolegama u osavremenjavanju nastave matematike.

Očekivani efekti primene IKT- a u nastavi treba da ukažu na to da se nastavni sadržaji na ovaj način mogu uspešnije prezentovati učenicima što doprinosi podizanju kvaliteta nastave.

3. PREGLED ALATA, OBRAZOVNIH SOFTVERA I UREĐAJA POGODNIH ZA UNAPREĐIVANJE NASTAVE MATEMATIKE

U okviru ovog poglavlja dat je pregled najčešće korišćenih programa, alata i uređaja s kojima su se učenici upoznali na časovima tehnike i tehnologije ili na časovima informatike i računarstva, a koji u značajnoj meri doprinose osavremenjavanju nastave matematike i čine je interesantnijom i dostupnijom učenicima. Date su neke od mogućnosti njihove primene na primerima iz OŠ „20.oktobar" u Vrbasu i pregled istraživanja u okviru kojih je ispitivan uticaj pomenutih alata na unapređivanje nastave i motivaciju kod učenika.

Na časovima informatike i računarstva u osnovnoj školi u okviru nastavnih oblasti Digitalna pismenost i IKT učenici se upoznaju sa alatima za obradu teksta, slika, izradu raznih vrsta animacija, grafičkim prikazom podataka, radom sa podacima, zatim uče da procenjuju kvalitet dostupnih informacija, upoznaju se sa pojmom digitalnog nasilja, takođe i savladavaju osnove

programiranja. Navedene veštine omogućavaju učenicima da uz pomoć nastavnika osavremenjuju nastavni proces i iz ostalih nastavnih predmeta, a naročito iz matematike.

Svi časovi koji su opisani u ovom delu su realizovani i pozitivno ocenjeni kako od stane učenika tako i od članova veća prirodnih nauka OŠ

„20. oktobar" u Vrbasu.

3.1. Primena programskog paketa GeoGebra u nastavi matematike

GeoGebra je besplatan program za dinamičku matematiku. Sama aplikacija je veoma jednostavna za korišćenje kako za nastavnike tako i za učenike. Zbog ovih karakteristika i dostupnosti već duži niz godina se intenzivno primenjuje u nastavi. Najvažnije karakteristike ovog softvera su sledeće: u isto vreme se pojavljuju dve reprezentacije istog matematičkog objekta, algebarska i grafička, na ekranu u algebarskom i grafičkom prozoru, respektivno. Pored navedenog GeoGebra omogućava i rad sa tabelarnom reprezentacijom, kao i trodimenzionalni prikaz. Promene kod jedne reprezentacije uzrokuju istovremeno ažuriranje druge. Veliki je broj radova u kojima istraživači izveštavaju o unapređivanju učenja matematike korišćenjem obrazovnog softvera GeoGebra [4]. Jedna od velikih prednosti GeoGebre je ta da se objekat koji posmatramo može predstaviti u trodimenzionalnom prikazu, što učenicima znatno pomaže u vizualizaciji problema. Takođe, pruža mogućnost „rotiranja" prostora što omogućava sagledavanje problema iz svih uglova, što u klasičnoj nastavi nije uvek lako izvodljivo [5].

Obrazovni softver GeoGebra ima velike mogućnosti kada je u pitanju predstavljanje i rad sa matematičkim sadržajima. Pored toga, GeoGebra ima još nekoliko važnih osobina [6]:

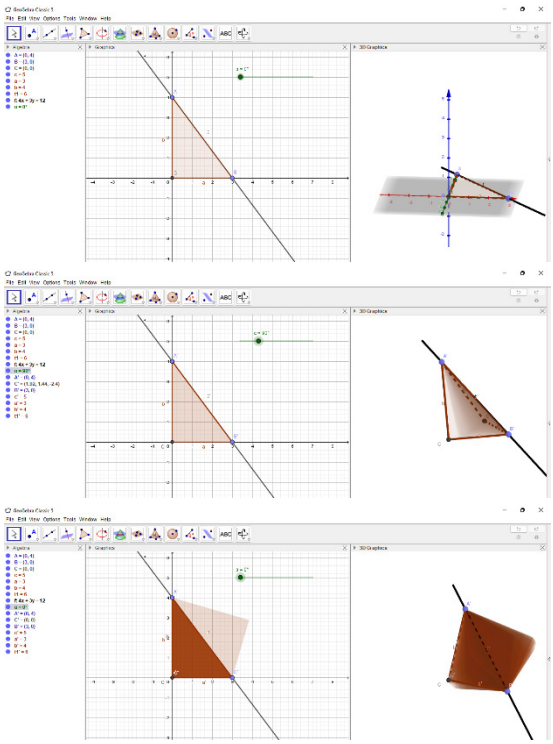
- Program je blizak korisniku, obuka za njihovo korišćenje je jednostavna, a poseduje i višejezični meni;
- Podstiče učenike da samostalno istražuju, kao i da uče pomoću eksperimenata i otkrića;
- Omogućava korisniku da podešavanja radnog okruženja prilagođava sopstvenim potrebama;
- Program je kreiran tako da pomaže učenicima da bolje ovladaju određenim matematičkim sadržajima koristeći njegove dinamičke osobine – učenici mogu jednostavno pomerati „slobodne objekte na radnoj površini, posmatrajući ih iz različitih uglova, a mogu i, koristeći klizač, menjati vrednosti određene promenljive i posmatrati kao promene tih vrednosti utiču na osobine zavisnih objekata;
- Korišćenje softvera GeoGebra omogućava formiranje radnog okruženja u kome bi klasično predavanje bilo zamenjeno problemski orjentisanom nastavom. Ovaj program je pogodan za rad u problemskim situacijama, jer podstiče učenike na razmišljanje, iznalaženje rešenja i donošenje odluka, ali istovremeno i omogućava proveru tačnosti rešenja i sagledavanje eventualnih grešaka, što doprinosi formiranju kvalitetnije unutrašnje reprezentacije;
- Stimuliše nastavnike da istražuju i unapređuju nastavu matematike, da koriste tehnologiju u cilju vizualizacije nastavnih sadržaja, kao i da organizuju interaktivnu nastavu ili učenje na daljinu.

Pomenute osobine programskog paketa GeoGebra, kao i to što je prilagođen korisnicima koji nemaju programerske veštine, su doprinele da se koristi od osnovne škole do univerzitetskog nivoa. Otvaranjem GeoGebra centra u Beogradu i GeoGebra instituta u Novom Sadu program postaje dostupan i na srpskom jeziku. Pored mogućnosti kreiranja materijala u GeoGebra okruženju, korisnicima se nudi i usluga u oblaku koja im omogućava da otpremaju i dele materijale sa drugim korisnicima, ali isto tako i da koriste već gotove obrazovne resurse uključujući i interaktivne radne listove, simulacije, igre i e- knjige.

Na *Slici 3-1* prikazan je primer grafičke reprezentacije rotacije pravouglog trougla oko katete, gde je ugao rotacije definisan pomoću klizača i može da uzima vrednost od $0°$ do $360°$. Ovaj primer ima višestruku primenu kako u osnovnoškolskoj nastavi matematike u okviru nastavne oblasti Piramida, tako i u srednjoj školi u okviru nastavne oblasti Izometrijske transformacije i Stereometrija. Na ovom primeru učenici jasno mogu da uočavaju koji položaj zauzima trougao za različite vrednosti ugla rotacije koji je definisan pomoću klizača. S druge strane, dinamička svojstva softvera GeoGebra omogućavaju učenicima da jasno vide koje geometrijske figure se dobijaju u trodimenzionalnom prostoru prilikom rotacije trouglova i četvorouglova oko unapred definisane ose.

Zbog širokog spektra funkcija koje pruža, GeoGebra se može koristiti gotovo u svakoj nastavnoj oblasti obuhvaćenoj osnovnoškolskim i srednjoškolskim programom nastave matematike, s tim da treba imati u vidu da tehniku treba koristiti prvenstveno u situacijama kada je njena primena opravdana i kada je upotreba tehnologije delotvornija od tradicionalnih metoda. U ovom primeru se jasno vidi prednost upotrebe tehnologije i dinamičkog svojstva softvera GeoGebra prvenstveno kao pomoć učenicima u vizuelizaciji problema i podsticanju na istraživanje i samostalno eksperimentisanje, ali

i kao pomoć nastavnicima u usložnjavanju zahteva koje postavljaju učenicima.



