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Preface

Eighth international scientific conference Technics and Informatics in Education – TIE 2020 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.

Some 64 papers have been submitted within various fields of technical, IT and technology-supported education at all educational levels – primary, secondary, higher education and education for adults. After reviewing, 57 papers were accepted for the current edition of Proceedings in the form of plenary lectures and original scientific papers. Five 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 2020.

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

Articles in the *Proceedings TIE 2020* are organized by the following topics:

- Plenary lectures
- Technics, Technology and Informatics in Education
- Teacher Professional Development and General Education Topics
- IT Education and Practice
- Engineering Education and Practice

Special activities within the Conference are the following:

- Round Table – 45 years of university education of technics and technology teachers in Čačak
- Open discussion and poster-presentation session:
  - Higher Education (HE) development in the realm of technics and technology;
  - Results of HE development projects 2017–2020, programme activities of Ministry of Education, Science and Technological Development (15 projects of the Faculty of Technical Sciences Čačak).

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

Chairmen's Foreword

Dear participants,

In the light of on-going, worldwide effects of COVID-19 and following the recommendations of international and national health authorities, Faculty of Technical Sciences Čačak organized the eighth international scientific conference 'Technics and Informatics in Education – TIE 2020' as an ONLINE MEETING. Even though this was completely new experience for the organizing committee, all technical details during the conference went on quite well. The scientific and organizing committees put in all necessary effort to organize the conference in new conditions.

The aim of this conference was to improve the exchange of knowledge and experiences between experts, scientific associates and professionals from Serbia and European countries, engaged in the subject matter. The conference provided an analytical review of technical, technological and IT education, as well as education regarding technical, technological and IT achievements including teaching aids, educational assistive technology, student books, etc.

Serbia already has 50 years long tradition of organizing various forms of seminars, workshops and scientific conferences devoted to improvement of those education topics in primary, secondary and higher education.

A series of conferences, entitled Technics and Informatics in Education, organized by our faculty in last 15 years, exhibit a continuous increase and development in this field, bringing to all of us new education technologies. This assembly continues the tradition of gathering scientific associates and professionals in technical, technological and IT education. Those scientific conferences have a huge impact on the development of technical education in Serbia.

Special focus is on the importance of IT in technical and professional education and correlation with natural, social and education sciences. We hope that experience exchanged during the sessions will be very useful for all participants, and that debate and networking was enjoyable.

The conference results also provide the basis for planning development in technics and informatics education in Serbia, as well as the exchange of educational patterns in the region and coordination with European trends in this field.

We hope you had a successful and fruitful meeting. Thank you for your participation.

Nebojša Mitrović
Živadin Micić
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Organization

The 8th International Scientific Conference Technics and Informatics in Education - TIE 2020 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
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Reminder

45 years of technics teachers' university education in Čačak

1975 – the year when Čačak became a university city

Pedagogical–Technical Faculty Čačak (today Faculty of Technical Sciences) started its activities in 1975, in the times when the actual Socialist Federal Republic of Yugoslavia achieved its highest growth and development. The name of the faculty – Pedagogical–Technical (Pedagoško-tehnički fakultet – PTF) – directly defined and reflected its main domain, and the main direction of the development of the institution.

The Faculty was established in 1974 according to the Decision of the Assembly of the Educational Society of the Republic of Serbia (decision No.01.1235/6-01), as academic unit of the University of Belgrade. The first generation of students was enrolled in 1975, while the education process started in November of the same year. The establishing of the Faculty (PTF) was facilitated by the successful work of the Technical College Čačak during the period of 15 years. The Faculty was founded with the aim of educating and producing **teachers of technical education, teachers of electrical engineering and teachers of mechanical engineering,** since a lack of qualified teachers in these areas was evinced in primary and secondary education. The primary role of the Faculty was to educate and develop these teachers' profiles at university level, in order to develop technical culture and literacy of the generations expected to apply their knowledge in the technical-industrial areas of the country, as well as to continue the development of the technical-industrial area. This has remained as an important orientation of the Faculty since.

Pedagogical–Technical Faculty became an important lever for the education of university profiles, primarily in Central and Western Serbia, and in 1976 the Faculty became one of the founders (signatories of the founding document) of the University "Svetozar Marković" in Kragujevac, nowadays University of Kragujevac, the academic family to which the Faculty belongs.

The founding of the Faculty was justified by the response of the first generation of students who enrolled in the first year of studies, either as full-time or part-time students. Almost 300 applicants applied for 180 available places for full-time students, and over 200 applied for part-time studies. In the first generation of graduates, in the school year 1979/1980, 22 students gained the title of teacher (five teachers of technical education, fourteen teachers of mechanical engineering and three teachers of electrical engineering), upon which followed years of successful education of future teachers. Another 335 graduates gained the title of teacher by 1987/1988 the school year.

In the years of successful development of technics teacher studies, engineering profiles have been established on rich teaching and research experience of professors and teaching assistants whose professional development followed the development of their students – future teachers.

Besides the education of technical teachers specialised for work in primary and secondary schools, a wide range of engineering profiles were added within the faculty education in the field of technics. This brought about the change in the name of the Faculty to Technical Faculty Čačak in 1988.

Parallelly with changes in the labour market, study programs for the education of teachers of electrical and mechanical engineering were over time replaced by the study programs for graduates in electrical and mechanical engineering. The progress of study programs for the education of teachers of technical education has continued, while the programs for the education

of teachers of technics and information technology have been developed (since 1993), and for teachers of informatics afterwards.

The four-year study programs that students opted for until the introduction of legal changes in September 2005 (when the new Law on Higher Education, containing the so-called Bologna model of education, entered into force) resulted in: 1257 teachers of technical education, 791 teachers of technics and informatics, 168 teachers of mechanical engineering, 122 teachers of electrical engineering and 17 teachers of informatics.

The implementation of the Bologna Declaration brought considerable changes in higher education in Serbia. Due to the accreditation of study programs in 2009, the Technical Faculty was the first in Serbia to develop five-year integrated academic studies for future teachers, which enabled graduates to acquire the academic title of Master teacher of technics and informatics. A number of 347 master teachers have graduated from that study program so far.

Among the teaching staff of almost every school in Serbia, there is a teacher in the field of technics and informatics who has been educated and graduated at the Faculty in Čačak.

Following the achievements in the European education space, the growing presence of modern information and communication technologies in education, and the needs of the education system in Serbia, the Technical Faculty has developed one-year master academic study program in the field of e-learning, upon whose completion students gain the title of Master teacher in technics and informatics for e-learning. Since 2009, 89 students have gained this title. Simultaneously, master academic studies of subject teaching of electrical and mechanical engineering have been developed, which consequently grew into master academic studies of subject teaching for professional courses.

The content of educational, scientific and research activities "outgrew" the framework of the previous activities of the Faculty, bringing about another change of name of the institution in 2012 to the Faculty of Technical Sciences Čačak, University of Kragujevac, where both master teachers of technics and informatics (300 ECTS) and master teachers of professional subjects for different fields (60 ECTS) are educated today.

Changes and trends related to the choice of professions of future students have not bypassed the teaching profession, which evidenced lack of interest in the previous years. One of the aims of this conference is to popularize teaching profession and view it as one of the most valuable and noble professions.

We are proud to bring attention to the fact that to this day more than 2805 teachers and master teachers, educated at the Faculty of Technical Sciences Čačak, have been employed all over Serbia, surrounding countries, and at the institutions of European and non-European education space, and thereby they are promoters of both the technics, and the Faculty.

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Plenary Session

Keynote paper
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Using Moodle Platform in Evaluating the Electrical Engineering Practices

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Abstract: *In higher education, practical classes are very important since the quality of the achieved outcomes largely depends on its realization. In laboratories students work under the supervision of teachers and associates at defined terms and they do not have the opportunity to work independently without the supervision of teachers, associates or professional staff. Additionally, in almost all higher education institutions the staff is overloaded so students do not have the possibility to have additional terms. It is noticed that in the traditional laboratories, students are "lending" the results of certain measurements to colleagues from the other group or even to colleagues who will attend the same course next year. In addition to this problem, there has been a decline in motivation among students when it comes to the application of any classical method in both theoretical and practical teaching. This paper presents the evaluation process in higher education teaching and one approach to the forming of a model for the evaluation of practical Internet based teaching. This model was used to evaluate the practical work of the first-year students of electrical engineering.*

Keywords: *HE education, Moodle; model for evaluating; practical work*

1. INTRODUCTION

New technologies have a great impact on higher education, and the concept of e learning is very important in every segment. Changes in the educational process caused by the use of new technologies are evident, especially in the last decade. In classic classrooms new technologies have been used for quite some time, where various interesting tools are used to improve teaching and learning processes [1, 2]. During the COVID-19 pandemic, the classic classroom has been replaced by a virtual one, and new technologies have come to the fore [3, 4]. All these changes have affected both teachers and their way of teaching, and students and their way of learning. In addition to the classic way of teaching in higher education institutions, various tools are used, such as Moodle [5], web portals, video materials, video conferencing, etc.

The Moodle platform has been used for many years along with the traditional way of teaching at the faculties where the authors work [6 - 13]. Moodle makes work easier for teachers and their associates in a way that they use it as a source of teaching materials, as a bulletin board, for communication with students, testing and automatic generation of the testing results. Moodle is important for students for several reasons, of which we highlight unlimited access to teaching materials, the ability to self-test their knowledge by taking quizzes composed of various types of questions, forums discussions and informing about classes and tests. The possibility to use all these resources via mobile phones is another good side of the Moodle platform which is especially important to students [14]. In addition to the traditional written materials, video materials can also be posted, as well as links to other activities such as online lectures. The use of the Moodle platform in the teaching process in higher education has become particularly important in recent months due to the transition to the online classroom caused by the COVID-19 pandemic. Moodle platform is significantly important because it enables sharing of resources with other higher education institutions.

In higher education, practical classes are one of the most important segments which affect the quality of learning outcomes and allow students to perform better in employment assessment tests. Practical classes are recognized by the law [15, 16] and by special criteria for education of engineers [17]. Practical classes are implemented through special teaching units (or subjects) and/or through exercises within teaching disciplines. Quality practical training on concrete practical examples

enables students to gain experience which is of great importance for their professional work after the graduation. As part of the teaching process, practical classes are evaluated in a way which depends on the area or subject.

The aim of this paper is to present a way of evaluating of higher education teaching with special emphasis on electrical engineering practices.

2. EVALUATION OF HE TEACHING PROCESS

The quality of the implementation of the higher education teaching process is monitored through various types of evaluations. Evaluation is a process of monitoring, measuring and evaluating effects and processes in education, and can be conducted through monitoring activities and processes (process evaluation) and determining the effects at the end of the process (effect evaluation) [18]. Evaluations can be internal or external depending on the evaluator, and aims to improve the education system and teaching process.

The theory and practice recognize three basic approaches for teaching in higher education. The first approach is lecture-oriented, often called traditional approach, and has the teacher in the center of the teaching process. In the second approach, the teacher can also appear as an organizer of learning-oriented activities. The third approach puts the student at the center of the teaching and learning process [19]. Assessment is a process where teacher performs verification and ranking the work of students, and is intended to continuously monitor students during the semester. Assessment of student learning outcomes is done through tests and various types of tasks. It includes the way teacher conducts the process as well as the communication with students. Thus, assessment aims to: check and evaluate learning, communicate to students, then motivate students to further work, learn, and organize the transition from one phase of study to another [20]. Checking and grading student work must be directly related to learning outcomes. It is important to emphasize that the verification and evaluation process should be objective, ie reliable, transparent and fair. A well-conducted assessment method will encourage students to further learn and improve, so it is important to pay attention to each segment of the teaching process.

It has already been pointed out that practical teaching is an integral part of engineering education. The evaluation of practical teaching in the education of engineers is very complex [13], [21-24]. Namely, if it is a question of realization of only one laboratory exercise, it is necessary to prepare it, both by teachers and assistant, and also by students. This is followed by the practical realization of the exercise in the laboratory where access is strictly limited, ie. a student cannot work without the presence of a teacher or assistant. It is known that the workload of teachers and assistants is very high, so if students do not use the scheduled term for work, usually do not have another opportunity to perform the exercise. After successfully completing the practical exercise, student prepares a report. After all completed exercises, student prepares a practicum of laboratory exercises and at the end of the semester defends the exercises, usually orally. Such approach may not lead to an objective assessment of the practical work and real knowledge of the student.

In order to achieve objectivity, as well as to obtain a comprehensive picture of the student's practical work, we suggest that electronic tests should be used to evaluate practical work, which have been widely used for quite some time [25]. Electronic tests can be realized in two ways, namely to replace the classic test with a computer-supported version or by applying special testing software that enables the application of completely new forms of tasks [18]. The computer-aided test provides significant advantages [26] such as: simple test compilation process, possibility of randomly generated questions, time limit, reduced probability of scoring errors, obtaining results immediately after the electronic test, etc.

Given that Moodle platform is very common in the teaching process of higher education the logical choice is to use its possibilities in terms of creating electronic tests for testing knowledge [1, 2, 27 - 31]. The desire to achieve objectivity in the evaluation of practical classes has imposed the idea of using the possibilities of the Moodle platform in order to form a database of relevant questions that faithfully reflect the practical work in the laboratory of electrical engineering [13].

3. MODEL DESIGN FOR EVALUATION OF THE ELECTRICAL ENGINEERING PRACTICES

This study has been realized at the Faculty of Maritime Studies Kotor of the University of Montenegro and at the Faculty of Technical Sciences in Čačak of the University of Kragujevac through a work on a joint bilateral project "An approach to forming a model for evaluating a practical Internet based education related to evaluation of electrical engineering practices [32, 33]. This section shows how to use Moodle (Modular Object-Oriented Dynamic Learning Environment) platform in the assessment of practical work for courses in the field of electrical engineering.

The Moodle platform is a free, online Learning Management System that enables lecturers to create their own private website anytime, anywhere, consisted of dynamic courses that extend learning process [5, 13]. This platform offers full support in holding online courses. Some

of the more important features of the platform are: production of multiple courses, schedule the plan of the courses (calendar), leading the course tasks, uploading different types of teaching materials, student examination and evaluation etc.

Moodle users when signing in, get different objectives, depending on the course there are attending. The most important role of users can be systemized to:

- Lecturers (they can update their courses, upload materials, evaluate students, check statistics etc.);
- Students (they can access uploaded course materials, take tests and quizzes, use tools for communication and group assignments etc.);
- Guests (they can check information about courses and if they have access, they can check certain course materials).

Moodle platform can organize information for course that comprises of different sections or to present it in a weekly form. For the electrical engineering course, we considered the option of the section form. The first section is always reserved for general and administrative information. In addition, the second section is consisted of information such as lecturer data, course calendar, news, forums etc. [2]. This is quite important as this platform provides lecturers more time for creating questions and study materials of higher quality.

Other sections can be organized in different ways. In the observed course, sections are organized by its course topics according to the course catalogue with corresponding materials updated each week. These are followed by sections that are reserved for practical teaching, student examination and records during the semester. In this manner, students have updated information about activities that need to be completed, so they could permanently follow the course and laboratory exercises.

Model design for evaluation of the electrical engineering practices is based on the Moodle platform performances, so that students can follow lectures and laboratory exercises, as well as to be examined by the available activity, i.e. Quiz (electronic test). Quizzes are a useful tool for students to test their level of knowledge [2]. The Question bank is structured through categories that contain multiple subcategories which are related to the different topics. Each subcategory consists of a sufficient number of questions (different types of the tasks) that serve as practical assignments. It is formed in order to objectively evaluate students' practical work through these electronic tests.

It is important to differentiate Question bank and Quiz. Subcategory questions are created independently from quizzes (electronic tests). Upon the creation of the appropriate Question bank we can form an electronic test as one of the Moodle platform available activity. Finally, the quizzes can contain different questions from subcategories using the option of random selection by the side of lecturer. In this way questions can be used wider in different electronic tests (quizzes).

Quizzes are a complex activity on the Moodle platform, with the possibility of using different kinds of questions. By forming quizzes from a Question bank (when creating questions, correct answers are provided) these can be objectively evaluated and students can see their results immediately after taking a quiz. In addition to these quizzes, there are parameters that can be set-up within the electronic test, such as: the date and time of the quiz availability, the number of attempts, the time for which the test should be solved, etc. If multiple attempts are allowed, the student will get different questions, respectively.

Also, Moodle platform provides a wide range of quiz types. For mentioned course in the electrical engineering, we chose the following types of questions: Multiple choice, True/False, Numerical and Drag and Drop items [5, 13]. Multiple choice questions are often created with four possible answers. When creating questions in the Question bank, one can choose to give negative points for answers that are not correct. One question (one correct answer) from the category Multiple choice questions is presented in Figure 1. The text of the question is: "The multimeter in the position from the Figure 1 is measuring:" where students can choose one of the four offered answers.

This question can be prepared in the form of True/False category (although this category of questions is consisted of two choices). The question can be reformulated to: "The multimeter in the position from the figure measures the direct current: "

When forming a question, the care should be taken how to clearly formulate it. We state that a certain question related to, for example, the connection of a measuring instrument can be asked within the same subcategory, but in different ways, so it implies different answer. For example, the question is: "Is the following statement true or false? In the circuit from Figure 2, the ammeter is correctly connected". The students can choose one of the two offered answers (True/False).

The image created for this task can also be used for the negative form question in the same subcategory: "Is the following statement true or false? In the circuit from the picture, the ammeter is not connected correctly".

A key aspect of the electrical engineering learning process is to develop the ability to solve practical problems and practices such as those encountered in the design of laboratory exercises. It is important to provide students with appropriate collections of

tasks/questions, electronic tests that will enable them to achieve the desired learning outcomes and continue with their studies.

Figure 1. *Example of Multiple choice questions (one correct answer)*

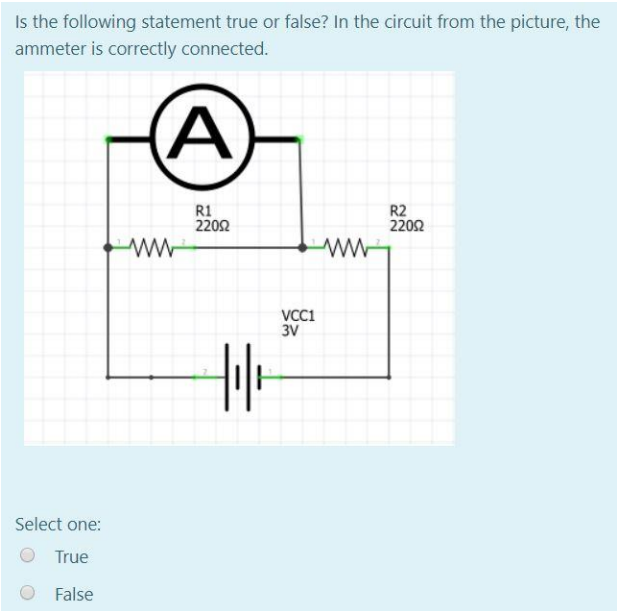

Figure 2. Example True/False question

4. CASE STUDY: EXPERIENCE AND STUDENTS' FEEDBACK

This section presents the analysis of model design conducted for first year students of the Faculty of Maritime Studies Kotor, University of Montenegro within the subject Fundamentals of marine electrical engineering and electronics I (winter semester) and Fundamentals of marine electrical engineering and electronics II (summer semester) in the part related to the evaluation of practical classes .