Slika 3-1 Rotacija pravouglog trougla oko hipotenuze za dati ugao u GeoGebra okruženju

. U radu [7] prikazani su neki primeri ovih igara kao što su tangram, problemi sa palidrvcima, domino pasijans i šahovski problemi.

Postoje brojna istraživanja koja se bave opravdanosti primene softvera GeoGebra u nastavi matematike, kao i njenom uticaju na motivaciju učenika. U periodu od 2015. до 2018. godine sprovedena je serija istraživanja o mogućnostima primene dinamičkog softvera GeoGebra u radu sa funkcijama. Glavni cilj ovog istraživanja je bio utvrđivanje stepena uticaja dinamičkog softvera u kolaborativnom radu na kvalitet znanja studenata i razumevanje određenih segmenata nastavnih sadržaja iz oblasti funkcija. Rezultati ovih istraživanja, opisanih u doktorskoj disertaciji, potvrđuju pretpostavku da primena metodskog pristupa zasnovanog na upotrebi dinamičkog softvera, koji se može kombinovati sa kolaborativnim, ali i sa individualnim radom, u obradi i prilikom uvežbavanja nastavnih sadržaja koji se odnose na funkcije sa parametrima, doprinosi boljim postignućima studenata u navedenoj oblasti, kao i unapređivanju kvaliteta njihovoh znanja o funkcijama i njihovim osobinama [8].

[9].

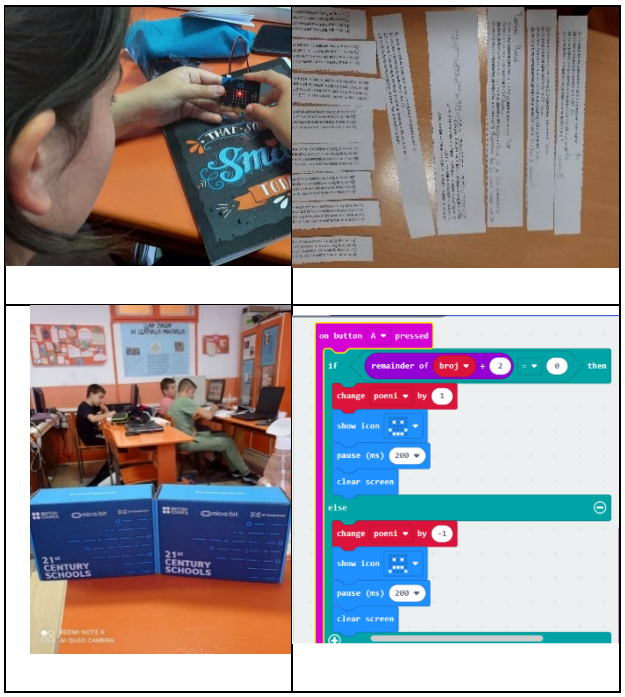
3.2. Primena micro:bit uređaja u nastavi matematike

Micro:bit je ručni, programabilni mikro-računar koji je razvijen prvenstveno kako bi zainteresovao decu za programiranje. Razvili su ga BBC, Microsoft i partnerske kompanije. Primena micro:bit uređeja u nastavi kod dece razvija širok spektar veština za 21. vek kao što su rešavanje problema, donošenje odluka, logičko i kritičko mišljenje, kreativnost, unapređivanje digitalnih kompetencija, kao i saradnje i timskog rada. Kroz različite projekte učenici demonstriraju STEM (Sciences Technology Engineering Mathematics) koncept. Zbog širokog spektra mogućnosti koje nudi korisnicima, micro:bit je našao primenu kako u prirodnim tako i u društvenim predmetima. U okviru projekta „Škole za 21. vek" škole su dobile određen broj micro:bit uređaja [10][11].

Na prednjoj strani micro:bit uređaja se nalazi 25 lampica koje su poređane u pet vrsta i pet kolona. Ove lampice su izrađene u takozvanoj LED (*Light Emitting Diode)* tehnologiji. Sa leve i desne strane se nalazi po jedan, A i B, taster. Micro:bit može da registruje koji od tastera je pritisnut i da reaguje na pritisak nekog od njih tako što će izvršiti neku radnju ili poslati informaciju nekom drugom uređeju. Micro:bit uređaj ima ugrađen i kompas, akcelerator i senzor temperature. Na ivici micro:bit uređaja se nalazi 25 pinova preko kojih, upotrebom provodnika sa krokodil štipaljkama možemo micro:bit uređaj da povežemo sa dodatnim senzorima, ali i upravljati brojnim uređajima. Mickro:bit je opremljen i BLE *(Bluetooth Low Energy)* antenom pomoću koje može bežično da komunicira sa više drugih micro:bit uređaja, računarom, mobilnim telefonom ili nekim drugim uređajem. Komunikacija sa drugim uređajima je dvosmerna, što znači da micro:bit može da prima podatke sa njih, ali i da im prosleđuje podatke [12].

Micro:bit je veoma jednostavno programirati u Blocks-u, Javascript-u, Python-u ili Scratch-u. Grafičko okruženje sastoji se iz tri dela. U centralnom delu nalaze se blokovi sa osnovnim naredbama za unos, prikaz, ponavljanje, uslovno grananje. U levom delu prozora nalazi se simulator (ako nemamo fizički uređaj) preko koga je moguće proveriti rad programa, kao i dugme za preuzimanje programa na fizički uređaj. U desnom delu prozora se nalazi prostor za ređanje blokova, tačnije prostor gde se odigrava programiranje. U tom delu prozora postavljena su dva bloka „On start" i „Forever", koji se koriste za izvršavanje programa na micro:bit-u, i to odmah prilikom

povezivanja (On start), ili „beskonačno" (Forever) dok ga korisnik ne prekine na „silu" [11].



Slika 3-2 Primena micro:bit uređaja u nastavi u OŠ „20.oktobar" u Vrbasu

Na *Slika 3-2* prikazan je čas održan u OŠ „20.oktobar" u Vrbasu, u odeljenju 5-2, 2021. godine, nastavna jedinica „Deljivost brojevima 2, 3, 4, 5, 9, 25 i dekadnim jedinicama – utvrđivanje". Kako se učenici u petom razredu na časovima informatike i računarstava upoznaju sa blokovskim programiranjem u Scratch-u, prvo su izradili program koji proverava da li je nasumično izabrani broj deljiv brojem 2 (analogno i sa 3, 4, 5, 9, 25 i dekadnim jedinicama), korišćenjem komande „remainder of" koja vraća ostatak pri deljenju, tako da učenici u tom delu nisu morali da budu upoznati sa pravilima deljivosti. Izrađen program prebacili su u uređaj i na časovima matematike pomoću micro:bit uređaja su utvrđivali pravila deljivosti. Pravila igre su sledeća: kada učenik pritisne zajedno taster A i B na ekranu se prikazuje nasumično izabrani broj iz nekog intervala. Ukoliko učenik smatra da je taj broj deljiv brojem 2 (analogno i sa 3, 4, 5, 9, 25 i dekadnim jedinicama) pritisne taster A, u suprotnom pritisne taster B. Za svaki tačan odgovor dobija se jedan poen, a za netačan odgovor se oduzima jedan poen. Broj ostvarenih poena se može proveriti u svakom trenutku tako što se micro:bit protrese. Na kraju časa učenici su popunjavali anketu o delotvornosti upotrebe micro:bit uređaja na času. Rezultati ankete su pokazali da su obrazovni ishodi ostvareni, kao i da su svi učenici bili visoko motivisani za rad.

Kratak video zapis opisane igrice se može naći na linku https://www.youtube.com/shorts/5EVRq-NVUV4.

Kao što je već napomenuto, micro:bit uređaj se može koristiti gotovo u svim nastavnim predmetima. Projekat „pametna bašta" demonstrira korelaciju tri nastavna predmeta biologije, informatike i računarstva i tehnike i tehnologije upotrebom micro:bit uređaja. Dostupni su i brojni drugi gotovi resursi, kao i smernice za izradu novih, što čini micro:bit jednostavnim za korišćenje. U okviru projekta „Škole za 21. vek" koji sprovodi Britanski savet izdata je zbirka primera priprema za časove i školskih projekata, na kojima se podstiče kritičko mišljenje i rešavanje problema i koristi micro:bit, „Kritičko mišljenje i rešavanje problema u školi" koja je dostupna onlajn na adresi https://www.britishcouncil.rs/sites/default/files/zbirka_dobrih_praksi.pdf.

Izveštaj u okviru istraživanja koje je sproveo Strategic marketing 2018. godine za potrebe projekta „Škole za 21. vek", pokazao je kako nastavnici veruju da su aktivnosti sa micro:bit uređajem povećale međusobnu socijalizaciju učenika kao i da su povećale „razmenu znanja među učenicima" i „poboljšale saradnju i komunikaciju sa ostalim nastavnicima". Nastavnike je oduševila spoznaja da su učenici koji su bili obično nezainteresovani i nisu se uključivali ni u kakva dešavanja u razredu bili prvi koji su se prihvatili micro:bit uređaja. Neki učenici su pokazali „neke potpuno nove potencijale što pokazuje da im je samo trebalo drugačije pristupiti". Pored navedenog sprovedeno je i istraživanje o uticaju projekta na decu ranjivih grupa. Ovo istraživanje je pokazalo da je program doprineo značajnom unapređivanju analitičkih veština, kritičkog mišljenja i veština programiranja kod dece iz osetljivih grupa, a naročito među devojčicama iz porodica nisko socio –ekonomskog položaja, koje ranije nisu imale priliku da koriste digitalne tehnologije. Program je doprineo povećanoj motivaciji za edukacijom i pohađanjem škole, posebno među decom sa ozbiljnim poteškoćama u učenju i decom iz veoma ugroženih zajednica, čija je motivacija predhodno bila umanjena zbog osećaja isključenosti, nesigurnosti i neravnopravnosti. Deca su razvila društvenu osetljivost i empatiju prema svojim drugarima sa invaliditetom tokom izvođenja zajedničkih projekata, što je takođe uticalo na njihovo dalje učešće u inicijativama za podršku drugarima iz ranjivih grupa. Primećeno je i povećano učešće na časovima, kao i proaktivniji pristup učenju zbog novih nastavnih metoda i interaktivnih obrazovnih tehnika [10].

3.3. Pregled alata informaciono-komunikacionih tehnologija i primeri njihove primene u nastavi matematike

Prezentacije su veoma korisno sredstvo u nastavi i imaju višestruki pozitivan uticaj na unapređivanje i osavremenjavanje nastavnog procesa. Prezentacije mogu kreirati nastavnici, ali i sami učenici mogu

predstaviti rezultate svojih istraživanja i projekata korišćenjem prezentacija. U grupu alata za kreiranje prezentacija spadaju MS Office PowerPoint, Prezi, Biteable i slični. PowerPoint je najpoznatiji i najčešće upotrebljavan program za izradu prezentacija i deo je MS Office paketa. Služi za izradu multimedijalnih prezentacija i omogućava dodavanje različitih efekata, zvukova, slika, grafikona i slično.

Prema mnogim autorima, PowerPoint ima niz prednosti kao što su [13]:

- Ušteda vremena (nema potrebe za pisanjem po tabli i diktiranjem),
- Mogućnost ponovnog korišćenja,
- Mogućnost izmene sadržaja na licu mesta,
- Istovremena upotreba teksta, slika i zvuka,
- Podrška različitim stilovima učenja,
- Dostupnost gotovih prezentacija na Internetu,
- Slajdovi se mogu odštampati.

Prezi je alat u okviru koga se kreiraju prezentacije na beskonačno velikom „platnu" dodavanjem slajdova različitih oblika. Dinamičnost je obezbeđena zumiranjem i nelinearnim kretanjem kroz sadržaj. Moguće je dodavati različite sadržaje, kao što su tekst, slika, video i sl. Sve prezentacije se kreiraju i prikazuju onlajn. Postoji veliki broj različitih i zanimljivo dizajniranih šablona koji mogu doprineti da prezentacija izgleda vrlo zanimljivo i profesionalno.

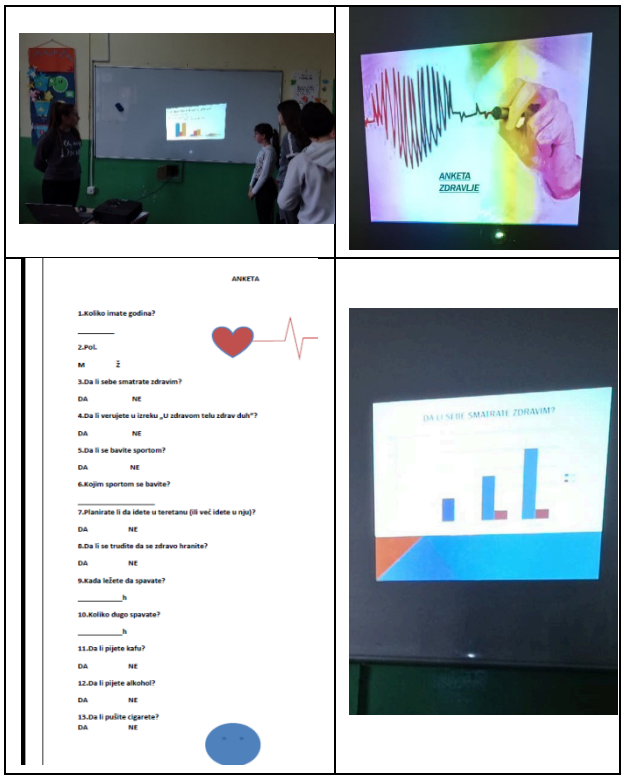
Široku primenu u nastavi matematike su našli alati za izradu upitnika, testova i kvizova. Neki od njih su Google upitnik (Google forms) i Kahoot. Google upitnik se koristi za izradu upitnika, testova i kvizova. Google upitnik se na jednostavan način deli sa drugim korisnicima putem linka, a može da se implementira i u Google učionicu, što predstavlja još jedan od argumenata za njihovu čestu primenu. Upitnici se mogu pretvoriti u test u okviru kojih kreatori definišu broj poena. Nastavnik na svom nalogu u realnom vremenu može da vidi odgovore učenika. Još jedna od prednosti korišćenja ovog alata je maksimalno pojednostavljena procedura pregledanja. Nastavnici mogu pogledati rezime svih ocena učenika, odgovore na pojedinačna pitanja ili sve odgovore jednog učenika.

Kahoot je, takođe, besplatan web alat za kreiranje interaktivnih upitnika koje možemo da koristimo u učionici u procesu nastave. Postoje tri vrste Kahoot forme koje možemo da kreiramo: kviz, diskusija i upitnik. Bodovanje se vrši na osnovu tačnosti odgovora, ali i na osnovu vremena u okviru kog je dat tačan odgovor. Pitanja se prikazuju učenicima, najčešće preko projektora. Učenici pristupaju kvizu putem svojih mobilnih telefona unosom odgovarajućeg pina. Na svojim telefonima učenici biraju ono polje koje označava odgovor za koji smatraju da je tačan. Nakon svakog odgovora dobiju povratnu informaciju o tome da li su odabrali tačan odgovor, a nakon toga i broj ostvarenih poena i trenutnu rang listu prvih pet učenika sa najvećim brojem bodova. Ovaj interaktivni kviz dodatno utiče na motivaciju kod učenika, dobra strana je i to što učenici odmah dobijaju i povratnu informaciju o svom uspehu. Nakon svakog pitanja se prikazuje tačan odgovor, tako da i ako učesnik ne odgovori tačno na pitanje ima mogućnost učenja na greškama. Ovakav način učenja podstiče i efikasnost kod učenika.