The model was initially based on questions type MCQs with four answers offered. The reason for this choice was the common practice of using this type of question in tests organized for students and seafarers when checking their knowledge by future shipping companies (preparation for the labor market) [34]. During the development of the appropriate question base, project team members explored various types of questions within the Moodle platform. Thanks to the ability of the Moodle platform to export and import questions, members of both project teams were able to exchange the created questions and modified it. On this way we got new ideas for creating other quizzes

Before the "final test" - an electronic test for assessing the practice of electrical engineering in the winter semester, students had the opportunity to familiarize with this type of knowledge test. No points were deducted for wrong answers. Also, they were given the opportunity to do the test once more to achieve a better result. The final test is reflected in the Faculty.

After completing the "final test" at the end of the summer semester, we surveyed students (N = 59). Here we publish students' opinions on:

1. objectivity of assessment by electronic test and
2. difficulty of the types of questions used.

The offered answers related to the objective assessment of the use of the electronic test can be found in Figure 3. It is used in the form of the Likert scale.

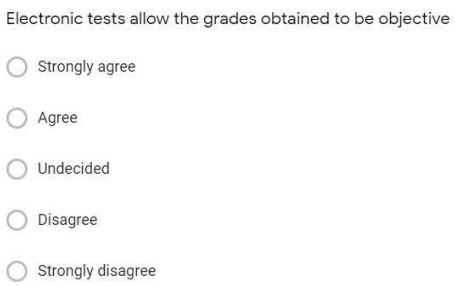

Figure 3. Question related to the objectivity of the electronic test

In Figure 4, we present the students' feedback regarding the objectivity of the use of electronic test. As it can be seen, the students agree with the benefits of quiz (with a share of 61.6%).

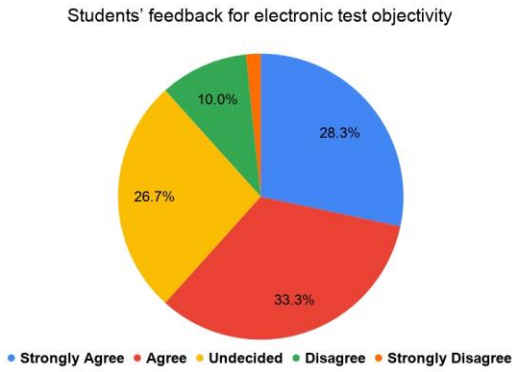

Figure 4. Students' feedback for electronic test objectivity

There are many types of questions on the Moodle platform that can be used to create a quiz (electrical test). Students 1 to 5 rated the difficulty of the questions: MCQ1-Multiple choice with one correct answer, MCQ2-Multiple choice with multiple correct answer, True/False, Numerical and Drag and Drop (grade 1 represents the "hardest" question and grade 5 the "easiest" question), as shown in Figure 5.

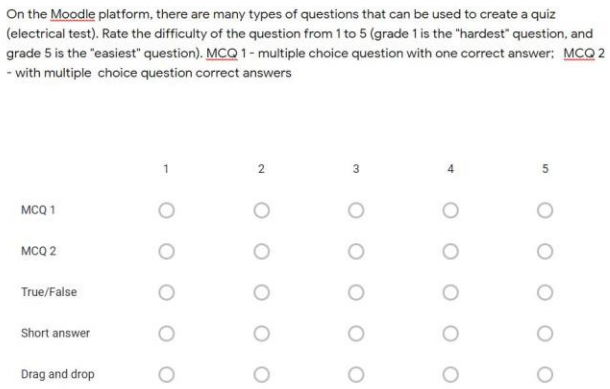

Figure 5. Question related to rated the difficulty of the different type of questions

Students' feedback about difficulty of different types of questions is shown in Figures 6, 7, 8, 9, and 10.

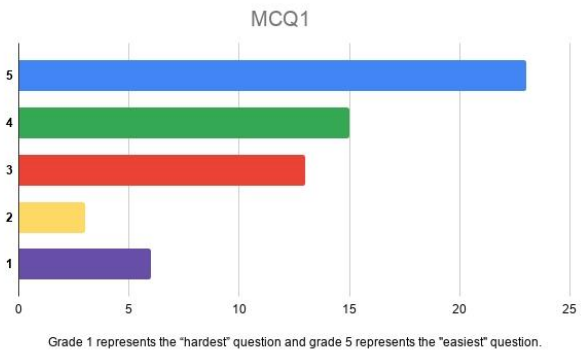

Figure 6. Students' feedback on the MCQ1

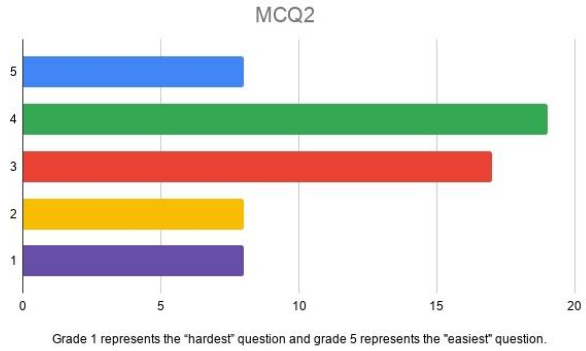

Figure 7. Students' feedback on the MCQ2

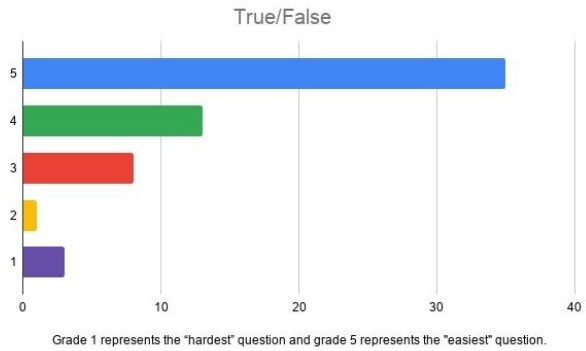

Figure 8. Students' feedback on the True/False question

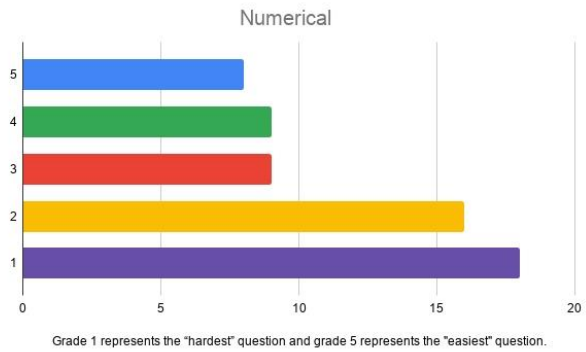

Figure 9. Students' feedback on the Numerical

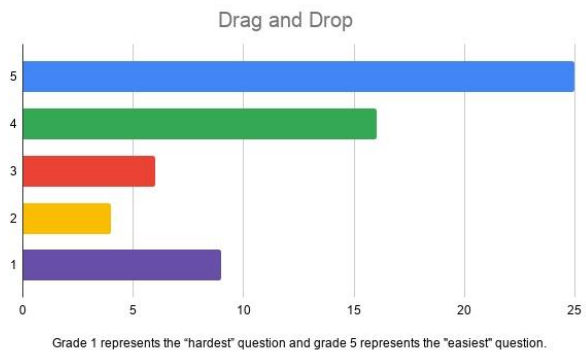

Figure 10. Students' feedback on the Drag and drop

According to the data shown in Figures 6-10, it can be seen that the easiest type of question for students was in the form of True / False, and the most difficult question type to understand and provide answer was Numerical question

4. CONCLUSION

First of all, the Moodle platform allows teachers to organize and manage the formed course in a good way. By using the tools available in Moodle to create teaching activities, the learning process becomes more engaging and increases students' interest in a particular area. Moodle also facilitates interaction between teachers and students, as well as between students themselves.

This paper presents an approach to forming a model for evaluating electrical engineering practices. The model is based on the formation of an appropriate bank of questions in which subcategories are defined with a sufficient number of questions to create a test. Some questions that faithfully represent practical work in electrical engineering are presented.

In order to improve the grading of practical teaching after the final test, the numerous interviews with students have been realized. Therefore, the related opinions about the objectivity and weight of practical teaching have been reported.

The experience gained using the presented model, as well as the ideas obtained through conversation with students and mutual dialogue of project team members of both institutions, enriched the created bank of questions and gave an idea for future joint work.

ACKNOWLEDGEMENTS

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Keynote paper
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The Role of International Standards in Education

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Abstract: *Well-organized education and training are the initiators of smart, sustainable, and inclusive growth. The new economy, characterized by constant and quick changes, requires constant improvements in the education system. Continued technological progress and the digital transformation of education require a systematic approach in line with international standards. There are numerous initiatives and activities for the development of standards and technical specifications. Standards ISO 21001 and ISO 29993 may help educational institutions to properly recognize the needs and expectations of various interested parties. Through an adequate application of a quality management system defined by the requirements of these standards, all the challenges faced by organizations that provide formal and informal education would be more easily overcome and achieving goals would be more effective and efficient. The technical specifications of IoT multimedia technologies and 5G immersive applications have a positive effect on the motivation and dedication of students, enabling real-time interaction in personalized environments. The global infrastructure and advanced services are the basis of success. It is necessary to continue the research of integrating new technologies into the process of education, the harmonization of standards and effective frameworks.*

Keywords: *Standards; ISO 21001; ISO 29993; 5G; IoT.*

1. INTRODUCTION

In the digital economy, the readiness and ability to constantly learn are becoming crucial for success, but also for survival, on the global market. The new economy, characterized by constant and quick changes, requires constant modifications to the education system. Successful modifications in education are carried out in accordance with the generally accepted standards. Technical standards are used in engineering courses by universities worldwide [1].

Organizing the planning, realization and evaluation processes of the provided education and training services, their advancement as well as improvement of all connected activities, competitiveness and comparability with the international instances and market [2], and most importantly – user satisfaction and the applicability of the acquired knowledge on all markets, taking into account the well-known criteria and demands, are sufficient reasons and justify the necessity of implementing and certifying standards ISO 21001 Educational organizations – Management systems for educational organizations – Requirements with guidance for use [3] and/or ISO 29993 Learning services outside formal education – Service requirements [4] within institutions of higher education, as well as in all other subjects included in the formal and informal education system [5].

ISO standards contribute to the implementation of the Goals of sustainable development set by the United Nations (SDG – Sustainable Development Goals), among which is SDG 4 – Education quality, which anticipates the securing of inclusive and quality education and the promotion of a possibility of lifelong learning [6]. The key initiators of smart, sustainable and inclusive growth are education and training, since they facilitate employment, improve productivity, innovation, competitiveness, reduce poverty, inequality and contribute to the achievement of gender equality [7].

Governments are investing in the digital literacy of their citizens. The EU European Commission's Joint Research Centre (JRC) has developed a digital competences framework called Digicomp [8] to help harness digital technologies' potential to innovate education and training practices. The United Kingdom Department for Education has created the National standards for essential digital skills [9]. These standards are intended to be used by organizations in the development of new essential digital skills qualifications.

2. CERTIFICATION OF EDUCATIONAL INSTITUTIONS

Standards ISO 21001 and ISO 29993 are based on standard ISO 29990 [10] whose goal is to unify the quality management systems and which was the foundation for the further development of the field of systematization and certification of education, both formal (through the implementation and certification of standard ISO 21001) and informal (ISO 29993). Constant technological changes and the emergence of new business models, the digital transformation of all fields of business, with particular implications for education, demand constant changes, whether formal in academic or vocational institutions, or informal through the development of „soft & hard skills", obtaining professional certificates which will gain additional importance through certification programs. Constant changes in education need to be carried out systematically, respecting certain principles which are primarily reflected and defined through the demands of the standards [11].

When it comes to the demands themselves, both standards recommend, but do not in any way limit or condition through the previous implementation of ISO 9001. ISO 21001 is a completely independent standard with a high level structure, completely harmonized with the settings of ISO 9001, while ISO 29993 is conceived as an addition to ISO 9001, but can also be certified completely independently, without any need for the previous implementation and certification of a quality management system according to ISO 9001. The focus in both is on facilitators and recipient of knowledge, i.e. the adequate analysis and distribution of user demands, with the defining of unique criteria of evaluation and assessment of the acquired knowledge. The biggest benefit is the classification and unification of the confirmation of achieved competences, which gains significance and recognition through the act of certification.

Through the implementation and certification of these two standards, comparability and transparency of services offered at the national and international level, increased efficiency and effectiveness thanks to the continued processes and evaluation tools which are a component of these international standards, as well as the final result – an increase in credibility of the educational organization which has the certified system are achieved. Of course, the certification of the management system always recognizes a certain group of interested parties as an end user, which is in this case the education service user, which has the aim of increasing the user's competences.

Educational institutions which apply ISO 21001 and ISO 29993 will more easily deal with challenges, achieve sustainable development and bigger credibility and influence in society.

2.1. ISO 21001:2018

ISO 21001 (Educational organizations – Management systems for educational organizations – Requirements with guidance for use) is adapted to the ISO 9001 structure and follows the existing trend of harmonization concerning coordinating and achieving a high level structure. ISO 21001 is clearly focused on students' needs, as well as on the constant improvement of the very service. The standard also includes advice which facilitates and increase the practicality of the very implementation within the service provider's organization.

As is mentioned in the ISO 21001 [3], the standard determines the demands for the management system for educational organizations (EOMS – Educational Organizations Management System) when such organizations have to show the abilities to support development and achieving competences through lectures, studying or research, aim to increase students' and other service users' (e.g. sponsors) satisfaction through the effective application of EOMS, including the processes for improving systems and securing harmonization with students' and other service users' demands, i.e. user competences achieved based on the education services provided. All demands of this standard are generic and intended for application on any organization which, through its educational programs, supports the development of competences through lectures, studying and research, no matter the type, size or method of education. Also, the standard can be applied on educational organizations within a larger organization whose basic activity is not education as such, but is not applicable to organizations which only produce or manufacture products for education and training, not providing any kind of education and training services.

2.2. ISO 29993:2017

The focus of ISO 29993 (Learning services outside formal education – Service requirements) is on processes and fields of system application concerning providing specific services. This standard [4] determines the demands for education services outside of formal education, including all kinds of lifelong learning (vocational training and in-house training, whether it is outsourced or provided in the company itself). All the aforementioned includes any kind of education service provided by the education service provider (LSP – *Learning Service Provider*), as well as sponsors who provide a service instead of the organizations themselves. The basic characteristic of this type of service is the defining of the goals of education and the assessment of services provided, as well as their performance through interacting with service users (the trained). The standard includes all education methods and techniques: face-to-face, e-learning or a combination of both.

3. IMMERSIVE MEDIA IN ONLINE EDUCATION

The application of IoMT (Internet of Media Things) technology has a positive effect on students' motivation and dedication, enables real-time interaction with abstract computer models and a complete personal experience of the education process [12, 13]. The Immersive Multimedia Experience is based on available and accessible AR (*Augmented Reality*) / MR (*Mixed Reality*) / VR (*Virtual Reality*) systems of augmented / mixed / virtual reality and telecommunication (5G mobile) conference systems [14, 15, 16, 17]. Continued technological advancement enables different alternatives with different levels of interaction and immersive experience. A high level of interactions and 3D reconstruction quality of a natural environment is desired. However, there is still no clear vision on how to integrate IoMT tehcnology and immersive media in the education process in a stable way.

3.1. Internet of Media Things

The IoT (Internet of Things) is a concept of connecting different objects (physical and virtual) onto the Internet infrastructure [18]. Interoperable information and communication technologies (ICT) enable the activation, transfer and analysis of data in intelligent advanced services environments. IoT characteristics support multimedia communications. However, multimedia applications are bandwidth-hungry and delay-sensitive. The rapid growth of multimedia traffic in IoT has paved the way for the innovation of new techniques to meet its requirements [12].

Internet of Multimedia Things (IoMT) devices are different from IoT devices. They require a bigger memory, higher computational power, and are more power-hungry with a higher bandwidth. The main characteristic of IoMT is the timely and reliable delivery of data. Therefore, it imposes strict quality of service (QoS) requirements and demands efficient network architecture. The users' perspective of QoS is known as quality of experience (QoE). IoMT enables applications based on the interaction between humans and devices (built-in, transferable and portable) in a complex multimedia environment based on global standards and effective frameworks. The key aspect of the IoMT based solution is massive scalability, widespread availability and cost-effectiveness of communication technologies [19].

The success of the IoMT depends greatly on the existence and effective operation of global standards. The standardization initiative, research projects, national initiatives and industrial activities are outlined in this section. There are already many standardization activities related to the IoMT, covering broad research areas. However, what is needed is a harmonization of standards and effective frameworks for large-scale deployment.

Several contributions to the full deployment and standardization of the IoT come from the scientific community. Among them, the most relevant are provided by the European Standards Organizations (ETSI, CEN, CENELEC, etc.), by their international counterparts (ISO, ITU), and by other standards bodies and consortia (IETF) [18].

The International Telecommunication Union (ITU) published Recommendations with the aim of promoting a unified approach in ITU-T for the development of technical standards enabling IoT on a global scale.

The ISO/IEC Moving Picture Experts Group (MPEG) is a working group formed by to set standards for audio and video compression and transmission. The Internet of Media Things and Wearables (IoMT) is a collection of interfaces, protocols and associated media-related information representations that enable advanced services and applications based on human to device and device to device interaction, in physical and virtual environments. The information refers to data sensed and processed by a device, and/or communicated to a human or another device. The MPEG IoMT standard covers five aspects addressed in individual parts as follows:

Part 1. Global architecture, use cases and common requirements

Part 2. System aspects (discovery, communication)

Part 3. Individual IoMTs, data formats and APIs (sensors & actuators, media processing & storage).

Part 4. Wearable IoMTs, data formats and APIs (smart glasses, camera, gesture recognizer, microphone, display).

Part 5. IoMT Aggregates combining individual IoMTs, eventually with other IoTs (smart offices).

The IETF is intensively working on a set of IoT-related standards. The IETF already has a decade of history specifying and documenting key IoT standards and guidance. IP and particularly IPv6 are the obvious choice for the IoT networking part, but the rest of the IETF IoT stack is currently undergoing a dynamic standardization process. The core IETF IoT protocol stack, as published in RFCs, is mature and suitable for deployment.

IEEE is a global, professional engineering organization whose mission is to advance technological innovation. The IEEE Standards Association (IEEE-SA), a globally recognized standards setting body within the IEEE, develops consensus standards through an open process that engages the industry and brings together a broad stakeholder community. IEEE standards set specifications and best practices based on current scientific and technological knowledge. The IEEE-SA has a portfolio of over 900 active standards and more than 500 standards under development. In its research into IoT, it has identified over 140 existing standards and projects that are relevant to the IoT.

Also, IEEE has created a Working Group VRAR (Virtual Reality and Augmented Reality) under the P2048 standard. Part 1 specifies the taxonomy and definitions for VR and AR devices. Part 2 specifies the taxonomy and quality metrics for immersive video. Part 9 specifies the taxonomy and quality metrics for immersive audio. By dividing immersive video/audio into different categories and levels, this standard could reduce the confusion nowadays.

3.2. 5G Immersive Applications

In terms of standardization, immersive media experiences (IMEx) has triggered multiple activities in the areas of coded representation of immersive audio, image, and video signals, as well as quality metrics for immersive services and applications. The goal of SDO activities is to document requirements, collect material to assess algorithm performance in reference models under common test conditions, and study methods for QoE assessment. Experts groups specify the taxonomy and quality metrics, develop a test methodology, study models of immersion, experience metrics and their measurability in immersive services. Industry forums and consortia develop frameworks for the interoperability of services and applications, establish and recommend best practices and guidelines.