Alati za kreiranje i obradu video materijala su takođe pronašli primenu u nastavnom procesu iako im to nije primarni cilj. Animatron je alat koji služi za uređenje video zapisa i za kreiranje video animacija. Izbor tema nam omogućava da koristimo unapred dizajnirane likove, pozadine i objekte. Takođe je moguće kombinovati elemente iz različitih tema. Na scenu možemo dodati video zapise, fotografije, pozadinsku muziku, tekst i objekte. Magisto je alat pomoću koga fotografije i video zapise možemo da pretvorimo u film. FreeCam je jedan od besplatnih alata za snimanje ekrana koji se mogu preuzeti sa Interneta ili koristiti onlajn. Zajedničko im je da, nakon pokretanja, dobijemo mogućnost da izaberemo površinu odnosno deo ekrana koji želimo da snimamo i da pokretanjem snimanja možemo da snimimo i glas. ScreenApp je jednostavan alat za snimanje ekrana koristi se bez kreiranja naloga, bez instaliranja softvera, sa mogućnošću preuzimanja snimka na računar.

U okviru projekta „Ekološke i zdravstvene navike stanovništva Vrbasa" učenici osmog razreda u svim etapama projekta koristili su znanje stečeno u periodu od petog do osmog razreda na časovima informatike i računarstva. Učenici sva tri odeljenja osmog razreda OŠ „20.oktobar" u Vrbasu podeljeni su u grupe koje su sačinjene od pet do šest članova. U prvoj fazi projekta osmišljavali su anketna pitanja pomoću kojih su ispitivali ekološke i zdravstvene navike stanovništva. Tom prilikom značajno su im koristili dostupni internet materijali u vezi sa pomenutom temom. Prilikom pronalaženja relevantnih informacija, učenici su koristili znanja iz oblasti Medijska pismenost koja se proteže kroz većinu nastavnih predmeta, a najveću primenu nalazi u okviru izučavanja sadržaja iz informatike i računarstva i tehnike i tehnologije. U drugoj fazi, učenici su se bavili kreiranjem same ankete. Sve grupe su u ovoj fazi koristile MS Office Word ili Google upitnik. Prilikom samog anketiranja ispitanika u trećoj fazi projekta takođe su korišćene informacione tehnologije. Naime neke grupe učenika su deo, a neke celo istraživanje sprovele korišćenjem društvenih mreža. U četvrtoj fazi projekta u kojoj su obrađivani podaci dobijeni u prethodnoj fazi, korišćen je MS Office Excel kako bi se podaci prikazali tabelarno i grafički. U petoj fazi učenici su predstavljali rezultate dobijene u prethodnim fazama projekta. Pretežno su rezultati prezentovani korišćenjem MS Office Power Point i Prezi prezentacija, dok su neke grupe koristile i

programe za video animacije. Neki segmenti rada na projektu su prikazani na *Slici 3-3*.



Slika 3-3 Segmenti izrade i predstavljanja projekta

Osim za izradu prezentacija, učenici OŠ „20.oktobar" u Vrbasu implementirali su svoje znanje stečeno na časovima informatike i računarstva o korišćenju PowerPoint-a za izradu interaktivnog kviza znanja i edukativnih igrica pomoću kojih su utvrđivali znanje o četvorouglovima, kao i Pitagorinu teoremu. Za izradu kviza znanja korišćene su naprednije opcije Prilikom podešavanja animacija kao što su „trigger" i dodavanje zvučnih efekata. Na *Slici 3-4* prikazane su igre „Asocijacije" i „Otkrij sliku" koje su učenici izradili. Treća igra u ovom kvizu je kreirana pomoću alata Kahoot. Pitanja su navođena od lakših ka težim, a shodno težini pitanja određen je i broj poena i dužina intervala u okviru koga se može odgovarati. Cilj ovog projekta je pored utvrđivanja znanja iz pomenutih oblasti matematike bio i učešće na konkursu „EduGejming – igre kao sredstvo za učenje" koji su u okviru manifestacije Maj mesec matematike sproveli Centar za promociju nauke i Nordeus fondacija. Opis video igre se dostavljao u video zapisu u trajanju od 5 minuta. Za kreiranje video zapisa korišćen je FreeCam, besplatan alat za snimanje ekrana.

Slika 3-4 Primena PowerPoint prezentacije i Kahoot alata u kreiranju interaktivnih kvizova znanja i edukativnih igrica

4. ZAKLJUČAK

Kako bismo išli u korak sa vremenom i zavredili pažnju svojih učenika neophodno je da nastavnici unesu inovacije u vaspitno-obrazovnu delatnost, pre svega kroz upotrebu informacionih i komunikacionih tehnologija, ali i kroz međusobnu saradnju i osluškivanje interesovanja svojih učenika. Pozicija učenika u tradicionalnoj nastavi ne deluje podsticajno, a samim tim ne može dati ni očekivane rezultate. Područje rada na računaru uz korišćenje interneta je teren na kome se deca danas veoma dobro snalaze, a samim tim su i motivisana na takav način sticanja znanja i veština. Primena savremenih nastavnih sredstava, pogotovo audio-vizuelne i računarske tehnike uz korišćenje multimedije i hipermedije, omogućava da se učenici znatno aktivnije uključe u nastavni proces. Što je neizostavan zahtev savremene nastave. Nastavni plan i program takođe ide u prilog podsticanja saradnje između predmeta. Pozicija nastavnika se upotrebom savremenih metoda značajno promenila, nastavnik nije isključivo predavač, nego organizator nastave i partner u neposrednoj komunikaciji. Kako bi

promenio svoju ulogu i osavremenio način rada od nastavnika se očekuje da se kontinuirano stručno usavršava u tom smeru, da se povezuje sa kolegama u i izvan ustanove radom na zajedničkim projektima i razmenom iskustva. Otuda se nameće pitanje: Koliko smo otvoreni da prihvatimo promene?

Znanja stečena na časovima informatike i računarstva široko su primenjiva kako u svakodnevnom životu tako i u svim nastavnim procesima. Način njihove implementacije može osmisliti sam nastavnik, ali i koristiti veliki broj otvorenih obrazovnih resursa lako dostupnih putem interneta.

Cilj rada bio je da se prikažu načini da se nastava matematike osavremeni i približi učenicima, koristeći znanja koja su već stekli na časovima informatike i računarstva i tehnike i tehnologije. Sa druge strane, u praksi se ispostavilo da rešavajući matematičke probleme i tragajući za njihovim rešenjima, učenici stiču i usavršavaju svoje digitalne kompetencije i proširuju stečena znanja iz oblasti IKT-a. Primena računara u nastavi matematike je raznovrsna, od upotrebe njjednostavnijih matematičkih editora za štampanje matematičkih sadržaja do programiranja i elektronskog učenja. Neki od primera primene IKT-a koji su se pokazali kao najefikasniji u nastavi prikazani su u Poglavlju 3. U prvom delu su date prednosti korišćenja softvera GeoGebra i primena na rotaciju figure oko unapred zadate ose. Micro:bit uređaj se pokazao kao veoma korisno nastavno sredstvo zbog jednostavnosti primene. Najznačajnija karakteristika ovog uređaja je ta što kod učenika značajno povećava motivaciju za rad. Kroz prikazani primer upotrebe micro:bit uređaja vidi se kako učenici povezivanjem znanja u vezi sa blokovskim programiranjem i znanja iz oblasti deljivosti brojeva, upravljaju radom micro:bit uređajima. Osećaj da nisu samo korisnici, nego da uređaj mogu da prilagode sopstvenim potrebama prilikom rešavanja brojnih problema, učenicima daje dodatnu motivaciju za rad i dalje istraživanje. Dostupni su brojni alati koji se mogu koristiti kako pojedinačno u određenim delovima časova, tako i kombinovano u izradi i prezentaciji projekata. Neki od primera primene su dati u Poglavlju 3.3.

U praksi se pokazalo da primena savremenih nastavnih sredstava u nastavnom procesu značajno utiče na povećanje motivacije učenika i njihovo angažovanje, olakšava pamćenje i učenje, podstiče kreativnost i istraživački duh.

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Nastava programiranja u oblaku: paradigma novog doba

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Rezime: *U radu su prikazani veb-bazirani servisi i alati koji se koriste u programerskoj praksi a mogu ih koristiti nastavnici i učenici prilikom savladavanja gradiva koje se odnosi na programiranje a predviđeno je programima nastave i učenja za predmet Informatika i računarstvo u osmom razredu osnovne škole, odnosno Računarstvo i informatika u drugoj godini gimnazije. Rad ima za cilj da uputi nastavnike u postojanje datih alata i popularizuje njihovu upotrebu i prelazak na novi koncept nastave kada je reč o programiranju, shodno prednostima koje dati alati imaju u odnosu na svoje desktop verzije sa kojima su nastavnici upoznati kroz udžbenike svih izdavačkih kuća dostupne na domaćem tržištu.*

Ključne reči: *JupyterLab; JupyterLite; GitHub; Markdown; Google Colaboratory*

Teaching of programming in the cloud: A paradigm for the new era

Abstract: *The paper presents web-based services and tools that are used in programming practice and can be used by teachers and students when mastering material related to programming. This material is provided in programs for teaching and learning for the subject of Informatics and Computing in the eighth grade of elementary school, i.e. Computing and informatics in the second year of high school. The paper aims to guide teachers to the existence of these tools and popularize their use and transition to a new teaching concept when it comes to programming, according to the advantages that these tools have in comparison to their desktop versions, which teachers are familiar with through the textbooks of all publishing houses available on the domestic market.*

Keywords: *JupyterLab; JupyterLite; GitHub; Markdown; Google Colaboratory*

1. UVOD

Nastavni sadržaji iz oblasti programiranja su u osnovnim školama prošli put od izbornog modula u okviru izbornog predmeta do nastavne teme u okviru obaveznog predmeta koja po svom obimu oduzima polovinu godišnjih časova predviđenih za realizaciju nastave. Data tema je složenija za učenike od ostalih ali je i neuporedivo značajnija sa tačke gledišta budućeg zaposlenja u IT sektoru koji se neprestano razvija i u kom je standard zaposlenih primetno viši u odnosu na druge oblasti.

Promene u statusu predmeta Informatika i računarstvo u osnovnim školama su nastupile od školske godine 2017/2018., dok je školske 2018/2019. godine počela primena novog Pravilnika o programu nastave i učenja za peti razred [1]. Istim Pravilnikom je predviđena promena programa nastave i učenja za šesti razred s tim što je on stupio na snagu od školske 2019/2020. godine. Sukcesivno su objavljeni Pravilnici za sedmi i osmi razred [2, 3] i u školskim godinama 2020/2021. i 2021/2022. redosledno je počinjala njihova primena.

Navedenim pravilnicima je predviđeno da se predmet Informatika i računarstvo izvodi u obimu od 36 časova u petom, šestom i sedmom razredu, odnsno 34 časa u osmom.

Predviđeno je da se u svim razredima nastavne jedinice grupišu u tri nastavne teme odnosno oblasti: Informaciono-komunikacione tehnologije; Digitalna pismenost i Računarstvo. Program je spiralnog karaktera tako da se svi sadržaji iz mlađih razreda, ponavljaju i proširuju u starijim. Takođe je predložena izrada dva projektna zadatka i to jednog za prve dve teme i drugog koji obuhvata gradivo iz nastavne teme Računarstvo.

Sadržaji i ishodi iz programa nastave i učenja za osmi razreda se izučavaju i u drugoj godini

gimnazije pri čemu nastavnici za realizaciju gradiva imaju na raspolaganju više nego dvostruki broj časova (74) u odnosu na osnovne škole [4].

Pravilnik za osmi razred koji se odnosi na informatiku i računarstvo je već sredinom 2021. godine (godinu dana nakon usvajanja osnovne verzije) dopunjen sa sadržajima i ishodima koji se odnose na veštačku inteligenciju, te između ostalog izmenjen u delu nastavnih jedinice iz teme Računarstvo [3: *Prosvetni glasnik 5/21*]. Na osnovu toga se može naslutiti koliko je ova oblast dinamična i podložna promenama/unapređenjima.

Iz toga proizilazi i cilj ovog rada a to je upućivanje nastavnika u novije verzije razvojnih okruženja od onih koja su zamišljena programom nastave i učenja a obrađena u udžbenicima za osmi razred. Predmet rada predstavlja osvrt na opšte prednosti novih okruženja ali i specifične prednosti prikazane kroz primere unapređenja nastavne prakse u slučaju upotrebe datih okruženja u nastavi.

2. NASTAVNA TEMA RAČUNARSTVO I ODABRANA RAZVOJNA OKRUŽENJA

Udžbenici kao "osnovna didaktički oblikovana nastavna sredstva" [5], moraju sadržati sve ishode predviđene Pravilnicima [1-4] kako bi bili odobreni za upotrebu i kako bi se našli u Katalogu udžbenika koji se objavljuje na zvaničnoj internet stranici Ministarstva prosvete, nauke i tehnološkog razvoja i u "Službenom glasniku Republike Srbije – Prosvetnom glasniku".

U prethodnih par godina su se pojavile i elektronske verzije udžbenika, sa brojnim dodacima u odnosu na štampane primerke, koji osavremenjuju nastavni proces.

Kada je reč o udžbenicima iz predmeta Informatika i računarstvo za 8. razred osnovne škole, u Katalogu udžbenika [6] se nalazi 6 izdavačkih kuća koje nude svoja izdanja. Za 2. razred gimnazija postoji udžbenik samo jednog izdavača [7].

U svim navedenim udžbenicima se sadržaji iz oblasti računarstva odnosno programiranja izučavaju u okviru *Jupyter Notebook*-a – interaktivnog razvojnog okruženja za programski jezik *Python* koje je nastalo u okviru projekta *Jupyter* 2014. godine.

Jupyter Notebook je kao razvojno okruženje odabran i u onlajn kursevima fondacije Petlja namenjenim učenicima 8. razreda osnovne škole [8], te 2. razreda gimnazije [9]. Pomenuti kursevi su razvijeni od strane fondacije Petlja kao nezvanična pomoć nastavnicima za sadržaje iz oblasti programiranja pre nego što su se pojavili zvanično odobreni udžbenici.

U poglavljima koja slede će biti prikazane prednosti novih okruženja nastalih u okviru projekta *Jupyter – Jupyter Lab* i *Jupyter Lite*, u odnosu na klasično okruženje *Jupyter Notebook*; predstavićemo mogućnosti upotrebe servisa *GitHub* kao onlajn repozitorijuma na koji nastavnici mogu postavljati zadatke i prateće materijale; na kraju ćemo se osvrnuti na okruženje *Google Colaboratory* koje, kao što mu sam naziv ukazuje, ima mogućnosti za saradnički rad preko mreže u realnom vremenu.

3. NOVOSTI IZ PROJEKTA *JUPYTER*

Projekat Jupyter je nastao 2014. godine kao neprofitna organizacija s ciljem da podrži razvoj nauke o podacima (engl. *Data science*) nudeći korisnicima *Python*-a, ali i drugih programskih jezika, novo interaktivno razvojno okruženje. Prvo takvo okruženje nastalo u sklopu projekta je bio *Jupyter Notebook*. Osnovna razlika u odnosu na *IPython Notebook* koji je nastao krajem 2011. godine i koji je poslužio kao osnova za razvoj *Jupyter Notebook*-a, je podrška za druge programske jezike.

U februaru 2018. godine se pojavila prva verzija *JupyterLab*-a – modernijeg poboljšanog okruženja koje je trebalo da nasledi *Jupyter Notebook*. Ipak, prošlo je blizu tri godine dok *JupyterLab* nije postao podrazumevano okruženje ako posmatramo način na koji su otvarani repozitorijumi sa *Jupyter*-ovim radnim sveskama preko servisa *Binder* [10].