As new use cases for a fully immersive AR and VR experience are introduced on the market, service providers will need to address bandwidth limitations, reduce E2E network latency and improve the overall QoS/QoE for streaming media services. The increased bandwidth capacity and decreased latency of new generation 5G networks will allow access to complex 3D immersive AV experiences [20]. These cutting-edge technologies superimpose digital data onto the physical world and enable computers to generate simulations of 3D images or create 3D environments.

Exploiting the immersion that it offers, VR technology is being increasingly used in fields such as entertainment, video games, training, and design. Early AR applications focused mostly on the entertainment and gaming industries, but current advances in the field have led to major interest from sectors such as education, professional training, knowledge sharing and collaborative environments.

5G wireless multimedia communication is a technology enabler for a massive market and ecosystem. It rather requires standard organizations and industry consortiums to work collaboratively with their own expertise and requirements for 5G in order to develop a healthy ecosystem with a unified 5G standard. 3GPP as the core standard developing organization for 5G communication technology has been at center stage of cross-industry efforts and has been evolving to be more open and flexible.

The 3GPP has been conducting standardization work on immersive media since its launch of 5G-targeted standardization activities in 2015, starting with the completion items in SA1 (*Requirements*) and SA4 (*Codecs and Media*) working groups.

- SA1 developed a set of use cases on immersive media in Release 14 TR22.891 and later in Release 15 TS22.261 for 5G stage 1 development, which described requirements toward supporting VR and interactive conversation use cases, including relevant latency requirements for video and audio.
- SA4 technical report TR26.918 documented a broad range of on-demand and live streaming, broadcast and conversational VR use cases, relevant VR technologies for audio and video and various subjective quality evaluations.

Immersive services such as AR/VR, UHD and 3D video have a crucial requirement, and the 5G network will be able to transfer this data traffic in a flexible and efficient manner. It is necessary to take into account the following three aspects: content quality, network constraints and device limitations. The user's device plays an important role in the E2E user experience. Therefore, 3GPP is working on

- Technical evaluation of the subjective quality of the relevant parts of the E2E system needs to be performed to assess the overall QoE.
- The full technical description and either an implementation of these blocks and/or performance requirements are required to ensure the tested QoE.

Higher picture quality is a general trend for all services and devices. With the expected increase of personal HMDs and new content generation devices, researchers have recently started to quantify, model and manage QoE when the user consumed content is beyond traditional audio and video materials. On the other hand, service providers seek to deliver as high a quality as possible, despite the growing associated costs and issues related to network capacity. Defining VR service–specific QoE metrics will allow 5G operators to understand and manage how end users are experiencing specific VR services. Based on these QoE metrics, operators may also perform problem analysis and troubleshooting. A VR-oriented E2E network operation and management system become crucial for understanding the user-perceived quality of immersive multimedia experiences. The VR video quality can be degraded by various faults which can be hard to separate or distinguish between. This necessitates the development of effective QoE-oriented E2E solutions at various points of the VR video delivery system for real-time monitoring, detecting and demarcating faults. This would enable service providers to enhance VR video streaming service experience through solution that can model and measure the perceivable media quality.

4. CONCLUSION

Standards ISO 21001 and ISO 29993 can aid educational institutions to recognize the needs and expectations of various interested parties and provide them with quality education throughout all phases in life the right way. Through an adequate application of quality management systems defined through the demands of standards ISO 21001:2018 and ISO 29993:2017, all challenges which organizations providing formal and informal education services face will be more simply overcome and achieving goals will be more effective and efficient.

Well-organized education and training are the initiators of smart, sustainable and inclusive growth. Special attention must be paid to digital transformation and changes in all spheres of life, including the digital transformation of education itself.

The global infrastructure and advanced services are the basis of success. The technical specifications of IoT multimedia technologies and 5G immersive applications have a positive effect on the motivation and dedication of students, enabling real-time interaction in personalized environments.

It is necessary to continue the research of integrating new technologies into the process of education, the harmonization of standards and effective frameworks.

Including education on standards and standardization integrated within the appropriate vocational courses into the programs of academic institutions, primarily in technical-technological fields, is also recommended.

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Program Translators Higher Education and Application of PP Simulator Educational Tool

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Abstract: *Software engineering higher education usually includes courses related to program translators (compilers/interpreters), which cover topics: compiler construction, formal grammars, programming languages formal grammars and other formal representations (such as extended Backus-Naur Form), automata theory etc. Aim of this paper is to present overview of the current state in higher education of program translators and to describe the pragmatic approach that has been established at Technical Faculty "Mihajlo Pupin" Zrenjanin, Serbia with creating and using PP simulator educational tool. The developed tool helps students learn about the lexical, syntax and semantic aspect of programming code quality, which is to be determined by the compiler simulator "PP simulator". Teaching results from Technical Faculty "Mihajlo Pupin" Zrenjanin, Serbia at course Program Translators were also presented and discussed.*

Keywords: *program translators, higher education, educational tool, simulator, lexical analysis, syntax analysis, semantic analysis.*

1. INTRODUCTION

Following industrial trends, higher education needs to adapt in aim to enable students to have appropriate knowledge and skills needed for their professional engagements after graduation. During study time, students could also improve their knowledge/skills by being included in professional environments with internship and competitions organized by companies.

Modern software industry emphasizes agility of software development process and software product quality with having implemented constantly changing user requirements. These directions shift focus from using traditional programming languages to frameworks. Software frameworks and design patterns enable faster production and better quality of software products. Software frameworks are based on native (core) programming languages, but they have their specific grammars.

Regardless of native programming languages or frameworks usage, software quality particularly addresses detection and correction of possible code errors – lexical, syntax, semantic and run-time. In professional and educational programming environment, program translators (compilers, interpreters) are used for the purpose of translating programming code from higher programming language into machine code, while checking the code for errors.

This paper presents educational content, methods and results in teaching Program Translators (Serbian: name: "Programski prevodioci", abbreviated: PP) as a higher education course at Software Engineering bachelor studies at University of Novi Sad, Technical Faculty "Mihajlo Pupin" Zrenjanin, Serbia (abbreviated: @TFZR) in school year 2019/20.

The rest of this paper is organized as follows. Section two presents background and related work, section three describes higher education of program translators in Serbia, section four presents improvements of teaching Program Translators @TFZR with teaching content, methods, materials, assessment in school year 2019/20, section five describes PP simulator tool, section six presents teaching results including students experiments, while section seven presents conclusions.

2. THEORETICAL BACKGROUND AND RELATED WORK

2.1. Bloom's taxonomy

Benjamin Bloom (together with collaborators) published in year 1956 a framework for categorizing educational goals – Taxonomy of Educational Objectives, known as Bloom's taxonomy [1]. Initial Bloom's version explains main categories: knowledge, comprehension, application, analysis, synthesis, evaluation. Revised taxonomy has been performed by a group

of cognitive psychologists, curriculum theorists and instructional researchers, testing and assessment specialists in year 2001 [2] [3]. The authors of the revised taxonomy emphasize dynamism, by using verbs and gerunds to label categories and subcategories. This way, the attentions is drawn away from the "static" notion of educational objectives in Bloom's original title. "These action words describe the cognitive processes by which thinkers encounter and work with knowledge [3]: remember (recognizing, recalling); understand (interpreting, exemplifying, classifying, summarizing, inferring, comparing, explaining); apply (Executing, implementing); analyze (differentiating, organizing, attributing); evaluate (checking, critiquing); create (Generating, planning, producing). "In the revised taxonomy, knowledge is the basis of these six cognitive processes, but authors created a separate taxonomy of the types of knowledge used in cognition: factual knowledge, conceptual knowledge, procedural knowledge and meta-cognitive knowledge." [3]

2.2. Program translators

"On the very earliest computers, programs were written and entered in binary form. Some computers required the program to be entered one binary word at a time, using switches on the front panel of the computer. Because of that, the size and the complexity of the programs were severe limited, debugging was very difficult task and development of programs was very difficult and error prone. The idea was to use computer itself to ease the programmer's work, by translation from a more human-readable form of the program into executable binary code." [4]

There are several forms of program translation [4]: from assembly language code to binary coded instructions; from higher level programming languages to executable binary coded programs performed by compilers and interpreters; preprocessing with transformation from one higher level programming language to other lower level programming language, and then compilation is performed.

Programming languages grammars are presented usually with Extended Backus-Naur Form (EBNF) and syntax diagrams. ISO/IEC 14977 standard defines the elements and procedures of using EBNF [5]. Syntax diagrams [6] present graphical representation of programming language instructions syntax.

Programming languages include components [4]:

- Lexical – lexicon is a list of all legal words, together with information about the word (meaning, role);
- Syntax – define the form and structure of legal expressions of the language;
- Semantic – deals with the meaning of the expressions.

Formal grammars are used to present certain aspects of programming languages and translators, where Chomsky's linguistic-related research has created roots to this field [7].

2.3. Related work

Program translators' research has results closely tied with industrial advancements. In early years of higher-languages development, issues that researchers dealt with were related to special meta-languages for program translator construction [8], effectiveness [9], [10] and performances [11].

Recent program translators-related research and practical results deal with more advanced technologies, such as transformation from one higher language to another [12], multi-syntax programming languages [13] and embedded systems programming [14].

Research regarding programming languages education includes results in teaching formal languages [15] and comparative study of teaching two programming languages with the use of special tool for their automated translation [16].

3. HIGHER EDUCATION OF PROGRAM TRANSLATORS IN SERBIA

Higher education in Serbia in the domain of information technologies includes Program Translators at Bachelor and Master studies. In this section educational content will be presented from three Serbian Universities:

1. University of Nis, Faculty of Electronics – bachelor studies course [17].
2. University of Belgrade, Electro-technical Faculty – Bachelor studies course [18] and Master studies course [19].
3. University of Novi Sad, Faculty of Technical Sciences – bachelor studies course [20].

Educational contents at all faculties include: Formal languages, Automata theory, Lexical, Syntax an Semantic analysis of code, Symbol tables, Intermediate code generation and optimization, Code optimization, Program translators generators, Memory management, Virtual processors and machines.

The theoretical contents were illustrated at practical laboratory work by using simplified programming languages - MiniC [20] and MikroJava [18]. In aim to enhance their grammars, students use program translator generator tools, such as Flex [21], Bison [22], YACC [23] etc.

4. TEACHING AND ASSESSMENT IN COURSE PROGRAM TRANSLATORS @ TFZR in 2019/20

In aim to encourage students to be more active, gain more knowledge and have better results in assessment (comparing to previous years students' results), several aspects of education have been improved by the new subject professor Ljubica Kazi (assigned to theoretical and practical classes starting from school year 2019/20 @ TFZR):

- *Teaching content* has been put into a context of the modern industrial environment and other practical-oriented broader areas.
- *Teaching methods and knowledge/skills assessment* have been designed according to Bloom's taxonomy, particularly to be adaptable to students' abilities and preferences, as well as to improve interactivity with students during teaching and learning period.
- *Specific educational tool ("PP simulator")* has been developed as an educational tool - to enable students' experiments with compiler's work simulation.

4.1. Teaching content

In aim to enable students have better understanding of the abstract terms, defined as a core content of the course, the idea was to present the content within the broader modern industrial and practice-oriented context. This way, students could grasp the importance and usability of the presented theoretical concepts. Having this goal in mind, the focus on the most important topics of subject was not missed:

- Programming language grammar;
- Programming code errors;
- Compiler construction.

Background topics were presented at theoretical and practical lessons and linked with the core topic:

- Structured and object-oriented programming;
- Analysis and documenting of applicative software with UML;
- Software development with class libraries creation and linking;
- Programming integrated development environments;
- Abstract presentation of program specification (algorithms, flow diagrams, UML models).

Core theoretical topics included in teaching were organized as the sequence of logical flow, starting with topics previously familiar to students:

1. Types of programming languages, computer architecture, machine-dependent languages, definition of program translators;
2. Programming languages grammar – general linguistics and computer-based linguistics, formal languages and grammars, Chomsky's formal grammars categorization, forms of presenting programming languages grammars (EBNF, syntax diagrams);
3. Programming code errors – errors categorization (lexical, syntax, semantic, run-time);
4. Basics of functionality and construction of compilers – goals of compilers, compiler work phases, compiler architecture components, compiler working process variants, compiler components usability and functionality principles;
5. Automata theory – definition and categorization of automata, characteristics, using automata in language processing, Turing machine and Universal Turing machine.

Core practical topics in the laboratory work included:

1. Examples of compiler (C# desktop application with dynamic link libraries, i.e. class libraries) and interpreter work (PHP web application and XAMPP) in program errors detection, error types, messages, error handling, exceptions, validations of user inputs;
2. EBNF presentation of programming language grammar (C#, html, PHP)'
3. Compilation of structural and object-oriented code
4. Tools for program translator creation, creating, adjustments and using PP simulator as an educational tool.

Additional topics that were included in teaching content were selected in aim to put the core content into broader modern industrial and practice-based context:

- Code writing conventions and programming style,
- Test-based specification in agile software development,
- Domain knowledge and ontology languages, domain presentation, RDF,
- Software interoperability,
- Software frameworks and specific grammars, comparing native programming language and framework grammar,
- Cross-compilers,
- Linkers and module dependency,
- Software quality – standards, aspects (process, product, software in use), coding conventions and heuristics, programming style, code refactoring, software testing, agile test-based requirements specification, error processing in program code (Exceptions), principles of object-oriented program organization (SOLID), software performances, software metrics, structure aspect of software quality, code optimization.

4.2. Teaching methods and materials

Teaching period in school year 2019/20 for the course Program Translators (@TFZR) is, according to accreditation, planned for third year of study at Software Engineering Bachelor studies, for the "summer semester", starting in February and lasting to end of May. According to accreditation, students attend two teaching hours of theory and two teaching hours of practical laboratory work.

School year 2019/20 was specific due to appearance of Covid-19 (Corona virus) pandemic and the teaching period could be divided into 3 sub-periods:

1. *Pre-Corona virus lockdown period* – with regular classes, where students attended theory and practical work classes in classroom and computer lab. Theoretical classes were performed with oral and PowerPoint presentations (Figure 1), having theoretical and illustrative contents. In empirical part, practical work was performed as demonstrative analysis of software solutions, tools, grammars and related exercises that students were obliged to do with assistance of teaching staff. During this period, high level of interactivity has been performed at both theoretical and practical work and students' activities in discussions and solving problems were awarded with bonus points.

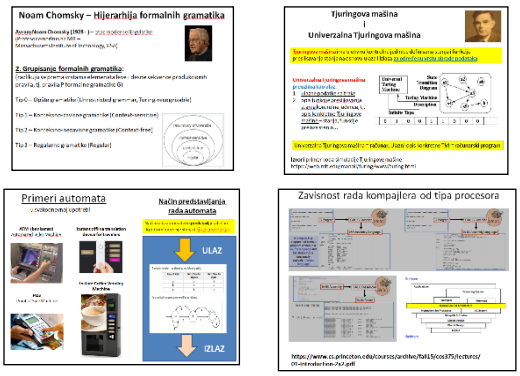

Figure 1. *Example of PowerPoint slides*

2. *Corona virus lockdown period* – online lessons, where electronic material (with theoretical content and practical content with illustrations of software solutions – source code of applicative software with class libraries and PP simulator, demonstrations with tutorials that explain the process and elements of solutions) was put on TFZR website at on-line teaching section within the course pages [24]. Students were offered to register at Facebook group PP@TFZR to receive frequent notifications about news and new materials that were submitted to on-line teaching section of Program Translators page at faculty website. Home works with practical orientation were included to replace the accreditation-defined "class attendance" points. To encourage students' interaction and activity, the aim was to have better learning outcomes by having students engaged during lockdown. There were two home work assignments:

   Homework 1 - input material was object-oriented applicative software (finalized version as continuing from regular practical classes) and the assignment was to create UML models to document the solution. Aim of this homework was to have students study the details of the applicative software, to understand and be able to make further analysis in next home work.

   Homework 2 - input was the same software solution as in home work 1, but with errors. The task was to start compiler and get report on errors, document lines of codes with errors, categorize errors, explain causes and correct them. The goal of second home work was to have students prepared for mid-term exam (with similar assignments).

3. *Post-Corona virus lockdown period* – elective classes, i.e. not mandatory classes. Students that wanted to attend, had to register for additional regular classes in classroom, with hygienic safety measures implemented. These classes were used for additional theoretical and practical explanations of on-line contents. These classes also had high level of interactivity with discussions, demonstrations of tools usage, students' questions and presentations of students' work.
4. *Students learning period* – work on their home works, projects and preparation for mid-term exam, as well as learning theoretical foundations. Practical learning work included empirical work with exercising in using, changing or creating program translators as tools, experiments with PP simulator work and other tools.

As a summary, during whole semester, *teaching methods* were selected in aim to increase students' attention and activity, so they included: presentations, illustrations, demonstrations, empirical work (experimental, practical work).

Special emphasize was put on preparation of *teaching materials*, which included:

- Power point presentations (examples presented at Figure 1);
- Theory text book;
- Handbook for practical work assistance;
- Simulation educational tool "PP Simulator" (Presented in section 5).

It is important to emphasize that theory text book was created to support only the core concepts of the course. Practical handbook included explanations, tutorial and examples for home

works, mid-term exam and project, as well as other topics included in core content. This way, students were given the essential source to prepare for all pre-exam elements and final theoretical exam. The books did not include additional content (background or additional industry/practical oriented content) in aim to avoid overload. The background and additional industry/practical oriented content were only presented during teaching time as illustrative for motivational and better understanding reasons. Knowledge in these fields was outside of the course boundaries, so the list of potential exam questions did not include these topics.

4.3. Knowledge/skills assessment methods

According to accreditation, course entitled "Program Translators" (PP@TFZR) includes three mandatory types of knowledge assessment:

- Mid-term exam (practical);
- Project (practical);
- Final exam (theoretical).

According to accreditation, in the grading points structure, the attendance at classes is also valued with certain points, but it does not encourage students to take active role in knowledge and skills development. Considering activity of students an important aspect of grading, additional bonus points were given to students that were collaborative in theory and practical work discussions or presented creativity and independence, preciseness and high level of details orientation during home works and regular class works.

Having enhanced Bloom's taxonomy as a starting point [1] [2], the assessment methods were designed at PP@TFZR to cover appropriate categories from the taxonomy (Table 1).

Table 1. *Categorization of knowledge/skills and appropriate assessment types at PP@TFZR*

Revised Bloom's taxonomy category	Type of knowledge/skills assessment at PP@TFZR
Create	Practical project
Evaluate	Mid-term practical exam
Analyze	Mid-term practical exam
Apply	Practical project
Understand	Mid-term practical exam Theoretical final exam
Remember	Theoretical final exam

Mid-term exam was organized to achieve pragmatic goal – to make students be able to detect program code errors, to classify them, detect causes and perform appropriate changes in aim to solve the problem.

Figure 2. presents an example of mid-term exam assignment, where students were given a software user interface, program code and compiler report about errors as input material.

The source code was the same one used for home works, but errors were made different. This way, students that regularly were active in home works could easily recognize code segments and benefit in faster tasks solving. Students task was, similar to second home work, to make classification of errors, explain them and provide solution with correctly written program code. Other type of assignment was to have correct program code and to make intentional errors of some type – lexical, syntax, semantic or run-time.

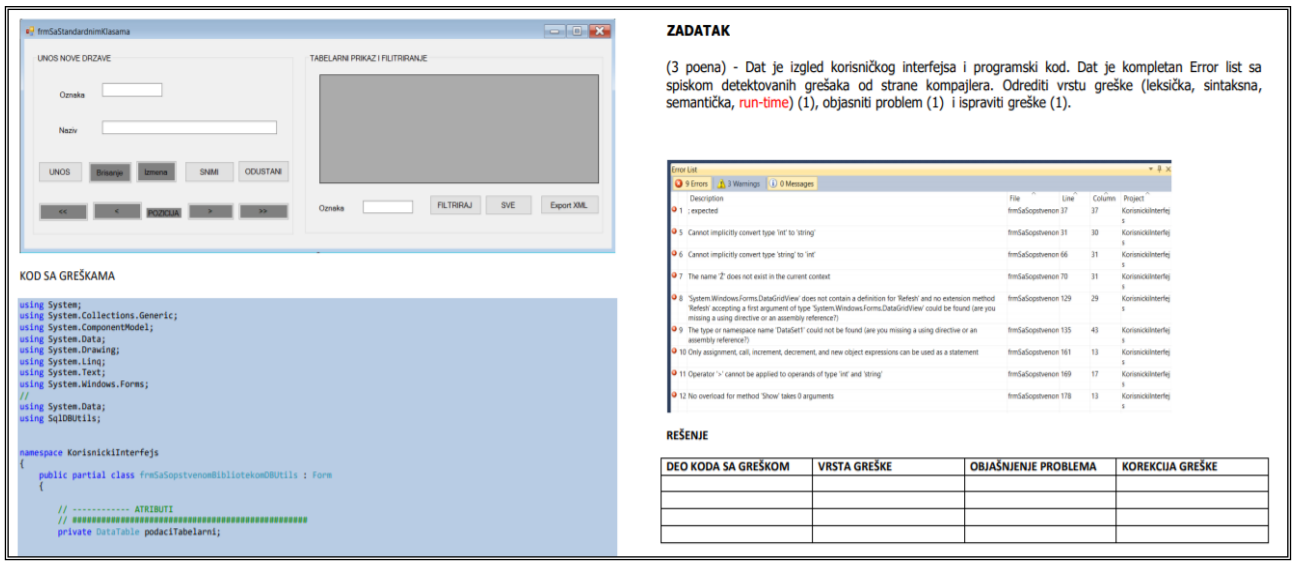

Figure 2. *Example of mid-term exam assignment at PP@TFZR in 2019/20 school year*

Project as a pre-exam practical work is designed to enable students to create, use or change a software solution in one of two mayor categories (elective):

1. Applicative software for certain problem domain
2. Compiler simulator that will have the functionality of analyzing lexical, syntax and semantic errors in program code segments or lines.

In aim to enable students to choose type of project (according to their self-estimation of knowledge, skills, available time, abilities, as well as their preferences/interests), there were 10 types of projects designed and offered to students to choose (with appropriate material and examples that are available for each type of project), as presented at Table 2.

Table 2. *Types of students' projects at PP@TFZR in 2019/20 school year*

TYPE	EXPLANATION OF PROJECT TYPE
1	Applicative desktop software, C#, using previously created Dynamic Link Library (DLL) for database connection and data operations, only changing an available example to different domain
2	Applicative desktop software, C#, using ready-made DLL for database connection, creating new DLL for data manipulation, changing an available example to different domain
3	Using compiler generator, for example GOLD [25], to analyze program code segment
4	Using compiler generator FLEX, BISON over the Mini C language, to expand the language grammar
5	Comparing grammars of two programming languages (e.g. C# and Java) with two applications over the same domain, with/without using database in the applicative software
6	Improving PP simulator to expand abilities to perform syntax and semantic analysis of program code – C# programming language
7	Improving PP simulator to expand abilities to perform syntax and semantic analysis of program code – other programming language (i.e. Java)
8	Creating program code analyzator for the programming language
9	Creating program code analyzator for the language used in programming (such as CSS, XML, JSON…)
10	Comparison of native programming language and framework with the example of applicative software

In any of these cases, software is created within certain development environment, which includes mandatory use of compilers - to detect errors and create EXE (executable file for desktop application) and DLL (Dynamic Link Library with classes) files.

As part of projects, students were assigned task to create errors intentionally, to have them categorized and corrected. If the PP simulator is chosen (project type 6 or 7), there were two types of errors to make intentionally:

1. Errors in program code line that represent an input to PP simulator (lexical, syntax, semantic);
2. Errors in PP simulator itself as an application (lexical, syntax, semantic and run-time).

5. PP SIMULATOR TOOL

During school year 2019/20 a tool for analysis of program line or segment has been developed by Ljubica Kazi at PP@TFZR. It was named "PP simulator".

PP simulator is able to analyze lexical, syntax and semantic aspect of quality of a program code line (Figure 3) and program code segment (Figure 4).

Work of PP simulator is based on:

- Predefined table of characters, that could be recognized as valid and categorized.
- Predefined table of words, i.e. character sequences that could be recognized and replaced with tokens.
- Predefined table of semantic patterns, considered appropriate syntax and semantic form.

In aim to make "PP simulator" work for particular programming language, it is necessary to have these tables filled with particular details related to the programming language grammar. This way, "PP simulator" is made ready to act upon the predefined grammar.

The process of "PP simulator" work and the principles of the tool function is described in sequence of automated actions the tool performs:

1. Recognition of characters and comparing with table of acceptable characters – lexical analysis.
2. Program line/segment reconstruction, eliminating blanks (space), line feed and carriage return symbols.
3. Recognition of words (lexeme) and comparing with table of acceptable words that could be replaced with tokens – lexical analysis (Figure 4). At the same time, recognized words are replaced with tokens and finally, the program code line is replaced with a tokenized sentence.
4. Comparing the tokenized line with syntax pattern and semantic pattern, determining if the tokenized equivalent of the program line/segment has been equal with any of the supported patterns. If the tokenized line matches with any of the patterns previously recorded, the line is considered correct. Otherwise, it is considered inappropriate for the previously defined grammar.

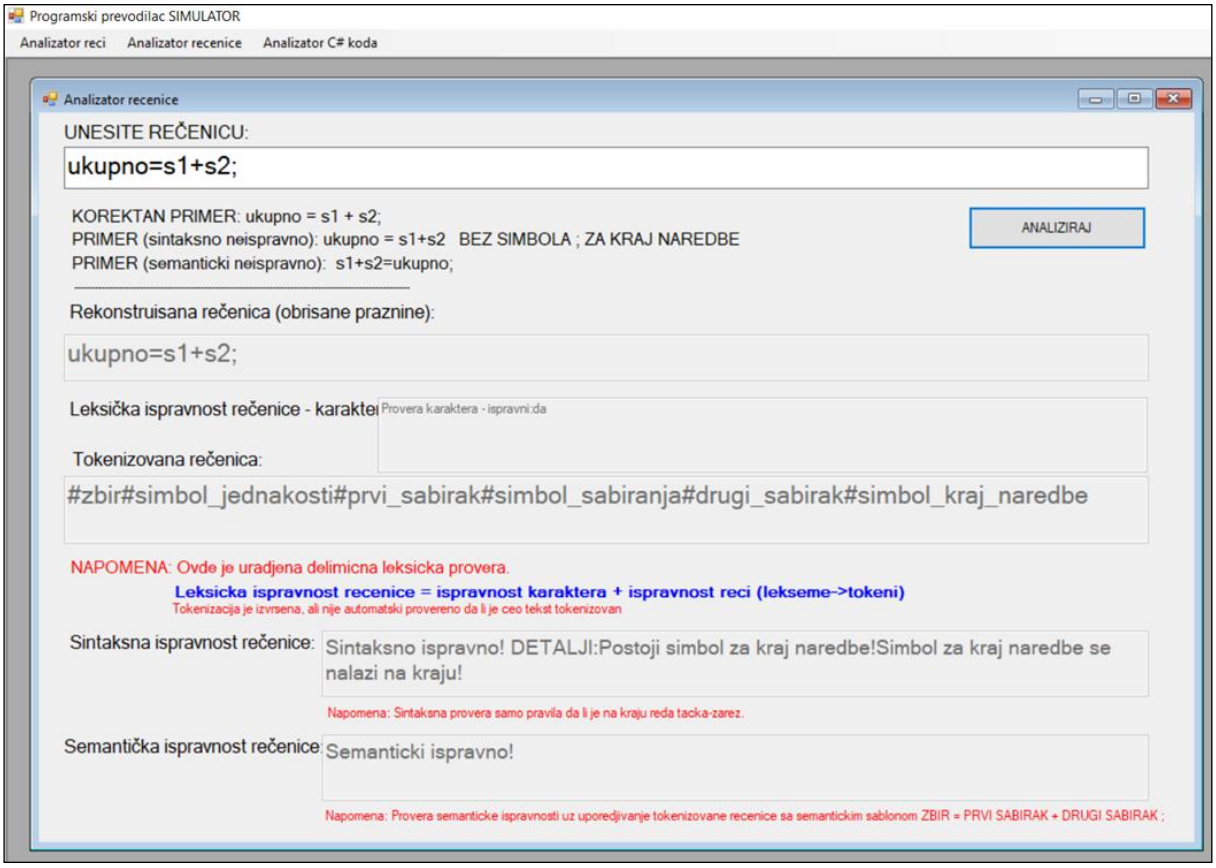

Figure 3. *Lexical, syntax and semantic verification of a program line in PP simulator*

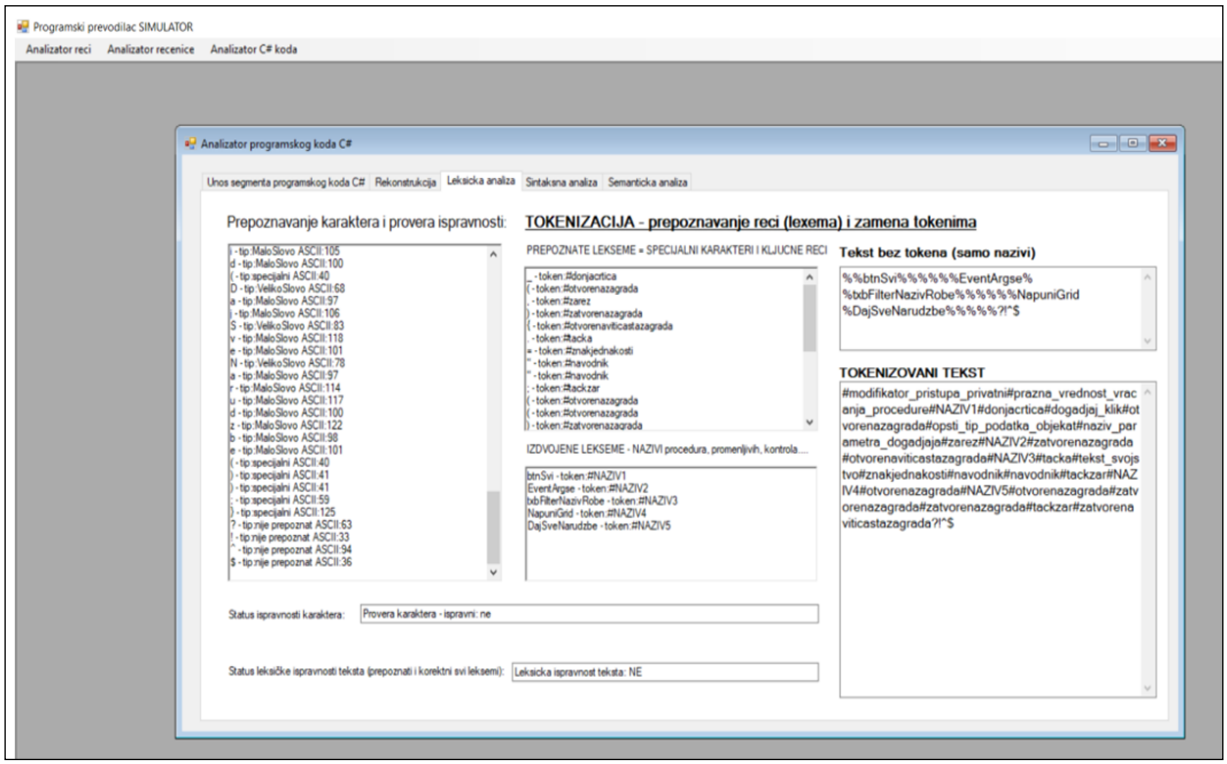

Figure 4. *Lexical analysis of incorrect code segment with recognition of character, words and tokenization in PP simulator*

6.TEACHING RESULTS

6.1. General teaching results

In this section the teaching results from the school year 2019/20 at PP@TFZR are presented. Research sample is based on 35 students results (complete number of 3rd year students in 2019/20 at the Program Translators course). The results are presented with the status on the end of semester (after the teaching session has ended) and after exams at June and July 2020.

Results are presented at Table 3 with class activity and number of students.

Table 3. *Teaching statistics at PP@TFZR in 2019/20*

Class activity	Number of students
Presence at regular theory classes	33
Actively work assignments at regular practical lab classes	27
Registered at Facebook group PP@TFZR (during lockdown)	24
Actively work on home works during pandemic lockdown	14
Registered and attending post-lockdown non-mandatory classes	9
Totally active at regular + lockdown + non-mandatory classes	34
Bonus for extra activity	24
Mid-term exam passed	24 (69%)
Project finalized	12
Passed whole exam	12 (34%)

In aim to demonstrate the effects of all efforts in improving teaching and learning environment for the course Program Translators @ TRZR in 2019/20, it would be beneficial to compare these results with teaching results from previous school years. It is important to mention that the course "Program Translators" started in school year 2017/18 with first generation of students.
In aim to have an approximately valid comparison, the teaching results will be presented for the same exam period, i.e. exams that were organized in June and July, immediately after the teaching semester for the course has been finished.

Data analysis is performed according to raw data available from the Program Translators pages @TFZR website [26].

Table 4. presents comparative data of general students' success for the exam terms June/July for three generation of students – school year 2017/18, 2018/19 with previous professor and, with new professor (having changed teaching goals, content, teaching methods, materials etc), generation 2019/20.

Table 4. *Comparative presentation of students' success for the PP@TFZR in three generation of students*

Year	Number of students in generation	Number of students that passed whole exam in June/July	% of students that successfully passed exam (June/July Exams)
2017/18	31	2	6
2018/19	36	2	6
2019/20	35	12	34

Figure 5. presents graphical representation of data provided in Table 4.

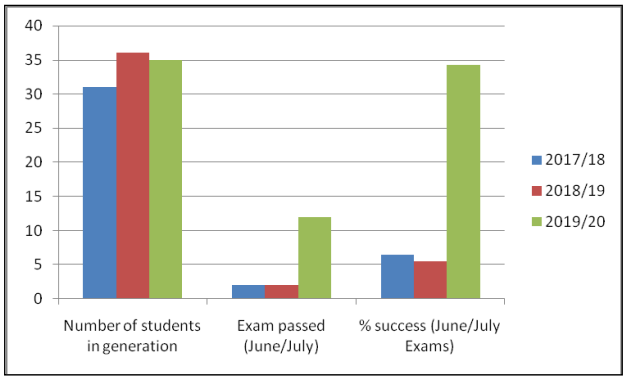

Figure 5. *Graphical presentation of comparative statistics of students success in three generations of PP@TFZR*

According to previously presented data, it is obvious that certain improvements have been made comparing to results from previous two school years period. Still, results for the overall students' success at first two exam terms (June, July) could not be considered satisfactory in 2019/20, since the whole exam passed only 34% of all students in generation.

6.2. Students' experiments in PP simulator-related projects

In projects in 2019/20 PP@TFZR, students used and changed PP simulator in aim to experiment (Figure 6, Figure 7, Figure 8, Listing 1 – authors are: student Bojan Babic with mentor Ljubica Kazi). Students used PP simulator for test code lines written in C# and Java programming languages.

In aim to make students aware of errors that compilers could detect (lexical, syntax, semantic) and run-time errors that could not be detected in compile-time, students were engaged, in their projects, to make intentional lexical, syntax,

semantic errors, as well as run-time errors. Example of making intentional run-time errors within the PP simulator tool is given at Figure 7.

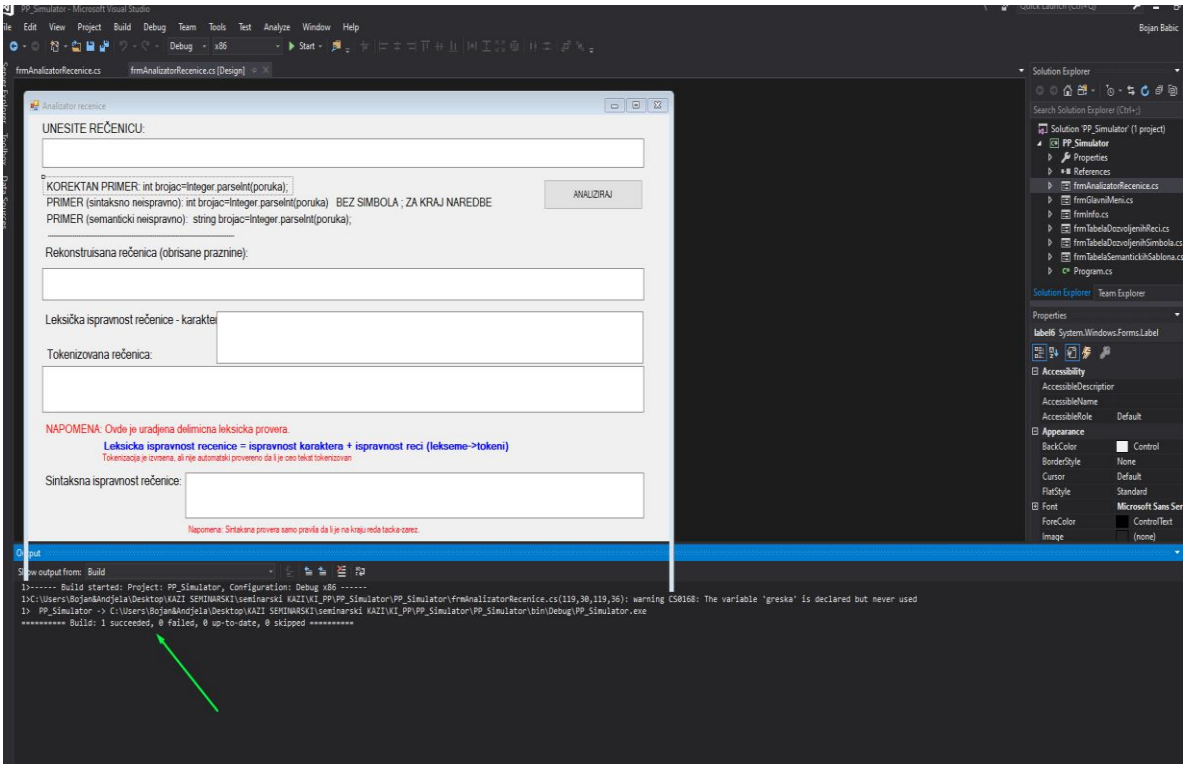

Figure 6. *Compilation result of the PP simulator as a software within Visual Studio NET*

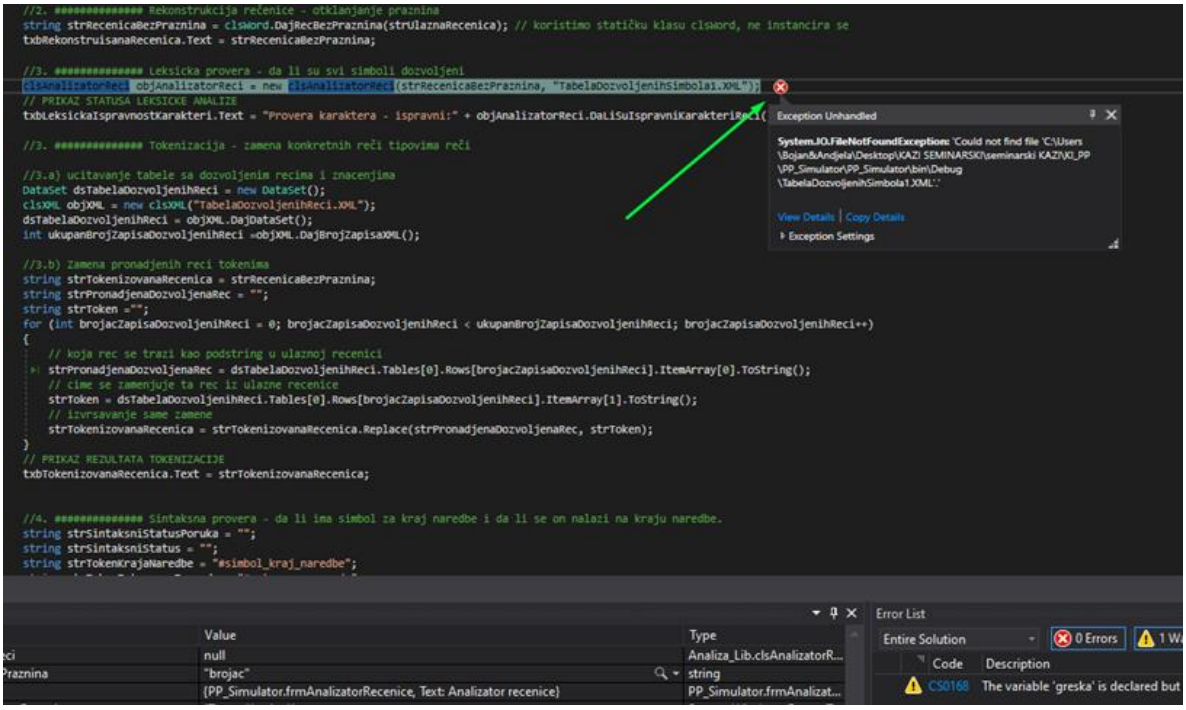

Figure 7. *Example of intentional run-time error in PP simulator*

Example of java program line to be tested in PP simulator with errors is given in Listing 1:

```
CORRECT
int brojac=Integer.parseInt(poruka);
LEXICAL ERROR
Int Br = Integer.ParseInt(poruka);
SYNTAX ERROR
int brojac=Integer.parseInt(poruka)
SEMANTIC ERROR
string brojac = Integer.parseInt(poruka);
```

Listing 1. *Example of experimental program line*

In aim to adjust PP simulator, code tables were updated to support lexicon and syntax/semantic patterns that are used for recognition and evaluation of the program line.