Prednosti *JupyterLab*-a u odnosu na *Jupyter Notebook* su brojne i na vebu se može naći mnoštvo tekstova i video snimaka na tu temu. Najpregledniji prikaz kroz 10 celina je dat u tekstu *Bhandari*-ja iz 2020. godine [11]:

- Sve pod jednim krovom – Lab ima ugrađen editor teksta te pregledač za fajlove formata JPEG, PDF, CSV, itd.
- Fleksibilan raspored – više tabova sa različitim sadržajem se može otvoriti u okviru jednog i rasporediti po želji;
- Promena redosleda ćelija u svesci – moguće im je menjati mesta metodom "prevuci i pusti" (drag & drop);
- Kopiranje ćelija između svezaka je takođe omogućeno *drag & drop* metodom;
- Više različitih pogleda na istu svesku – moguće je jednu istu svesku pregledati bez i sa izvršenim kodom što je korisno za pregled *markdown* sadržaja;
- Moguća upotreba konzole gde se vidi istorija izvršenog koda;
- Tema sa tamnim bojama pogodna za rad u večernjim časovima;
- Iz tekstualnog fajla sa kodom (u editoru) može da se izveze fajl u konzoli i tako testiran fajl prosledi saradnicima;
- Simultano pisanje i pregled markdown sadržaja;
- Jednostavan prelazak na okruženje *Notebook*-a ukoliko se za to ukaže potreba – u URL adresi deo /lab zameniti sa /tree.

Trenutno je u postupku razvoja distribucija *JupyterLab*-a pod nazivom *JupyterLite* koja je napravljena na bazi njegovih komponenata i koja se u potpunosti pokreće u veb-pregledaču podržana jezgrom jezika iz veb-pregledača. To znači da nema potrebe za pokretanjem servera na vašem računaru.

Kako na zvaničnom *Jupyter* blogu navodi Jeremy Tuloup, jedan od saradnika na projektu [12], „cilj projekta je da obezbedi lako računarsko okruženje dostupno za nekoliko sekundi jednim klikom, u veb pretraživaču, i bez potrebe da se bilo šta instalira na uređaju krajnjeg korisnika. Sa distribucijama u pregledaču, nema potrebe da se obezbedi okruženje za izvršavanje u pozadini. Pošto je aplikacija uglavnom skup statičkih datoteka, lakše se skalira, a takođe je i lakša za implementaciju."

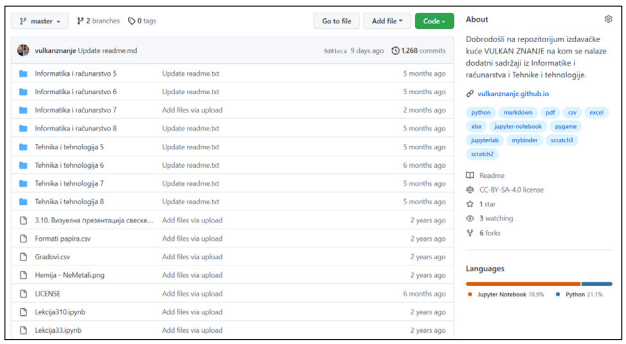
Pored toga, prednosti *Jupyter Lite*-a kada je reč o njegovoj upotrebi u nastavi su:

- Nema potrebe za instalacijom na računarima u školi i kod kuće;
- Nema pokretanja lokalnog servera te se sprečava situacija koja se veoma često događa na času - da učenici slučajno zatvore server i da im zbog toga radne sveske ne funkcionišu;
- Kada se pokrene i učita sve u veb-pregledaču, može da radi bez veze sa internetom (*offline*),

4. ONLAJN REPOZITORIJUMI NA *GITHUB*-U

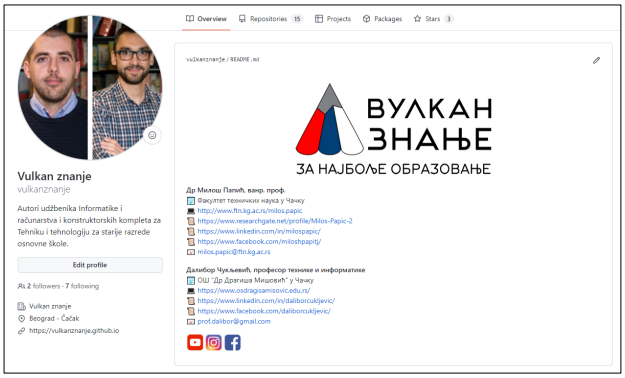
Izučavanje sadržaja koji se odnose na upotrebu okruženja iz projekta *Jupyter* je u tesnoj vezi sa servisom *GitHub*. Naime, na pomenutom servisu postoje unapred postavljeni podaci od strane drugih korisnika koji se mogu koristiti za obradu, analizu i vizuelizaciju u okruženjima *Jupyter Notebook* odnosno *JupyterLab*.

Na *GitHub*-u postoje i kompletni repozitorijumi sadržaja korisnih za upotrebu u nastavi kao što su sveske sa postavljenim zadacima koje učenici treba da reše; CSV fajlovi koji se učitavaju u sveskama i iz kojih se podaci koriste; prateći fajlovi poput slika u PNG ili JPEG formatu, PDF fajlovi, i dr. Jedan od takvih repozitorijuma se nalazi na veb-adresi https://github.com/vulkanznanje/Fajlovi i prikazan je na slici 1.



Slika 1. *GitHub repozitorijum*

Da bi prikazani repozitorijum nastao, autor istog najpre mora napraviti nalog na *GitHub*-u. Izgled glavne strane za jedan nalog je prikazan na slici 2. Glavna strana najčešće sadrži fotografiju autora i kratak opis, kontakt podatke, itd. Za oblikovanje teksta i umetanje grafičkih elemenata je potrebno poznavanje jezika *Markdown*.



Slika 2. *Glavna strana korisničkog naloga na GitHub-u*

Na jednom nalogu se može napraviti više sopstvenih repozitorijuma ali se korisnik može povezati (*fork*) i sa postojećim repozitorijumima i prilagođavati ih po potrebi na svom nalogu.

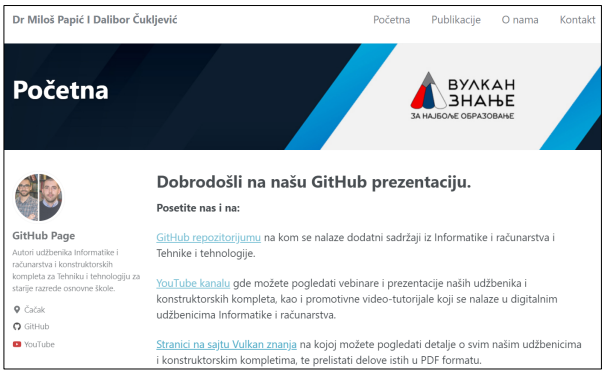
Pored toga što se neometano mogu koristiti tuđi materijali, ova karakteristika je značajna za dalji razvoj i unapređenje istih, kao i za socijalno umrežavanje – *GitHub* se može posmatrati kao svojevrsna društvena mreže jer svaki korisnik ima svoj CV, kontakt podatke, itd. Takođe, svaki korisnik dobije obaveštenje o povezivanju drugih korisnika sa nekim od njegovih repozitorijuma.

Na GitHub-u se mogu pronaći instalacije za brojne korisne programe. Na primer, u repozitorijumu na adresi https://github.com/RexScratch/sb3tosb2 se nalazi program za konertovanje fajlova izrađenih u *Scratch*-u 3 (.SB3) u fajlove kompatibilne za *Scratch* 2 (.SB2). U repozitorijumu na adresi https://github.com/jupyterlab/jupyterlab-desktop se mogu pronaći instalacioni fajlovi sa uputstvima za instalaciju *JupyterLab Desktop*-a koja je jednostavnija od svih drugih dostupnih instalacija desktop verzije ovog okruženja.