The error code lines and correct ones were put into the text box at the top and after starting the analysis, for the correct code line the result is given at Figure 8.

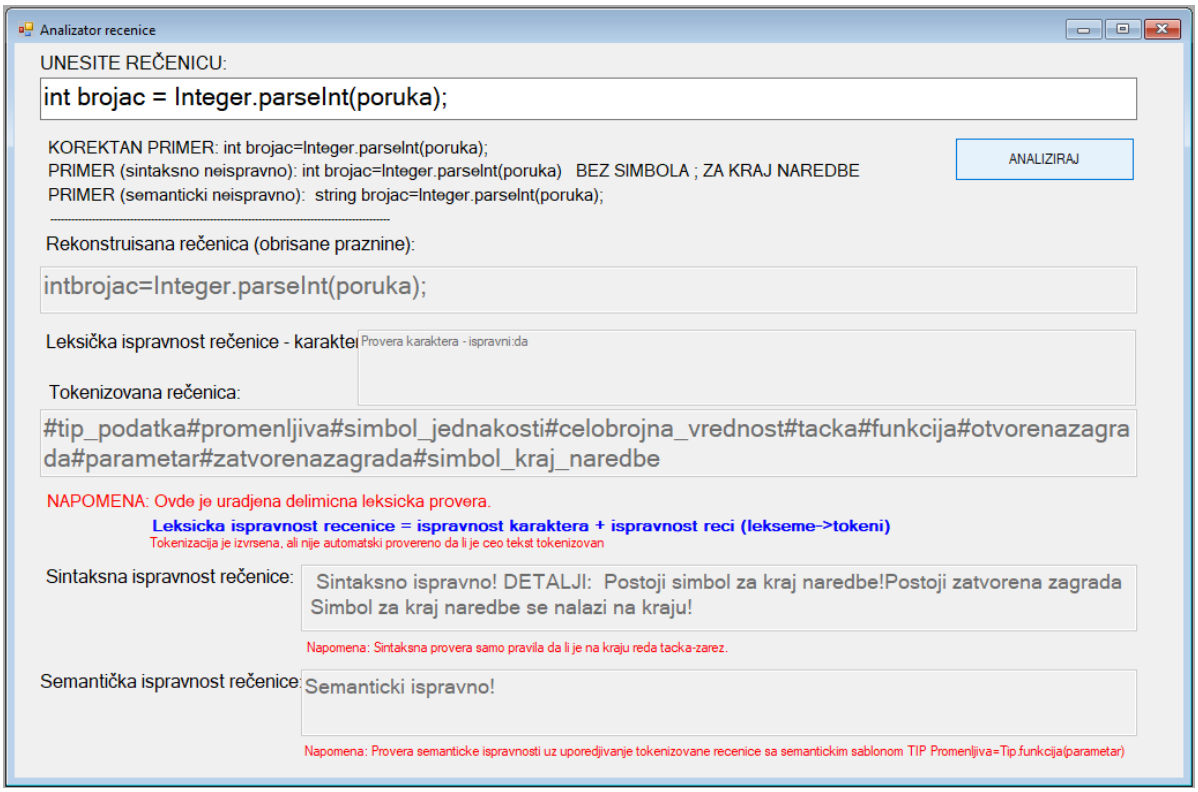

Figure 8. *Students project – results in experimenting with correct java program line in PP simulator*

7.CONCLUSION

Higher education constantly adapts to the needs of technology advancements, by including new teaching contents, but also new teaching materials, methods and tools. This paper presents improvements in teaching at course Program Translators at University of Novi Sad, Technical Faculty "Mihajlo Pupin" Zrenjanin, Serbia, made in school year 2019/20. Changes have been made in teaching content, teaching methodology and assessment, as well as in teaching material and educational tools ("PP simulator").

Aim of this paper was to present all the included changes, with particular emphasis on the developed tool "PP simulator". Finally, the outcome of all the efforts for the teaching improvements have been presented with teaching results statistics after first two exam terms (for the generation of students in school year 2019/20), compared to success percentage from previous two school years students.

General results of the presented teaching should be put in context of teaching process, materials, methods and tools, but also the specific situations with corona virus pandemic restrictions, which disabled students to attend regular classes in two months period starting from March 16 2020. It has been shown that students' interest to attend and actively participate in interactive regular classes has been much greater than doing home works during lockdown period. Finally, 69% passed mid-term exams, which shows that all improvement efforts made positive outcome.

Creating and documenting a software solution (with creating and handling errors with the use of compiler) is the essence of the students' project, which requires more time and effort. At first two exam terms 34% of all students have finished their projects and passed the whole exam. 25% of them chose to modify PP simulator.

Even the PP simulator has been designed as an universal tool for program code evaluation

(regardless programming language), it is expected in next years to be improved. Currently, it supports lexical, syntax and semantic evaluation of a code line and only lexical analysis and verification of a code segment. This version of PP simulator is based on syntax and semantic patterns which are compared with tokenized code lines in aim to determine their suitability. Of course, improvements should be made in this core principle of detecting the correct syntax and semantic forms of program code lines.

Having PP simulator closer to theoretical foundations of compiler constructions will enable students' better understanding of abstract concepts of formal grammars, automata theory and others. Having a better version of PP simulator will improve teaching environment in such way that it will encourage and direct students towards creating or modifying compiler simulators. This way, some of the project types will be excluded (such as 1 and 2), while those closer to compiler constructions will be emphasized.

Teaching content, methods, materials and tools are under constant improvements and adjustments to enable students have adequate knowledge and skills required in industry. In that context, it is very important to emphasize that, even new technologies and development environments encourage improvements in teaching process, the course core content should remain in focus, together with implementing academic principles of teaching and careful students' workload planning.

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Session 1:

Teacher Professional Development and General Education Topics

Notes:

8th International Scientific Conference
Technics and Informatics in Education
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Session *Teacher Professional Development and General Education Topics*

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Empowering Teachers' Digital Competence Through the Implementation of the "Digital Classroom" Project

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Abstract: *In a Knowledge Society, the kind we aspire to today, the education system becomes the pillar and the initiator of general progress in society, while knowledge is perceived as the most important human resource and capital. The inevitable changes in the education system are primarily reflected in the change of necessary competencies of teachers. Acquiring digital competence by way of applying information technologies in the teaching process becomes a prerequisite in professional development of teachers. In this paper we shall consider the basic training concept and the main results of the evaluation of the "Digital Classroom" project, implemented by the Institute for the Improvement of Education with the objective of empowering digital competence of teachers. The assessment of the increase in teacher competence was carried out using the pretest-posttest concept where 80% of teachers who completed the training had greater achievements than the average achievements of teachers before the training. The effects of the training become noticeable in all aspects measured on a sample of teachers.*

Keywords: *ICT; teacher's professional development; digital classroom; teachers' digital competence*

1. INTRODUCTION

The significance of information and communication technologies (ICT) in all aspects of society today is the standard for development in the global information society. In recent years, the government of the Republic of Serbia has implemented a number of strategic documents as a set of guidelines for informatization of the education system.

The institutional, as well as the legal framework are provided at first implementing the Guidelines for Improving the Role of Information and Communication Technologies in Education brought by the National Education Council of the Republic of Serbia in 2013 [1], while the Ministry of Education, Science and Technological Development of the Republic of Serbia, in partnership with the British Council, published the Digital Competence Framework – A Teacher for the Digital Age in 2017 [2]. The Framework was completely revised in 2019 in a joint effort by the Institute for the Improvement of Education, the Ministry and the Institute for Education Quality and Evaluation.

One of the most important projects under the auspices of this kind of Government Strategy, carried out by the Institute for the Improvement of Education, in collaboration with the Ministry of Education, Science and Technological Development, is the project called Digital Classroom/Digitally Competent Teacher – Introducing Electronic Textbooks and Digital Educational Materials which is included in the Plan of Priority Objectives and Activities of All State Administration Bodies and Government Services for IT Sector Improvement in Serbia for 2018 and is ranked fourth on the priority list consisting of nineteen priority projects [3].

2. THE OBJECTIVES OF THE "DIGITAL CLASSROOM/DIGITALLY COMPETENT TEACHER" TRAINING

At a conference on 8th January 2008 a document named ICT Competency Standards for Teachers (UNESCO, 2008) was presented, introducing guidelines for skills standards for teachers that are to be accomplished through professional development. At the same time, professional development of teachers through use of information and communication technologies is recognized through three main approaches [4]:

- Technology Literacy,
- Knowledge Deepening and
- Knowledge Creation.

The main objective of this project is contributing to the development of digital competences which are defined as the set of knowledge, skills, attitudes, abilities and strategies that are required when using information communication technologies and

digital media, with the purpose of improving teaching and learning processes and other activities in connection with the teaching profession reflectively, flexibly and safely in both online and offline environments (Ferrari, 2012).

The objectives of the training for trainers/teachers included acquiring digital competence, providing information and communication structure in schools, as well as teaching practice and professional development of teachers and are defined as:

- Acquiring and developing a level of digital competence for teachers in order to enable work with information and communication technologies;
- Training teacher mentors for further training of participants based on the „train-the-trainer" model, including acquiring soft skills;
- Training teachers to be able to prepare, adjust and use digital educational materials;
- Practically applying digital textbooks in the teaching process, thus providing the teacher with opportunities to realize teaching in a modern way with integration of teaching content;
- Introducing teachers to and training them for work on contemporary tools for learning management systems – LMS platforms;
- Encouraging teachers to create cognitively stimulating activities intended for pupils in a digital environment.

The top priority of the programme's development plan is:

P1 – Developing digital competence in both pupils and teachers and using information and communication technologies in the educational process.

The training programme was created according to the outcome-based approach to learning and teaching and is directed towards developing the following areas of competence in both teachers and students:

(K1) competency for a narrow area of expertise

(K2) competency for teaching and learning

3. THE "2000 DIGITAL CLASSROOMS" PILOT PROJECT

The project was carried out during 2018 as a pilot project named "2000 Digital Classrooms".

In phase one of the project 98 teacher trainers were trained, and among them a number of trainers were selected and they received certificates for further training and giving support to a group of selected teachers. All of the chosen certified teacher trainers were obliged to provide mentoring assistance to teachers working with digital educational materials and digital textbooks.

The training participants were 2000 first grade (Serbian, math, science and social studies, art, music and foreign languages) and fifth grade teachers (Serbian language and literature, math, history, geography, biology, informatics and computer science, technics and technology studies, art, music and foreign languages) working in primary schools educated to actively use modern technology and modernly designed e-textbooks in their work.

The teachers chosen by their schools to be trained for the programme, received adequate equipment, digital materials and teacher trainer support.

3.1. The training concept

The teacher training was devised as a three-day course divided into modules in accordance with the objectives of the training.

1. Support in acquiring digital competence in areas of:

- Handling computer equipment;
- Using the principles of constructivism for the purpose of applying technology in teaching – teaching then and now;
- Opening, accessing and managing accounts on the digital educational resources' portal;
- Functionality of educational portals intended for realization of teaching in a digital environment;
- Using the Internet, e-mails and cloud services safely.

2. The practical application of digital textbooks in teaching:

- Digital educational content – digital textbooks (Using integrated textbook sets);
- Contemporary tools for distance learning LMS - Learning Management System.

3. Lesson planning

The task for the teachers was to plan a lesson on their own in form of a presentation. The best lesson plans were added to the Lesson Database which can be found on the official website of the training programme www.digitalnaucionica.edu.rs and is available to all the employees working in education system.

3.2. Handling computer equipment

This segment of the training focused on introducing teachers to the components of the computer system; connecting basic computer parts to peripheral devices; setting the image display mode on the computer screen and the projector and computer networking.

Each trainer/teacher got acquainted in detail with the union of hardware and software, the connection between the computer and peripheral devices, and also with working in an operating system and connecting the computer to a local network.

The teachers were given equipment which consisted of a computer, a projector, an Internet connection and required peripheral devices. One of the outcomes for this segment was to train every teacher to use the provided equipment with the purpose of presenting other content and materials from the training.

3.3. The constructivist approach to teaching

Constructivism as a theoretical concept was presented in training, a concept that insists on the fact that knowledge building is based on individual experience and that knowledge as such is unique to each individual. New terms introduced into the context of educational policy are "lifelong learning" and "knowledge society".

The main characteristics of school based on constructivist principles are: knowledge is acquired by being actively introduced to new content, the students are responsible for their learning, learning develops the culture of learning thus providing a broader autonomy to learners.

3.4. Opening, accessing and managing accounts on the digital education resources portal

Based on the public notice issued by the Ministry of Education, Science and Technological Development, a large number of textbook and teaching resource publishers sent their digital materials to the Institute for the Improvement of Education in order to be accredited, and subsequently, the Institute gave permission for the use of digital educational resource portals.

Teachers were able to create their own accounts on the portals of their chosen publisher and use the portals in teaching.

Educational portals such as these provided the teachers with the following:

- Using digital textbooks;
- Establishing contact directly through the portal (access to one's own school, other teachers – colleagues, school classes and pupils);
- Having direct communication with pupils (internal e-mail system, discussion forums, chat rooms…);
- Assignments/tasks, tests, exercises, homework (tools for creating such modules or access to the assignments);
- Monitoring progress – pupil progress statistics (reports on individual pupils or whole classes).

3.5. Using the Internet, e-mail and "cloud" services safely

The teachers got to know the rules for safe use of Internet browsers, as well as how to independently communicate with other participants via e-mail using free providers and also, how to use "cloud" services.

In order to facilitate adoption of this training segment, the teachers were obliged to open email accounts through free providers, choosing the parameters based on the recommendations from the training.

Special attention was directed towards Internet ethics, copyrights and types of licenses. In a number of workshops, the teachers received assignments on specific topics with the task of finding contents relevant to the topics on the Internet first, then safely downloading it and finally using it to create their own presentations. While doing this they had to pay attention to copyrights, properly citing their sources and licenses.

3.6. Digital education and digital educational content

This segment of the training emphasized the main characteristics of digital textbooks – they are based on multimedia and hypertext, therefore, they are not linear, but rather, their contents branch in various directions.

Within workshop activities, the teachers were given an assignment to examine digital textbooks from various publishers and determine the kind of digital textbook, as well as its main features. The next step required that the teachers, based on the established criteria, choose the digital textbook that is best suited for the subject their teach.

3.7. Contemporary tools for distance learning LMS - Learning Management System

As a unified software system that enables virtual, collaborative environment for the complete teaching process, the Learning Management System, LMS was presented to the teachers.

The advantages of the blended learning/hybrid learning which combines face-to-face teaching with computer-assisted teaching, mixing the use of contemporary digital media with the traditional and well-established teaching techniques were presented.

The teachers were not given explanations on the technical characteristics of such systems, they were introduced to the pedagogical aspects of it, with emphases on the ease and speed of communication with pupils.

4. ASSESSMENT OF THE TRAINING EFFECTS ON TEACHERS

The assessment of the increase in teacher competence was carried out using the pretest-posttest concept without forming a control group. Teachers were not randomly sampled, questionnaires were distributed to all the teachers who had completed the training (1920 teachers) and they were first questioned immediately before

the training began. Three months after the training, electronic questionnaires were sent to e-mails of all the teachers who were already tested before the training. A total of 1407 teachers completed the questionnaire.

The instrument for assessment of the effects of teacher training consisted of four parts.

The first part was the knowledge test. The test was created with the purpose of evaluating the level of teachers' digital competence before and after the training.

The knowledge test included twenty multiple choice questions with one or more correct answers, covering 11 areas that were presented in the training, so that the following areas are included with at least two questions: Operating computer equipment; Principles of constructivism for the purpose of applying technology in teaching – teaching then and now; The use of the Internet, e-mail and "cloud" services; Opening, accessing and managing accounts on the digital educational resources portal; Functionalities of the learning management system intended for the realization of the teaching process in the digital environment; Digital educational content - digital textbooks; Use of a unified textbook set - practical application; Use and creation of additional materials / tests; Modern tools of the learning management system (LMS, Learning Management System); Advantages and problems in the use of modern tools (LMS); Working in a digital classroom.

The second part of the instrument consisted of teachers' self-assessments in relation to the practices associated with digital and online learning. This part of the instrument gathers information from teachers using a five-level Likert-type scale [6], about how often they practice certain digital and online learning activities in their teaching. This part of the instrument consists of 12 items which refer to how often do the teachers create digital materials for teaching and learning and whether they are adjusted to the pupils' needs, how often do they use digital technologies in assessing pupils' achievements, how often they motivate students to get involved in various digital environments that encourage learning (networks, collaborative services, repositories), etc.

The third part of the instrument consisted of self-assessment of teachers' digital competence. This part includes 21 items, the teachers are asked to evaluate, on a five-level Likert scale, the degree to which they agree with the claims about different levels of development of digital competence. The claims were based on the Digital Competence Framework – A Teacher for the Digital Age, which was adopted by the Ministry of Education, Science and Technological Development in 2017. [2]

The fourth part of the instrument served to gather information on digital infrastructure that exists in schools. These data were not directly under evaluation, however, they do represent a relevant source for the evaluation, given the fact that adequate infrastructural conditions are a necessity for a successful application of digital and online learning in regular school classes, which is the main objective of the training.

4.1. Estimates of changes in teaching practices on a sample of pupils

Assessment of the growth of teacher competencies and perceptions, based on a sample of pupils, is being done according to the pretest-posttest concept, including a control group with multiple dependent variables. The choosing of pupils was conducted taking into account the criteria of geographic similarities with the experimental school, so as to minimize the influence of different variables from socio-cultural context.

The sample consisted of fifth grade pupils, since questioning first grade pupils by way of self-assessment tests would be impossible (the teachers attending the training were first grade and fifth grade teachers). All the claims were adjusted as much as possible in order to be age-appropriate for the pupils.

Electronic questionnaires were sent to nine experimental schools, and in each school a fifth grade class, taught by the teachers who finished training, was questioned, and in nine control schools as well, a fifth grade class was chosen from each school to complete the questionnaires, a total of 402 students. In the posttest phase, the same students answered the questionnaire, with 309 students from a total of 17 schools answering the questionnaire.

Equalizing between experimental and control group schools was conducted according to geographical criteria, thus controlling the influence of socio-cultural variables and the level of development of municipalities. Given the fact that there were fewer schools than teachers in the assessment, this kind of equalization was possible.

The instrument used to evaluate the effects of training through changes in teaching practice was directed towards measuring different perceptions of pupils, as someone who is completely unbiased to report on prospective changes in digital and online learning in teaching. The instrument consisted of two parts.

The first part of the instrument consisted of pupil evaluation of teachers' practice in relation to digital and online learning. This part of the instrument serves to gather data from the pupils via five-level Likert scale, on how often the teachers practice in school certain digital and online learning activities that include students. This part of the instrument consists of 11 items which question how often pupils use digital technologies in learning activities.

The second part of the instrument included self-assessment of pupils' digital competence. This part

of the instrument, much like the one for teachers, is based on the Digital Competence Framework – A Teacher for the Digital Age, however, with major adjustments, to be age-appropriate for the pupils.

For Data processing, the data were collected on the basis of the electronic platform Qualtrics, and were processed in the opensource programming language R.

4.2. Teacher progress on the ICT knowledge test

On the pretest, teachers scored an average of 11.28 correct answers out of possible 20 (σ=3,54; max=19; min=0). None of the teachers achieved the maximum number of points, and the distribution of teacher achievement according to the Shapiro-Wilks test does not deviate from the normal distribution (w = 0,98; p>0.05) [7].

After three months the teachers were given the same knowledge test. This was possible since there was no opportunity to make a parallel version of the test that would be equally difficult, and making it would require a piloting phase, and also, a lot of time passed between the two tests. In support of this decision is the fact that the pretest was difficult, and there was no fear of the ceiling effect, in other words, with a level of certainty we can claim that the same test can be able to detect teachers' progress.

The teachers scored on average 13,98 points on the posttest. Only six teachers achieved the maximum number of points on the knowledge test, which further indicates that the test was sensitive enough to register real progress of teachers and avoid the ceiling effect. This distribution deviates from normal distribution, which can be expected from a posttest, because the examinees were significantly more successful than doing the pretest. This distribution also does not deviate from the normal distribution (w = 0.94; p> 0.05).

On figures 1 and 2 the teachers' progress is shown graphically, first on a density function (the area under this function corresponds to the probability from 0 to 1 for the given value and then through a classic histogram showing the number of teachers in relation to the sum of correct answers on the knowledge test.

One of the important illustrations of how successful the training was and improved the ICT knowledge of teachers, tells us the decrease in the percentage of teachers with very low achievements.

On the pretest, 7.2 or less correct answers were given by 7.2% of teachers, while on the posttest, this percentage of teachers decreased to only 1% of teachers.

Given that this research was done on the entire population of teachers who are subject to evaluation of training effects, it makes sense to talk only about the intensity of the effects, but not about the statistical significance that tells us about the probability that the results obtained in the sample are credible for population. The magnitude of the effect is such that it can be considered as large (Cohen's d = 0.82) [8].

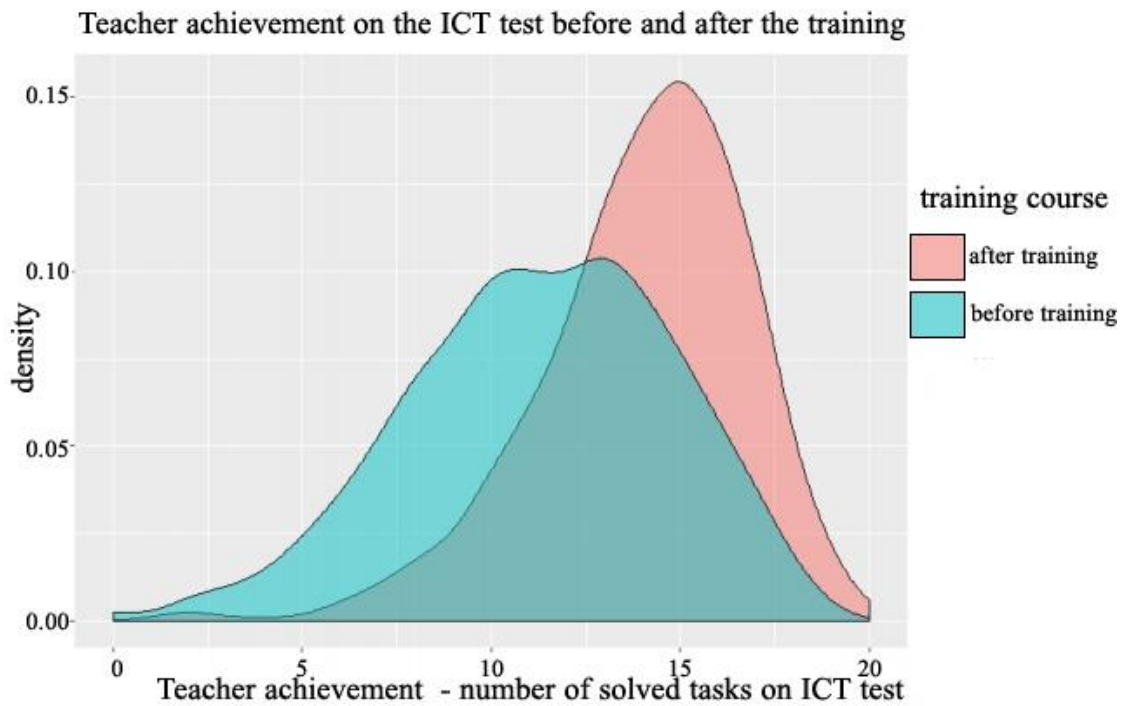

Figure 1. *Density function showing teachers' pretest and posttest achievement (*X axis - *achievements – the number of solved assignments on the ICT knowledge test;* Y-axis *– density)*

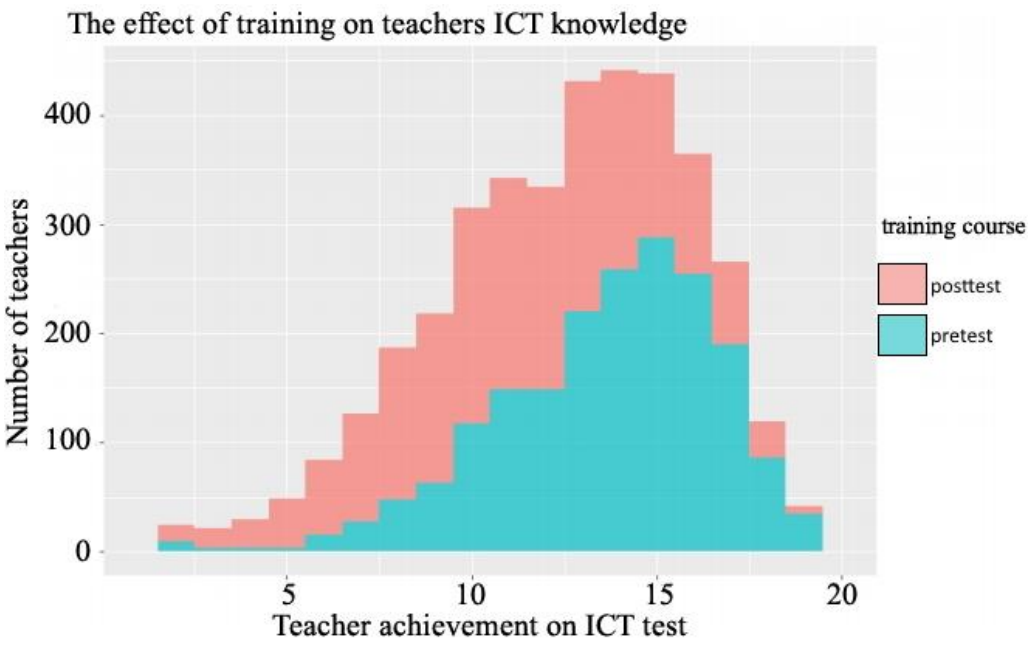

Figure 2. *Teachers' achievements before and after training – the number of teachers in comparison to the number of solved assignments (X-axis – ICT knowledge test achievements; Y-axis – The number of teachers)*

In conclusion, we can claim that 80% of teachers who completed the training had greater achievement than the average achievements of teachers on the pretest. If we were to randomly pick a teacher's knowledge test achievements before the training and the knowledge test achievements of a randomly selected teacher after training, in 71% of cases the after-training teacher would have greater achievements. Given the fact that various researches show that the effect of intervention is mostly lost after three months, these results indicate that such a strong effect of training can be accepted as lasting.

4.3. Changes to teachers' self-assessment practices related to digital and online learning

The teachers estimated that they started using digital and online learning in their classes to a greater extent after the training. Before training, the teachers estimated that on average, on a five level scale, they would use digital environment and materials once or twice per semester (M=3,33). After training, the teachers reported using this kind of practice once or twice a month, on average (M=3,66).

Taking into account all the digital and online learning practices, before training the teachers showed they were least likely to provide support for students in an online environment (once or twice per year), while using this environment most frequently to search for and download digital materials off the Internet for the purposes of teaching and learning (several times a week).

The greatest effect of training on changing teaching practices was the increase of sharing experiences and knowledge through digital environments for collaboration with other teachers, as well as greater use of existing digital technologies in teaching (portals, films, presentations, online tests, etc.).

During training, this segment showed the greatest difference in teacher experience. Also, teacher collaborations over various online services, as teachers claim, was the segment of training that was the most elaborate and it allowed them to easily adopt the experiences of their colleagues.

The minimum training effect was observed on encouraging pupils to use digital technologies in order to join learning communities outside school environment (using various portals, learning networks, forums, blogs). Also, a minimal effect was noticed when it comes to teachers downloading and searching digital contents on the Internet, since the teachers had been doing this to a great extent before the training.

The magnitude of the effect of changing teaching practices as a result of training varies from moderate to small, depending on the segment of training (from Cohen's d = 0.41 to d = 0.08). This means that 66% of teachers who completed training will have more developed digital and online learning practices then before training, and for those practices that had the strongest effect during training. If we were to randomly pick a report on digital practices of a teacher before and after training, in 61% of cases the teacher would have more developed digital practices after the training.

The extent of the effect of changes to teachers' perception of their own competence as a result of training varies from moderate to slight, depending on the digital skill in question (from Cohen's d = 0.46 to d = 0.02).

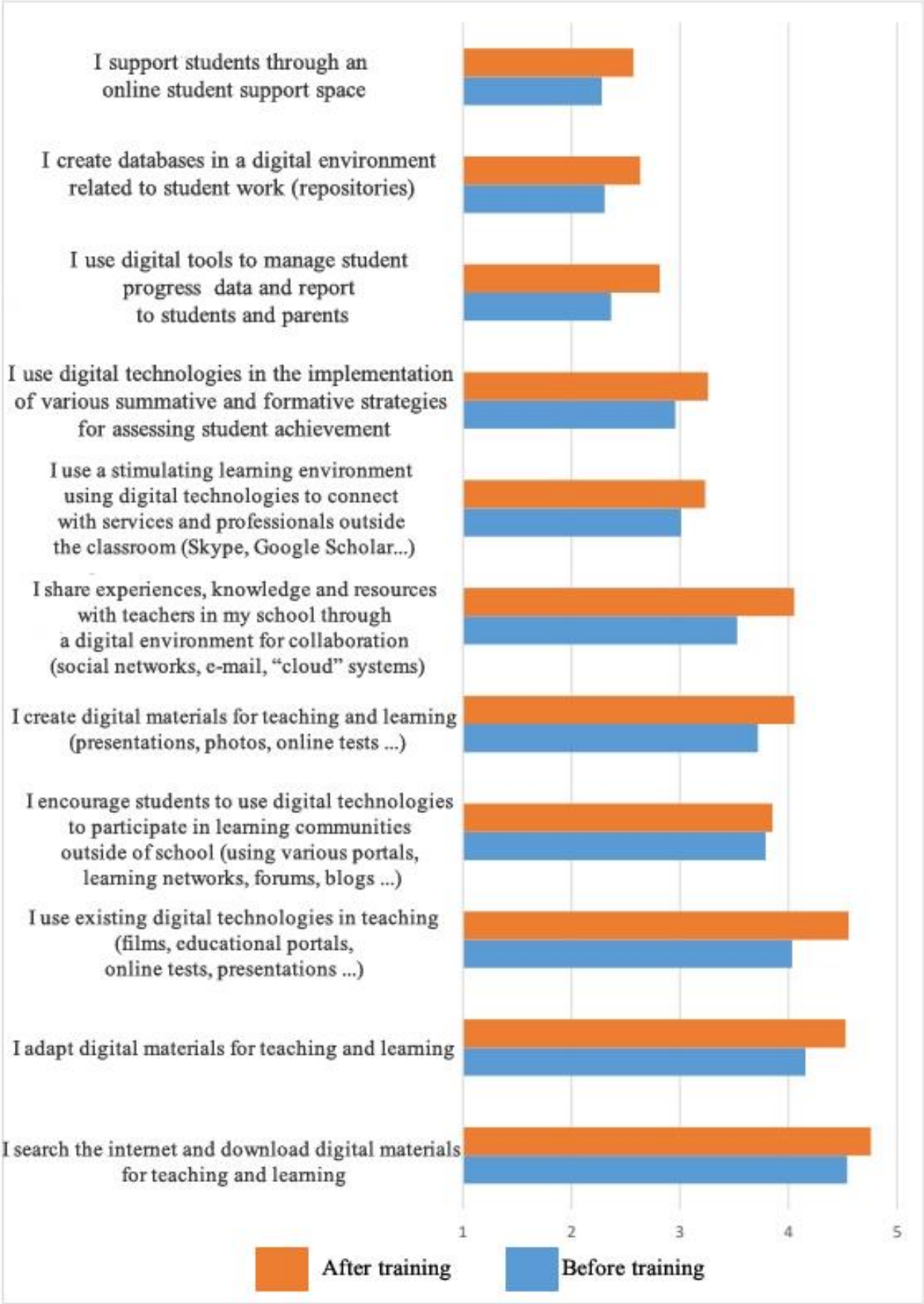

Figure 3. *Changes in teaching practice in regard/relation to digital and online learning*

4.4. Changes in teachers' self-assessment in connection to their own digital competence

The teachers have reported that they started to perceive themselves as significantly more digitally competent. Before training, on average, they would report that they agree to some extent or that they are not sure to what extent they could apply different skills and knowledge in relation to digital competence(M=3,83). After training, on average, the teachers report significantly higher self-confidence and agree to some extent or completely agree that they can implement different knowledge and skills in relation to digital competence (M=4,23).

Taking into account all of the digital skills tested, before training the teachers would estimate having the least knowledge on how to use digital tools for conference calls and collaborative "cloud" systems. What they estimated having greater knowledge of was searching the Internet and saving and finding information on the computer.

The greatest effect of training on teachers' perception of their own digital competence can be seen on teachers' use of collaborative "cloud" services and using these repositories when working with pupils. The least effect of training on perception of one's own competence has been noticed in those digital skills that the teachers had previously, before training, perceived as being most competent at (searching the Internet and storing information on the computer).

The extent of the effect of changes to teachers' perception of their own competence as a result of training varies from moderate to slight, depending on the digital skill in question (from Cohen's d = 0.46 to d = 0.02).

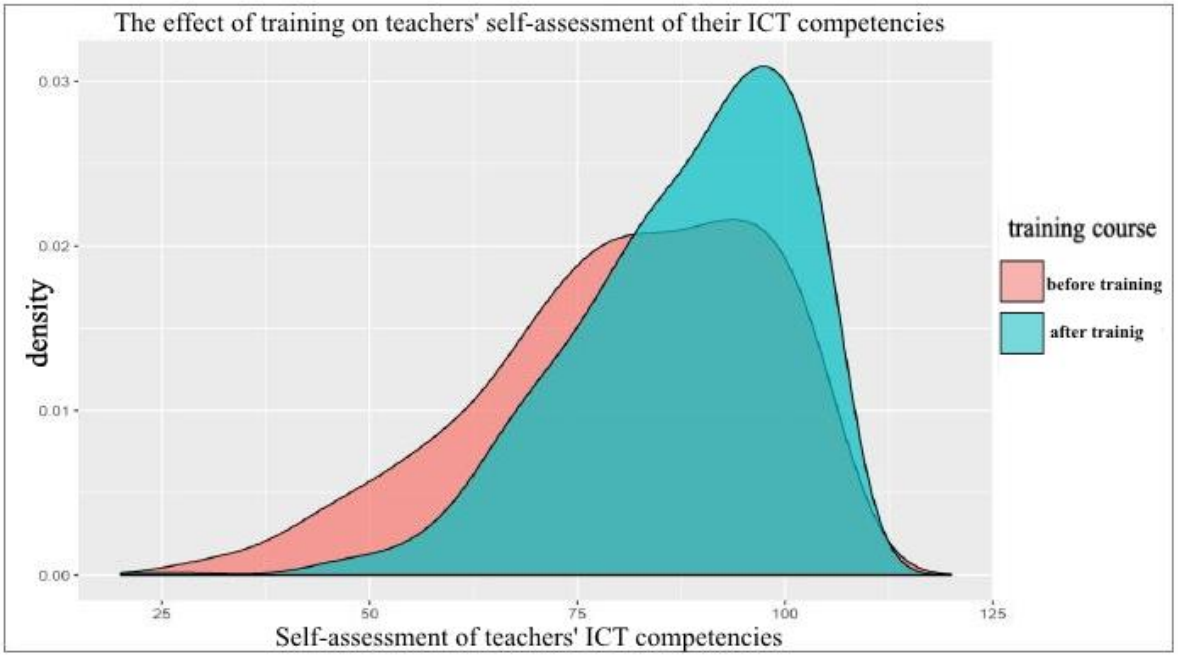

Figure 4. *Density function of self-assessment of teachers' ICT competencies before and after training*

Figure 5. *Changes in teachers' self-assessment regarding their own digital competence 1*