4.1. GitHub Pages

Nastavnik preko *GitHub*-a može napraviti i svoj sajt odnosno internet prezentaciju (slika 3). Za ovu svrhu se koristi servis *GitHub Pages* čija je najveća prednost (pored jednostavnosti upotrebe) to što se ne plaćaju domen i hosting.

Internet prezentacija prikazana na slici 3 se nalazi na veb-adresi https://vulkanznanje.github.io/. Za svaku prezentaciju se određuje ekstenzija domena *github.io* dok se naziv domena prilagođava nazivu *GitHub* naloga ili nazivu repozitorijuma na osnovu kog se pravi prezentacija (*GitHub Page*).

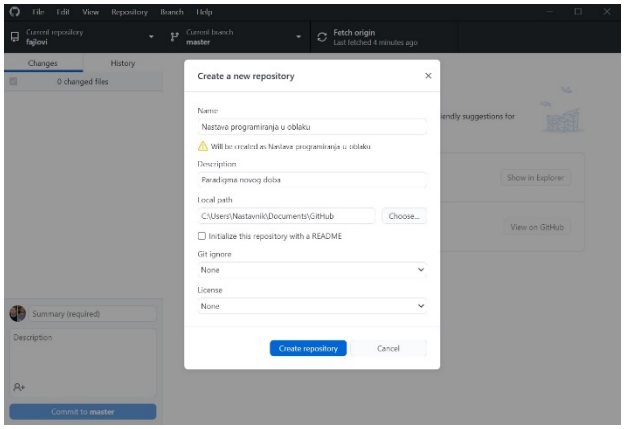


Slika 3. *GitHub prezentacija (lična strana)*

Za izradu *GitHub Page*-a nije potrebno poznavanja *HTML*-a i *CSS*-a, kao ni elementarno predznanje iz nekog od dostupnih *CMS* sistema (*Wordpress*, *Joomla*...).

4.2. GitHub Desktop

Korisnici koji ovladaju upotrebom prikazanih servisa, mogu instalirati *GitHub Desktop* koji dodatno pojednostavljuje rad sa repozitorijumima i manipulaciju sadržajima u njima. Instalacioni fajlovi za *GitHub Desktop* se nalaze na veb-adresi https://desktop.github.com/.



Pored intuitivnog korisničkog interfejsa, prednost ovog programa je što se rad sa repozitorijumima može obavljati offline a da se kasnije, nakon povezivanja na internet, sve izmene sinhronizuju.

Po osnovu prethodno navedenog, može se konstatovati da *GitHub* može biti veoma koristan za nastavnike koji žele da unaprede i dodatno personalizuju svoju nastavu.

5. *GOOGLE COLABORATORY*

Google Colaboratory (skraćeno *Google Colab*) je nastao krajem 2017. godine kao *Google*-ov servis koji predstavlja analogiju projektu *Jupyter*. On je zasnovan na *Jupyter Notebook*-u pri čemu *Colab* sveske predstavljaju *Jupyter* sveske koje hostuje *Colab*.

Colab sveke se mogu čuvati na *Google disku* i deliti sa drugima tako da se mogu saradnički uređivati. Mogu se preuzimati u izvornom *Jupyter* formatu **.ipynb**. Nisu potrebne dodatne instalacije modula da bismo mogli da učitamo svesku sa *Google diska* i pokrenemo bilo koji kod jer su moduli već instalirani u okviru *Google Colab*-a.

Za *Colab* u celini nije potrebna nikakva instalacija jer se usluga u potpunosti izvršava u oblaku. Tu leži i očigledna mana *Colaba* – ne može se ni u kakvoj varijanti koristiti offline. Kao i svi drugi *Google*-ovi servisi, *Colab* je potpuno besplatan. Za njegovu upotrebu je samo potrebno posedovati *Google* nalog.

Prilikom rada u *Colab*-u, koriste se resursi *Google* servera umesto sopstvenog računara. Ovo je značajno jer pokretanje *Python* skripti često zahteva mnogo računarske snage i može potrajati, tako da pokretanjem skripti u oblaku ne morate brinuti o jačini računara. Ipak, *Google Colaboratory* nema neograničene resurse, te za napredne projekte postoji *Colab Pro* – verzija *Colab*-a koja nije besplatna.

U *Colabu* se može klonirati *GitHub* repozitorijum, te učitavati pojedinačni fajlovi sa *GitHub*-a.

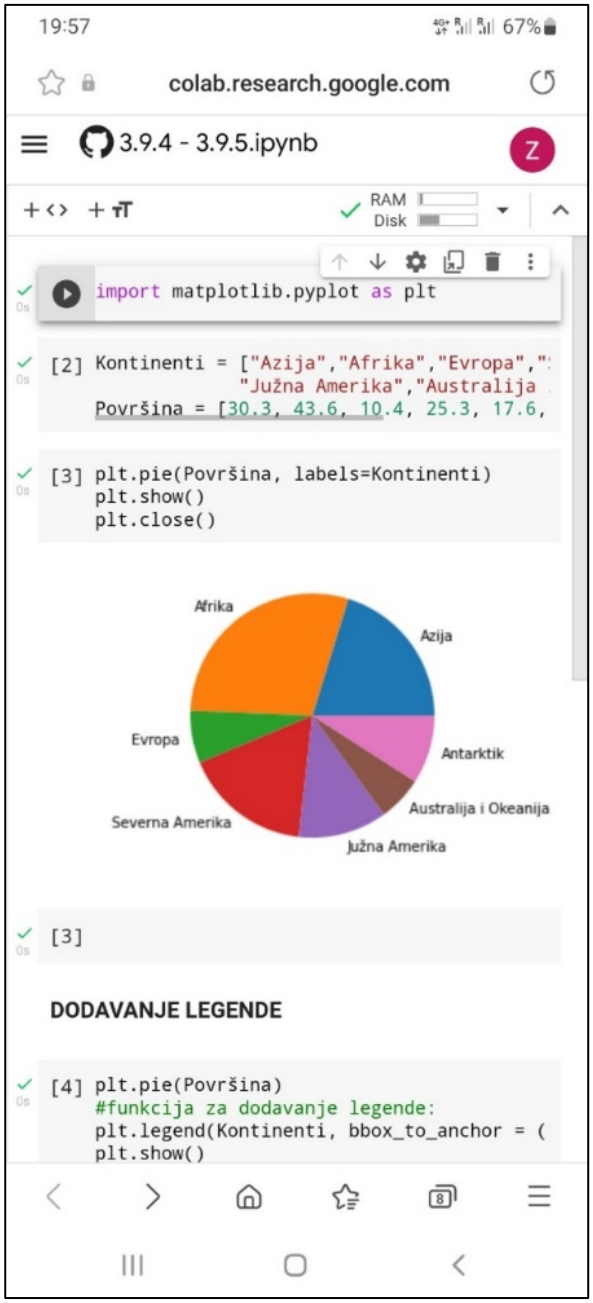
Colab ima značajnu kolekciju predefinisanih delova programskog koda – isečaka (*snippet*) koje možete jednostavno da uključite u svoj kod. Na primer, ako želite da automatski upišete podatke u *Google* tabelu, postoji isečak (snippet) za to u *Google* biblioteci. Osim ponuđenih isečaka, mogu se napraviti i sopstveni isečci za radnje koje se često obavljaju.

Sagledavajući pojedinačne nastavne jedinice iz oblasti Računarstvo u osmom razredu, može se konstatovati da ne postoji nastavna jedinica koja se ne može realizovati u *Google Colab*-u. Moguće je uvoziti sve biblioteke koje koristimo u nastavi pri čemu nema instalacije specifičnih biblioteka jer su sve već instalirane. Moguće je snimati fajlove na *Google* disku ili na *GitHub*-u; preuzimati sveske u .ipynb formatu; čuvati ih u drugim formatima (txt, csv, xlsx), te uvoziti iz tih formata. U ćelijama se osim kodova može dodavati tekst (*markdown*) ili slike.

Najznačajnija prednost *Colaba* sa aspekta nastave je u tome što je moguć saradnički rad tako da se određeni segmenti nastave mogu realizovati kao rad u paru ili grupni rad. Ovo je veoma značajno kod izrade drugog projektnog zadatka.