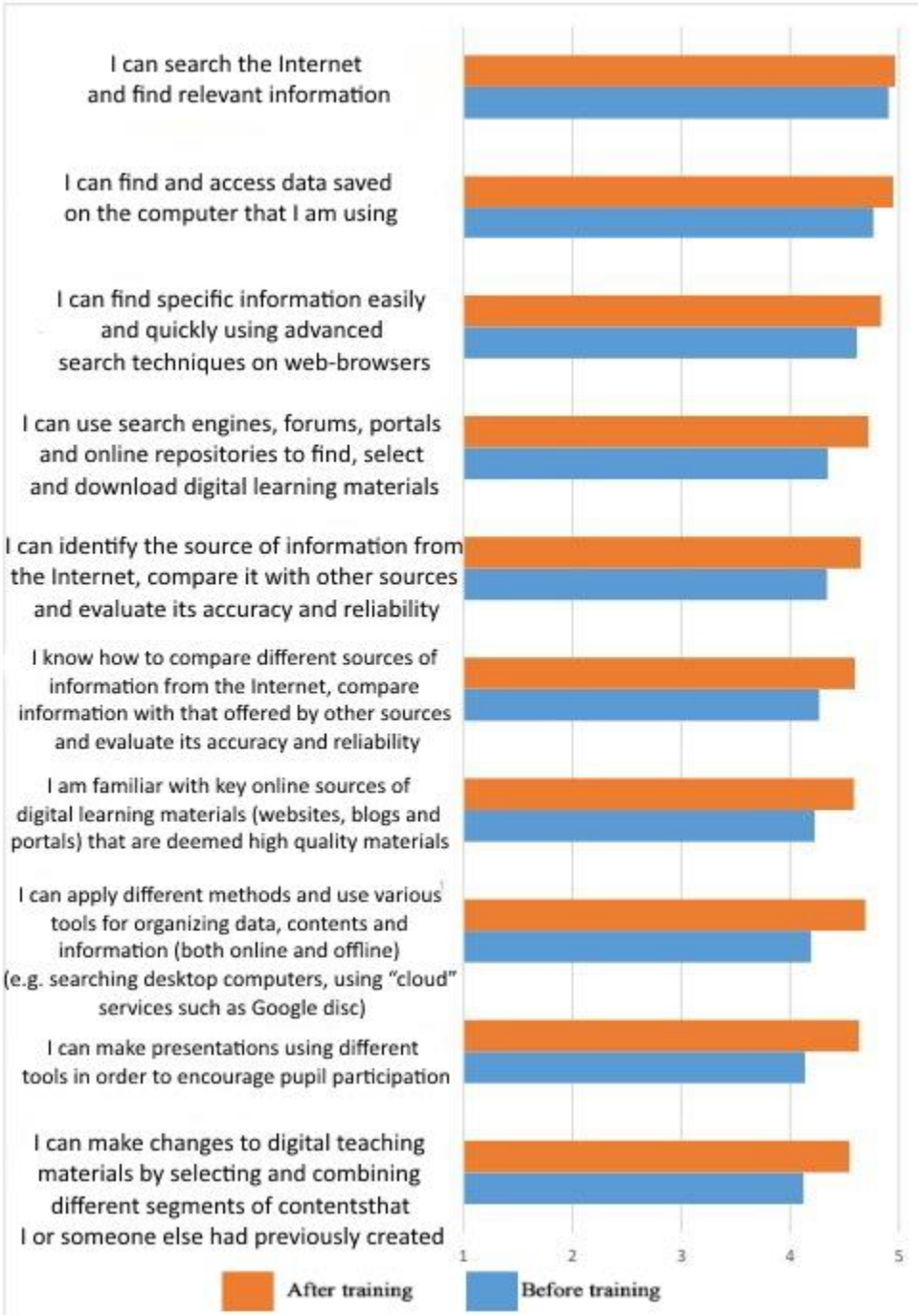

Figure 6. *Changes in teachers' self-assessment regarding their own digital competence 2*

4.4. Conclusion on the effects of training on teachers

The effects of the training are noticeable in all aspects measured on a sample of teachers. Teachers' perceptions have significantly changed after training. The teachers have reported that they use different acquired digital skills in teaching more often than before, that interaction with pupils occurs in digital environment to a much greater extent, and also, that they make greater use of various digital contents in teaching. The teachers also report that they feel much more confident in their digital competence, especially when it comes to skills they were least confident about before training, mostly having to do with using different digital environments for interaction and collaboration.

The most encouraging fact is that the training had great effects on teachers' understanding of various aspects of digital knowledge. If we take into consideration that perception, even though considered to be one of key methods of various psychological and pedagogical evaluations, is always susceptible to various bias, and especially self-perception, this growth of directly evaluated teachers' knowledge of digital content can indicate that the teachers, thanks to the conducted training, have been significantly empowered to successfully use digital and online learning practices in their teaching.

5. CONCLUSION

Over the course of three years of realizing the project "Digital classroom", the Institute for Improvement of Education has trained 20 000 teachers working in primary and secondary education in the Republic of Serbia. The most encouraging fact is that the training had great effects on teachers' understanding of various aspects of digital knowledge.

The plan of the Institute, in agreement with other educational policy makers, is to train all teaching staff working in pre-university education, as basic point in achieving complete informatization of the education system.

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Session 1: *Teacher Professional Development and General Education Topics*

Review paper
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The Challenges for Teachers: Augmented Reality as Educational Technology for Students with Dyslexia

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Abstract: *Nowadays, teachers face many technological challenges to improve learning and teaching process. Using modern educational tools in an inclusive educational setting is challenging, especially in teaching students with dyslexia. The paper describes dyslexia and the reasons to use IT tools in the teaching of students with dyslexia. In the second part of the paper, augmented reality was considered as an educational tool; this is based on the review of the researches on the advantages and disadvantages of educational implementation of augmented reality. The examples of augmented reality tools in learning and teaching students with dyslexia support the functionality of augmented reality as an educational technology in inclusive education.*

Keywords:*inclusive education, dyslexia, educational technology, augmented reality, multisensory learning*.

1. INTRODUCTION

Nowadays, teachers work in a technologically fast-changing environment that offers many opportunities and demands. While technologically developed learning and teaching environment enables the improvement of teaching, it also creates, from the teacher's standpoint, many challenges due to the constant necessity for the teacher adapting to and learning about new educational technologies and tools.

Learning and teaching process is empowered by the current technology (Ab Aziz et al., 2012; Quintero et al., 2019; Serin, 2017). Technology increases the effectiveness and attractiveness of learning and teaching. It is especially important in the educational programmes for students with disabilities, special educational needs, learning difficulties. Their education can be improved with multimedia technology.

Researches of technology-enhanced learning (TEL) considered different emergent technologies: virtual reality (VR), augmented reality (AR), ubiquitous learning (u-learning), mobile learning (m-learning), gamification, serious games, learning analytics (Bacca et al.,, 2014; Quintero et al., 2019). All of that is the basis for enriched multimodal learning environments. The goals of implementing a different form of technology-enhanced learning focused on "improving students' opportunities to pursue their education to the highest level possible, secure employment and live independently" (Ab Aziz et al., 2012, p. 335). The popularity of augmented reality applications has increased in the last decade (Serin, 2017).

According to the Serin's review, it was confirmed that the use of educational means in the educational environments has increased the level of success of the learners, "and made the process of learning amusing, active and effective"(Serin, 2015, p 4). Some forms of virtual reality, for example, augmented reality, keep the students busy; the materials can be transferred to the real world easily; they provide rich cognitive clues and multi-dimensional feedbacks; they get interaction with the content; they amuse during learning and make the learning process easy. In this context, augmented reality is recognised as technology "based on the natural and physical interaction by offering the visualization of the virtual objects without disintegrating the learners from the real environment" (Serin., 2017).

The focus of this paper is the implementation of augmented reality in inclusive education settings.

Members of UNESCO have implemented the policy of educational inclusion for more than two decades; the main objective of educational inclusion is a reduction of the marginalization and exclusion of students with different learning preferences in the education system (Quintero et al. 2019). The focus of the concept of inclusive education is on the right

and chance of each child to participate in education according to their individual learning need.

Who is this review paper for? It is primarily intended for teachers who, when working with students, are to use the capacities of modern information and computer technologies (ICT) for learning. An important target group of this paper are also the experts in information technology and computer engineering, who are to develop technologies working as a team with teachers.

2. A REMINDER OF DYSLEXIA

IT support for specific learning disorders is one of the important implementations of IT in education. Specific learning disorders are considered in the context of school skills development, especially reading. There are four main diverse reasons a reader might struggle: (a) developmental issues, including learning disabilities like dyslexia, (b) lack of exposure to reading material, (c) poor health, and (d) cognitive overload (Huisinga, 2017, p. 12). Dyslexia is in the focus of this paper.

The traditional approach is that dyslexia represents an unexplained reading difficulty that exists despite normal intelligence, appropriate sensory and motor functioning, and adequate conditions for learning. It is a quite frequent disorder which is identified in about 5-11% of school children, depending on the environment (Birsh, 2005, as cited in Obradović, Bjekić, & Zlatić, 2015, pp. 292).

According to the International Dyslexia Association, "Dyslexia is a specific learning disability, neurological in its origin. It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. These difficulties typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction. Secondary consequences may include problems in reading comprehension and reduced reading experience that can impede the growth of vocabulary and background knowledge" (AID, 2017, p. 3). Summarizing this description, dyslexia can be defined as "a specific learning disability which affects a person's ability to read, spell and understand language while reading or writing" (Gupta et al., 2019). Manifestations of dyslexia vary from person to person. Each person overcomes dyslexia differently depending on their way of learning and other cognitive abilities.

According to Dyslexia International, at least one of ten people is a person with dyslexia. It is around the world more than 700 million persons with dyslexia (Sisodia, 2018). According to the Italian Dyslexia Association (AID), in 2014 there are 3.5% of students with dyslexia in the Italian population between 6 and 18 – it is around 90.000 students aged 6-18. The situation was very problematic in some European countries. In English-speaking countries, the percentage of persons with dyslexia is around 10%. On average, there are at least two students with dyslexia in each class and each teacher has to deal with this problem every day. It would be very useful for teachers to access effective technology. In India, approximately 35 million schoolchildren are children with dyslexia. At the HEIs level, researches show an increasing number of students with dyslexia, "including a high percentage of art and design students" (Huisinga, 2017, p. 13). According to the European Dyslexia Association, "the group of European Citizens with dyslexia and specific learning disorders encompasses between 9 and 12 percent of the population, navigating through life in a largely non-"dys" friendly world" (EDA).

It is known that amended, atypical processing of information is the basis for difficulties of people with dyslexia (Obradović et al., 2015). Among the different perspectives of cognitive specificity of dyslexia, the dominant view is that this developmental disorder is characterized by deficient linguistic processing, based on degraded phonological representations (Gillon, 2004; Snowling, 2000; Carroll et al., 2003; Hudson, 2007, Walley et al., 2003; as cited in Obradović et al., 2015). The phonological deficit hypothesis is a prevalent explanation for the cause of difficulties of dyslexic individuals (the assumption is that specific reading difficulties are the consequence of cognitive deficits connected with the phonological processing and representation of the units of the speech sounds) (Elbro & Jensen, 2005; Snowling, 2000; Share & Stanovich, 1995). The biological basis of dyslexia is the assumed congenital anomalies of the cortical structures participating in phonological processing and reading process, located in perisylvian regions and affecting predominantly the left hemisphere (Galaburda et al., 1985; Temple et al., 2001; as cited in Obradović, 2013).

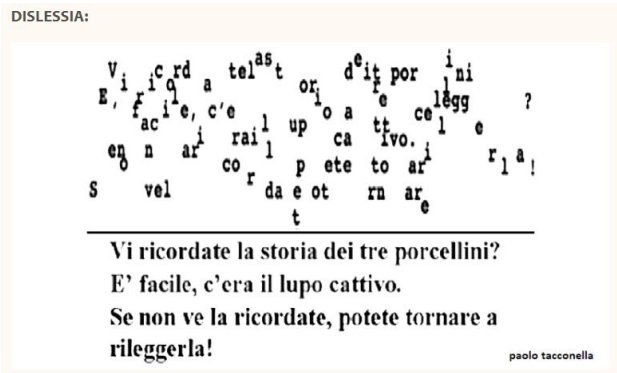

Figure 1. *Persons with dyslexia recognition of text (AID, retrieved from https://www.aiditalia.org/it/la-dislessia*

The effects of dyslexia also vary from language to language. Mastering reading skills in all languages and scripts implies learning the connections of graphemes with phonemes, i.e. learning

orthography. In alphabetic scripts, the correspondence between phonemes and graphemes is not always complete, i.e. the scripts differ in the degree of f this connection complexity (Seymour, Aro, & Erskine, 2003).

Orthographies vary in the continuum from a highly irregular relationship, which is characterized by a complex and inconsistent grapheme-phoneme correspondence (the same sound can be spelled in several ways, and the rules of using graphemes are not clearly defined) to those where the degrees of correspondence between grapheme and phoneme is consistent, and the rules are clear and transparent. The example of highly irregular orthography is English orthography, where the correspondence between graphemes and phonemes is highly complex and inconsistent. English has 26 graphemes, and 46 phonemes, which can be spelled in 1,120 ways (Coulmas, 2003). On the other hand, there are so-called "shallow orthographies" (e.g. Russian, Spanish, Finnish, Serbo-Croatian) where the correspondence between spelling and pronunciation are more regular and consistent, and the spelling rules are clear, although the correspondence is still not equivalent (Borgwaldt, Hellwig, & De Groot, 2005, as cited in Obradović, 2013).

What we today know about dyslexia relies heavily on the findings obtained in the non-transparent orthography of the English language. A review of literature in this field has determined that in the period from 1998 to 2012, as many as two-thirds of the published articles on dyslexia originate from the English language area (Ziegler et al., 2003). However, due to the considerable inconsistency of English script in relation to the others, the question is how appropriate generilizations, drawn from one language writing system and applied to another, can be (Obradović, 2013; Share, 2008). Such challenges have shifted the research focus towards cross-linguistic studies on reading.

According to many findings, such interference of phonological processing (degraded representations of words, phonological working memory deficits or difficulties of recalling verbal stored materials) is not accompanied by analogous difficulties in processing visual material (Spaulding et al., 2008; Archibald & Gathercole, 2006, 2007, as cited in Obradović et al., 2015). Asymmetry in the quality of processing visual and verbal information in people with dyslexia might contribute to the visual preferences in relation to verbal information in various stages of automated data processing, but also to gaining access to the data in the learning process, or in the style of learning. In recent years, there are opinions (Davis, 2010, as cited in Obradović, 2013) that dyslexia itself carries a particular learning style, which is characterized by global perception, thinking in images, intuitive and multi-dimensional thought and curiosity, and which significantly affects the frequent occurrence of innovative and creative solutions in all scientific and artistic fields, and top achievements in different professions than in the general population.

The classic way of teaching is not helpful for students with dyslexia/specific learning disabilities (SLD). This is the reason why there are many multisensory programs for students with dyslexia in the last decades and a space for the creative use of ICT in their education.

The bases of multisensory approach in learning and training students with dyslexia have been an integral part of many programmes for remedying and overcoming reading difficulties (e.g. Palinscar & Brown, 1984; Temple et al., 2003; Trei, 2003; Joyce, 2004, as cited in Obradović et al. 2015). The multisensory approach refers to any learning activity that provides simultaneous input or output through two or more sensory channels. The material taught in this way is easier to remember. This approach is considered suitable for people with dyslexia and bilingual persons who may have difficulty in understanding verbal instructions. That is, by assumption, due to a failure in people with specific learning disabilities, a sensory channel may have restrictions, so it is sometimes very difficult for them to receive information from only one sensory modality properly.

At the end of the 1990s, this notion that students with dyslexia have different patterns of hemispheric processing of data has led to the expiration of their presumed preferences for visual-spatial learning strategies (Obradović, 2013). This idea is further developed by West, and perhaps it could be said that the examination of modal preferences of people with dyslexia was best initiated by West's highlighting (West, 1997, as cited in Obradović et al., 2015, p. 292); the positive aspects of dyslexia that can be used in the process of learning in small groups, and contributing to the achievement of more efficient results in the whole group, and especially the students who have reading difficulties. West has used the Galburda's research to show that persons with dyslexia who rely on data processing in the right hemisphere have practical advantages over the typical population in certain learning situations, pointing out the positive aspects of dyslexia and underlining that people with dyslexia have developed the ability to visualize creative thinking, developed visual-spatial skills, a holistic rather than an analytical approach, and developed skills of practical problem-solving (Obradović et al., 2015: pp. 292-293).

One of the most important problems in teaching students with disabilities is the problem or difficulties in communication. The development of adequate communication is an important, perhaps crucial step, in teaching students with disabilities. Therefore, various forms and means of technological supports are sought and developed -

such as augmented reality technology, augmented reality communication, alternative communication, etc. (Alant, Bornman, & Lloyd, 2006; Mirenda, 1999; Obradović & Bjekić, 2018). E-learning as an educational technology simultaneously uses different sensory channels (visual, auditory, tactile perception channels).

3. EDUCATIONAL DIMENSIONS OF AUGMENTED REALITY

Most of the researchers considered augmented reality (AR) as "a new technology medium that is still very early in its development but is likely to become common educational technology as researchers and educators address the opportunities and challenges it creates (Walker, 2017, p. 1). Milgram (according to Kahn, Johnston & Ophoff, 2019) recognized AR on the dimension of mixed reality (Figure 2).

AR can support and engage students to learn by allowing them to experience content through multiple mediums (Huisinga, 2017). For the students with dyslexia, AR can add digital support and aids for struggling readers to use with non-digital printed text and books (Huisinga, 2017).

Walker mentioned the history of AR (Walker, 2017, p. 2): The term "augmented reality" was used in 1992 to describe a platform used by Boeing as a manufacturing innovation which allowed workers to see digital prompts over real-time imagery to support the completion of assembly tasks. Now, at the end of the twenty-first century, AR is a feature of many applications on a variety of devices, including traditional computers, mobile phones, and, increasingly, wearable devices. AR platforms and applications display digital information on a live view of the real physical world.

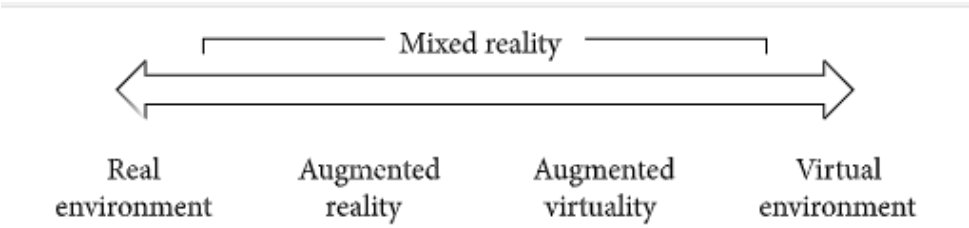

Figure 2. *Milgram's mixed reality continuum (according to Kahn, Johnston &Ophoff, 2019, p. 2)*

3.1. Basics of Augmented Reality

Augmented reality as a kind of virtual reality is defined from different approaches:

- "as a Medium wherein digital information overlays the physical world; dependent on the perspective of the individual interacting with and experiencing the AR Medium" (Caudell, 1992; Azuma, 1997; Kaufmann, 2003; Zhou, Dah & Billinghurst, 2008; and Craig, 2013; as cited in Huisinga, 2017, p. 2);
- "as the kind of reality which integrates virtual object or virtual view in the real object or real environment; it is a technique that augments virtual view into the real world and doesn't break the user connection/interaction with a real world unlike virtual reality" (Khan et al. 2017, p. 500);
- as a system which allows for combining or "supplementing" real world objects with virtual objects or superimposed information, and which is resulted with the coexistence of the virtual objects in the same space with the real world" (Bacca et al., 2014, p. 133);
- as technologies that project digital materials onto real world objects (Cuendet, Bonnard, Do-Lenh, & Dillenbourg, 2013, as cited in Bacca et al., 2014, p. 134);
- as a supplement of the reality (Bacca et al., 2014);
- "as an extension of virtual reality with some advantages over virtual reality" (Wojciechowski & Cellary, 2013, as cited in Bacca et al., 2014, p. 134);
- as a mixed reality in which the virtual objects are located in the physical, outer world (Serin, 2017, p. 5);
- as a technology in which the virtual data and the real environment are brought together in a simultaneous interaction (Azuma, 1997; Milgram & Kishino, 1994; as cited in Serin, 2017, p. 5);
- AR strengthens and augments the physical reality, which can be obtained through the sense organs, with the virtual objects.