Google Colab se može koristiti i na pametnim telefonima što se takođe može iskoristiti kao interesantna inovacija u nastavnom procesu (slika 5).

Za učenike koji žele da samostalno uče i istražuju mogu biti korisni ugrađeni primeri za učenje prvih koraka, te indeks sa dokumentacijom i pomoći.



Slika 5. *Google Colab na telefonu*

6. ZAKLJUČAK

Sfera IT je takva da se razvojna okruženja, alati i servisi neprestano inoviraju i unapređuju. Opredeljenje profesionalaca za određeni softver zavisi od specifičnih potreba projekta na kom se radi. U školama nije moguće obraditi sva okruženja ali to nije ni cilj. Kroz nastavu informatike i računarstva u oblasti programiranja učenike treba naučiti programerskom načinu razmišljanja. Stoga nastavnici zbog svoje širine u pristupu treba da prate razvoj oblasti i koriste određene prednosti inoviranih okruženja ukoliko ih smatraju korisnim za učenike. Radovi poput ovog imaju za cilj da kod nastavnika probude želju za daljim samostalnim istraživanjem i praćenjem trendova u predmetnoj oblasti što je u skladu sa konceptom celoživotnog učenja.

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Appendix B:

Enhancing digital and psychological resilience through peer networking in the online environment in times of crises ERASMUS+ project and interconnections

Notes:

Enhancing digital and psychological resilience through peer networking in the online environment in times of crisis: ERASMUS+ project and interconnections

DigiPsyRes Research Team
University of Kragujevac, Serbia

Within the TIE 2022 conference, a special thematic segment is dedicated to the current ERASMUS+ project (segment of the partnership in higher education) entitled "Enhancing digital and psychological resilience through peer networking in the online environment in times of crises – DigiPsyRes" (2021-1-RS01- KA220-HED000032204). This multidisciplinary project deals with the problem of the growing need for psycho-social support in times of crisis by enhancing digital and psychological resilience through peer networking in the online environment. The main goal of the project is to build capacities, readiness and procedures to empower students to enhance their digital and psychological resilience. The project is coordinated by the University of Kragujevac (2021-2024) and partner institutions are The University of Foggia, Italy, and The Kazimierz Wielki University in Bydgoszcz, Poland.

Starting with the main idea to create a more resilient student population in a digital environment during crises, the project will tend to achieve the following specific objectives:

- Identification and analysis of the students' psycho-social needs and difficulties in the distance education environment in times of crisis;
- Development of the framework for supporting students in overcoming the identified difficulties in the distance education environment;
- Development of training programs for providing horizontal (peer) support to students related to mental health and digital resilience, in an informed and confidential manner;
- Piloting and development of the initial training of students who will further on provide mental health support and enhance students' digital resilience;
- Establishing students' e-networks for the support, as well as networking of university's unites, centres and university community subgroups relevant for horizontal student's mental health support;
- Development of related e-sources for the network of students' support and relevant toolkit (portals, guides etc.);
- Raising awareness of the importance of digital resilience and psycho-social wellbeing of students in times of crisis.

In the long-term sense, this project aims to create the path for students to become a population that is more resilient in digital environments and ready to learn to be safe but open at the same time, and to accept the new ways of digital behaviour as part of their everyday life and work.

The project activities are designed in such a way to address each of these specific objectives through nine overall project results. One of the first activities was the development of the questionnaire to gather information and conduct the analysis of state-of-the-art including (a) identification of students' difficulties in personal, educational and social relations in the digital environment during a pandemic, and (b) identification of students' perception of the university support to their psychological resilience and wellbeing and digital resilience. These findings are presented in the Report on needs analysis research, which is intended to be the initial input for the development of the Guide for Digital and Psychological Resilience Support Networking where the partners will define instructions for HEIs on how to establish a network for peer support and enhancement of psychological resilience and digital resilience.

At this stage of the project progress, with the first objective being achieved (identification and analysis of the students' psycho-social needs and difficulties in the distance education environment in times of crisis) and the second one being opened (framework for supporting students in overcoming the identified difficulties in the distance education

environment), the TIE2022 Conference is hosting the following project dissemination activities: a round table, and a special thematic session.

A special thematic parallel session *Psychological and digital resilience*, is organized and completed with seven selected papers, all addressing different aspects of psychological and digital resilience of university students, teachers and institutions themselves in times of pandemic. The first three papers provide a closer look at the preliminary results of the research on psychological and digital resilience and perceived difficulties of students in Italy, Poland and Serbia during the Covid-19 pandemic. Two other papers present findings from their exploratory research of students' coping during the pandemic and discuss them in the context of self-determination theory and in the context of the organizational resilience of higher education institutions. The final two papers examine resilience from the perspective of university teachers, and provide a systematic approach to student peer support through building their capacities for collaborative problem-solving.

The roundtable is titled *Digital and psychological resilience support by networking and peer problem-solving.* The aim of the roundtable is to present two projects (DigiPsyRes and PEERSolvers) and discuss their intersections.

The project "The PEER model of collaborative problem solving: Developing young people's capacities for constructive interaction and teamwork" is the national scientific research project of the Faculty of Philosophy, Department of the Psychology, the University of Belgrade, supported by The National Ministry of Education, Science Technological Development of the Republic of Serbia.

Peer support is addressed as a set of complex social skills based on collaborative competencies and peers' understanding. Although it is one of the results of socialization, peer support demands learning the procedures for mutual support, especially for networking support.

The main common focus of both projects is related to peer support, peer problem-solving and networking in the context of supportive participation in the community, as well as enhancing the resilience of young people and their social activity (presented in detail in Table 1).

Table 1. DigiPsyRes and PEERSolvers projects summaries

Project title: Enhancing digital and psychological resilience through peer networking in the online environment in times of crises **Acronym: DigiPsyRes**	**Project title:** The PEER model of collaborative problem solving: Developing young people's capacities for constructive interaction and teamwork **Acronym: PEERSolvers**
The project has been funded with support from the European Commission, under Key Action 2, Erasmus+ Cooperation partnerships in higher education. This project aims to address the problem of the growing need for psycho-social support in times of crisis by enhancing digital and psychological resilience through peer networking in the online environment. The project develops training programs for peer support to enhance psychological and digital resilience based on the peers' competencies supportive for collaboration and teamwork, and establishes a procedure of students' networking and the supportive network at three universities: the University of Kragujevac, Serbia, The Kazimierz Wielki University in Bydgoszcz, Poland, and the University of Foggia, Italy.	The project is supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia, program ''Ideje''. The development of soft skills – especially those required for collaborative problem-solving (CPS) and teamwork – is a prerequisite for both individual and societal progress in the contemporary world. Recent research suggests that these skills do not emerge spontaneously but need to be supported and scaffolded. The Project aims at establishing a valid, evidence-based approach to building young people's capacities for constructive interaction and CPS. In specific, it seeks to implement and test an innovative model of intervention, positing four elements of effective CPS: Personality, Exchange in dialogue, Emotional intelligence, and Resources (hence, the PEER model).
Link: https://digipsyres.kg.ac.rs/	**Link**: https://peersolvers.f.bg.ac.rs/about/

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Nasl. str. prištampanog teksta 1: Appendix A: Symposium "Technics and Informatics in Education: School Teachers for Teachers". - Nasl. str. prištampanog teksta 2: Appendix B: Enhancing digital and psychological resilience through peer networking in the online environment in times of crises ERASMUS+ project and interconnections. - Radovi na srp. i engl. jeziku. - Tekst štampan dvostubačno. - Tiraž 100. - Str. III: Preface / Ivan Milićević. - Str. IV: President's Foreword / [Dragana Bjekić, Nebojša Mitrović]. - Bibliografija uz svaki rad.

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1. Fakultet tehničkih nauka (Čačak)

a) Образовна технологија - Зборници b) Техника - Образовање - Зборници c) Информациона технологија - Образовање - Зборници d) Учење на даљину - Зборници e) Наставници - Стручно усавршавање - Зборници

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