One of the illustrative descriptions of the AR is the following (Dunleavy, Dede, & Mitchell, 2009, as cited in Huisinga, 2017): "Digital handheld devices (smartphones, tablets) provide one way to experience AR by overlaying digital content with the physical environment. The camera of the device can recognize physical content using natural feature tracking or GPS coordinates to trigger the augmented content. By looking through the handheld digital device, a viewer sees the digital content overlaid with the real-time image pulled in through the camera. AR allows for digital resources to infuse the world of non-digitally connected items."

The three main characteristics of AR are: (a) combination of a real and virtual world, (b) real-time user interaction ability, (c) realization in 3D space (Khan et al. 2017, p. 500).

Key aspects of AR are the following (Craig, 2013, as cited in Huisinga, 2017,p. 27):

- The physical world is augmented by digital information superimposed on a view of the physical world.
- The information is displayed in registration with the physical world.
- The information displayed is dependent on the location of the real world and the physical perspective of the person in the physical world.
- The AR experience is interactive, that is, a person can sense the information and make changes to that information if desired. The level of interactivity can range from simply changing the physical perspective (e.g., seeing it from a different point of view) to manipulating and even creating new information.

AR can be applied in the multisensory context (as a combination of all senses - hearing, touch, smell) (Bacca et al., 2014). AR strengthens and augments the physical reality, which can be obtained through the sense organs, with the virtual objects (Serin, 2017, p. 6).

3.2. AR Implication in Education

As a blending of virtual and physical worlds in real time, AR can be used in the classroom to supplement physical materials and add new dimensions to classroom learning (Husinga, 2017, p.12).

The AR applications, that are very popular in many fields, have been started to be used in the educational environment easily by the usage of mobile devices (Serin, 2017, p. 5).

According to Serin, the attitudes of the educators and learners have a key role in enabling AR applications to be used smoothly in educational settings (Serin, 2017, p. 4)

Although there are many systematic literature reviews of technology use in education, there are only a few systematic reviews on researches on the effectiveness of educational AR. Bujak et al. (2013, as cited in Serin, 2017, p. 6) have categorized the advantages of using the AR in the educational areas under three titles: physical, cognitive, and contextual. In the review of advantages of the use of AR for educational purposes, some advantages are following (Aziz et al., 2012; Bacca et al., 2014; Quintero et al., 2019; Sirakaya & Sirakaya, 2018):

- increases achievement,
- facilitates learning
- enhances motivation,
- enhances attention,
- ensures permanent learning,
- improves immediate memory (short-term memory),
- improves understanding and memory,
- increases interest in lessons,
- develops positive attitudes,
- enhances spatial skills,
- ensures cooperative learning,
- ensures learning by having fun,
- heighten the excitement of the learning experience,
- enhances engagement,
- increases confidence,
- increases the level of commitment and interest,
- improves satisfaction,
- provides opportunities for self-learning,
- facilitating interaction,
- enhances collaborative learning,
- decreases cognitive load,
- realization of the experiment in a safe environment…

There are also some limitations in using AR for educational purposes (Quintero et al., 2019, p. 61):

- technical problems experienced while using AR is the leading and most important limitation;
- technical problems experienced about GPS, technical problems experienced about perceiving the marker;
- teachers' lack of sufficient information to develop AR materials;
- AR assisted lessons require more time compared to traditional lessons.

A most important aspect of AR for education is the interactivity of the AR (AR requires interaction). The AR as an effective tool to teach abstract concepts since they provide a sense of reality through 3D visualization.

Huisinga makes a review of the examples of uses AR in the classroom (Husinga, 2017, p. 28):

- adding audio and definitions to a word wall;
- augmented posters with images, video, audio, 3D models, text, links to websites; quizzes to engage students;
- connecting videos of project presentations or lectures to an overview bulletin-board/poster or summary hand out;
- showing 3D visual representations of chemical reactions, where students get to push different elements together;
- showing interactive 3D models of items difficult to access (organ dissection, cellular systems or functions);
- gamifying learning and allowing everyday spaces to be transformed with an overlay of information;
- using AR to "travel" on class field trips not only too difficult to reach locations but different times as well;
- allowing students to access digital resources while interacting outside;

- showing real-time translations of printed text to different languages (Google Translate app)
- engaging students in mathematics by connecting real world experiences to mathematic equations.

Considering the attitudes of students towards the AR applications in education, Serin (2017) emphasized positive attitudes.

Considering teachers' views on the augmented reality applications, Serin (2017) summarizes the views of the teachers on AR applications:

- Visualization of the 3D course contents increases the creativity skills of the learners.
- AR apps are more efficient on those students who are reluctant and not active during the classes. They become more active and interested.
- These apps are convenient tools for learners to learn in their speed and styles.
- These apps increase the in-class communication amongst the learners.
- The AR apps provide a suitable atmosphere for student-centred and experience-based learning.
- These applications provide time-saving, especially while teaching 3-dimensional concepts because there is no need for methods like drawing, describing, and imagining.
- It can be easily utilized in the classroom settings on the condition that the amount of light is accurate, and the pointer is pointed decently (Serin, 2017: 10)

Based on the systematic literature review of the AR applications in education, Bacca et al. (2014, p. 146), summarized results in the following way:

- The number of published studies about AR in education has progressively increased, especially in the period from 2010.
- Science and Humanities & Arts are the fields of education where AR has been applied the most. Health & welfare, Educational (teacher training), and Agriculture are the research fields that were the least explored.
- AR has been mostly applied in higher education settings and compulsory levels of education for motivating students. Target groups like early childhood education and Vocational educational Training (VET) are potential groups for exploring the uses of AR in the future.
- Marker-based AR is the most used type of AR. In addition, location-based AR is being widely applied. This can be due to the availability of sensors in mobile devices like the accelerometer, gyroscope, digital compass, and the possibility of using GPS. Marker-less AR needs some improvement in algorithms for tracking objects but the use of Microsoft Kinect is becoming more and more popular.
- The main purpose of using AR has been for explaining a topic of interest as well as providing additional information. AR educational games and AR for lab experiments are also growing fields.
- The main advantages of AR are learning gains, motivation, interaction, and collaboration.
- Limitations of AR are mainly: difficulties maintaining superimposed information, paying too much attention to virtual information, and the consideration of AR as intrusive technology.
- AR has been effective for: a better learning performance, learning motivation, student engagement, and positive attitudes.
- Very few systems have considered the special needs of students in AR. Here there is a potential field for further research.

3.3. AR and Educational Inclusion

According to Walker (2017, p. 1), the potential of AR is only limited to the user's imagination, and is, therefore, one of the more innovative, exciting technologies that special educators can use in their classroom.

The augmented information may be applied to all senses; this makes AR a promising strategy to favour processes of educational inclusion (Sheehy et al., 2014, as cited in Quintero et al., 2019) since it favours multiple means of representation, of action, and multiple ways of engaging students in the learning process (Meyer et al., 2014, as cited in Quintero et al., 2019).

In a detailed review of some studies and researches (widely available literature) that address the use of AR for the creation of inclusive learning scenarios. Quintero et al. (2019) concluded that the use of AR to achieve educational inclusion has been not deeply explored. They emphasized some evidence of the effectiveness of AR with students with disabilities support:

- AR makes it possible for children with disabilities to understand concepts faster and better;
- AR offers exciting and fun teaching aids for students with special needs as it catches their attention.

Walker, also, confirmed that "AR is a particularly powerful tool for individuals with disabilities due to the tools' capabilities of displaying context-relevant digital information that can support the needs of the individual at that moment and provide just-in-time learning (Walker, 2017, p. 3).

Quintero et al. (2019) considered the implementation of AR with different groups of students with disabilities:

- For the individual with hearing impairments, the AR allows the use of mobile devices and the visual channel is often preferred for

perceiving information; the applications developed for this population combine videos with other visual tools or interactive multimedia, also promoting the use of glasses for AR and QR codes (Parton, 2010, 2017, as cited in Quintero et al., 2019); the effects are: eliminating or diminishing the hearing barrier, improving communication.

- For individuals with Autism Spectrum Disorder, AR facilitates the creation of applications recognizing facial emotions; AR helps teachers to reduce their workload and supports better concentration and motivation in children with Autism (Escobedo & Tentori, 2014, as cited in Quintero et al., 2019).
- For individuals with intellectual disabilities, AR has influenced the treatment due to its low cost and the use of gamification, created an interactive textbook for children with learning disabilities due to neurobiological disorder, using AR, video, and images to enrich learning by interacting with the exhibits; the effect is: improving the level of understanding.

According to Quintiero et al. (2019), types of technology, including assistive ones, developed to support using AR for educational inclusion, are different. Technologies used with AR in inclusive education are mainly mobile AR (44%). The "based on the vision" significance (16%) multimedia tools with AR. The next subcategory in importance, based on sensors (6%), refers to those sensors used to search and record the movements of students with some physical or motor disability. Kinetic devices (6%) also help to control movements in combination with AR. Next, 3D (6%), may have been included by more studies in their applications, but only 3 studies mentioned it."

Based on the review of researches, Quintero et al. (2019) concluded that research confirmed the effects of AR in inclusive education are the following:

- Improves communication in students with disabilities;
- Raises interest, attention, motivation, and school performance in students with SEN;
- The teacher can create personalized content for the child;
- Increases knowledge of the subject in students with SEN;
- Improves the teaching of work and employment skills;
- Motivates physical activity in students with disabilities;
- Improves navigation through digital maps;
- Increases access to distance education;
- Reduces the burden of teachers of students with disabilities;
- Improves the physical and mental health of the elderly;
- Improves knowledge of indigenous culture and traditions.

In the research of the impact of different technological trends on inclusive education (Aziz et al., 2012), analyzed cloud computing and augmented reality in education.

The main results supported that "augmented reality offers significant benefits to the learning process". Two potential issues that may inhibit effective implementation of AR (and mobile technology) in the learning of the learners with disabilities, or with the special educational needs, are (a) teachers' lack of training on how to use the technology and (b) the lack of a pedagogical framework on how to include the technology to meet the needs of diverse learners (Walker, 2017).

4. AUGMENTED REALITY AS SUPPORT FOR STUDENTS WITH DYSLEXIA

ART (Augmented reality tool or technology) as an ICT tool enables users to see and experience the real world mixed with various virtual objects, without losing the sense of reality. ART take benefit both for the students with dyslexia and for their educators "since it can transform the learning procedure into more stimulating and entertaining" (Persefoni & Tsinakos, 2016).

Augmented reality technology (ART) can be widely used in working with persons with dyslexia. AR supports all domains of work with persons with dyslexia:

- AR (or ART) in diagnoses dyslexia (Tenemaza, Navarrete, Jaramillo, & Rodriguez, 2019),
- AR (or ART) for treating persons with dyslexia,
- AR (or ART) in educating students with dyslexia.

Laura Anne Huisinga (2017) considered how AR support struggling readers in higher education, especially art/design students in higher education. Her results show that most students, including self-identified struggling and typical readers, would use AR support for other text if provided. Results highlight the potential for using AR on text to provide reading support and the need for additional research on its implementation and impact. The basic conclusion of this research is the following: augmented reading supports for academic text increase motivation, engagement, and confidence in understanding as perceived in struggling readers as well as typical readers (Huisinga, 2017, p. 98)

How students with dyslexia (a specific reading disorder in general) use AR for reading support?

AR supports struggling readers, including scaffolding for vocabulary acquisition and comprehension, which could be overlaid on the static text. Husinga describes AR as educational technology for students with dyslexia:

> "The design of the augmented scaffolding could be based on common core literacy standards, particularly looking at improving synthesis and analysis of reading material and vocabulary acquisition. Research supports explicit instruction practice, particularly when used for struggling learners Yet, direct teacher involvement is not always possible. Developing scaffolding for struggling readers through the use of AR could provide the needed support independently, to be used in a classroom or at home. Direct instruction through the use of scaffolding has been proven to help struggling readers achieve above the level they could on their Scaffolding could be built into an AR experience to provide direct instruction for vocabulary acquisition and comprehension. AR also would bring many affordances of digital text to static print text, which can aid struggling readers" (p. 100).

Huisinga (2017) provides clarity of four main areas of AR applications: (1) the uses for AR in the classroom, (2) the affordances and challenges of using AR for education, (3) how AR experiences are designed, and (4) insights and lessons that can be pulled from studies for both AR research and instruction.

Augmentative and Alternative Communication (ACC), based on the augmented reality and alternative communication, is a specific type of communication intended for people with complex communication needs. ACC supports different AR technology. To implement AAC communication in inclusive educational systems, there is a need to establish national policies in Balkan countries (Obradović & Bjekić, 2018). It is necessary to organize a specific teaching staff education (including student–teachers and practicing teachers) for implementing AAC systems and AR in the educational system.

Walker (2017) described the following mechanisms of AR support for students with dyslexia:

> "Teachers can introduce words in context by labelling physical objects with text labels that AR application can read. AR application can read aloud difficult words, display additional information on an academic topic, provide video instructions and provide details about upcoming procedures when attempting a multistep activity, or deliver prompts to individuals to support independent living. AR can provide a myriad of solutions if we consider practical applications for AR in education in addition to more consumer-friendly entertainment value designs" (p. 3).

Three examples of implementation of AR as support for people with dyslexia are presented: Augmenta11y (Sisodia, 2019), AURISMA (Husinga, 2017), and "I love dyslexia" (Papa, 2016).

Example 1: Augmenta11y (Sisodia, 2018)

Augmenta11y is an application for Android and iOS devices, to help children with dyslexia learn easier. Mudita Sisodia discussed the process of Autmenta11y development (Augmenta11y as augmented reality tools) which was created for helping persons with dyslexia to read better real-world text. After analyzing of available products for supporting students, people with dyslexia, and analyzing comments of the people who work with persons/students with dyslexia, Oswald Labs' team developed some recommendations for preparation AR for students with dyslexia (Gupta et al., 2019; Sisodia, 2018):

- Sans-serif fonts such as Arial, Verdana, and Comic Sans are the least confusing for people with dyslexia. There are also fonts such as OpenDyslexic that are specifically designed to combat this disability.
- Text and background colour combination and contrast aided in making the text more legible to the users.
- Users often have a problem when moving from one line to the next; they tend to skip over lines; they allowed students with dyslexia to customize the text line-height.

Augmenta11y is an augmented reality application for helping people with learning disabilities like dyslexia to easily read the paper and other material in the real world. Augmenta11y helps users to scan text using their smartphone, which will then be superimposed with the same text but styled to suit the preferences of the user. Augmenta11y was developed in Oswald Labs XX.

This application has three features:

- Reader Mode: The user can read the text unaffected by external environmental factors by tapping on a text box and entering the Reader Mode. If required, the user can also have the text read aloud to them.
- Customizable Settings: Different users with dyslexia may have different requirements for styling the text that helps them read better. To facilitate customization, Augmenta11y allows them to adjust properties like fonts, text to background colour contrasts, and line-height. The application also provided a Major Object Detection mode that identifies the largest pieces of recognized text and displays only those, hence avoiding a cluttered reading experience.
- History: This application keeps track of previously detected text for future reference.

Example 2: AURASMA (Huisinga, 2017)

The application AURASMA for students with reading impairment, dyslexia, is developed by the Husinga and team. Huisinga described AURASMA in the following way:

"The three top-level components to an AR system include the sensor, processor, and display. When using AR through a mobile application such as Aurasma, the Tablet or smartphone fills the requirements of sensor, processor, and display, leaving the user free to focus on the virtual content, the interactions, and the physical world. This augmented reading study focuses on the creation of AR experiences through the mobile AR application Aurasma. Designing content for AR through mobile apps like Aurasma consists of creating overlays that can be seen/heard virtually over physical content. Overlays can consist of videos, images, audio, URL links, or 3D graphics. While some AR systems are capable of haptic feedback, olfactory, or gustation simulation, these abilities are not readily available currently for mobile AR technology. When creating video, audio, or photos for an Aura, a digital overlay in Aurasma, the simplest course is to use your smartphone or Tablet. Content can be directly uploaded to create an AR experience through the Aurasma App. Otherwise, content can be added to an AR experience through Aurasma's browser creator studio" (p. 40).

Example 3. "I love dyslexia" (Papa, 2016)

What are the specificities of AR implementation in students with dyslexia learning a foreign language? Aggeliki Pappa recognized that a major problem of today's education for students with dyslexia is education system constraints which prevent learners from being effectively included in the learning process of a foreign language (FL) depriving them of necessary life skill and a global voice. Papa described principles of "I love dyslexia" school:

"The award-winning 'I love dyslexia' (ILD) in Athens, Greece, is the first and only internationally, highly specialized school for holistic EFL-FL learning to students (children and adults) with dyslexia and SEN, introducing an innovative combination of authentic and complete FL tool collection and a pioneering multi-level program set to fill the big gap for effective EFL-FL access for millions of students with SEN worldwide, while its system could be implemented in settings where English is taught as a first language. ILD highly structured tool combination and holistic program of studies are designed based on brain targeted teaching, shelf awareness sessions, design thinking and mind mapping, smart multisensory mnemonics, synthetic and analytic teaching, drama and project passed differentiated activities, use of new technology and augmented reality tools in combination with activities in an outdoor natural environment, as well as mindfulness and Aikido as educational tools to develop inner harmony and meet challenges of living to thrive in life. Last but not least, ILD provides experiential training courses on EFL-FL and SEN, empowering educators worldwide with practical knowledge and effective tools to support all their students to succeed in EFL-FL learning" (p. 47).

5. CONCLUSION

In the new technology environment for teaching, the teachers meet different challenges and they are trying to involve in their educational practice. Augmented reality as educational technology is one of the challenges. Augmented reality enables virtual object involvement in real environments to support and facilitate real-time interaction. The research of educational applications of augmented reality is still in an early stage.

However, augmented reality technology can be considered as a technology for the diagnosis of dyslexia, for the treatment of students with dyslexia, and it is particularly important to research possibilities to use AR in education students with dyslexia.

Also, it is necessary to organize a specific teaching staff training for implementation of the augmented reality educational technology.

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Logistics Education in Universities in 21st Century: New Trends and Challenges

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Abstract: *In this paper has outlined and discusses the need for the application of logistics and logistics information systems in the academic programs at the Universities. One of the inherent characteristics of the global society is a continuous change in area of education. In practice, universities must keep abreast of business and entrepreneurialism. However, within a university's own portfolio, how they design and deliver practical education programs can differ. Only academic programs with productive and valuable educations form can be competitive and relevant to market offer. What real change can occur, dependent of symbiose of study programs and business needs. Logistics is critical for economic activities as it entails the physical movement of people, goods and services. The logistics system is just one of the segments of the information flow of the Supply Chain Management from suppliers and manufacturers to consumers. In the process of globalization, such activities today are unthinkable and unsustainable without information systems. At the heart of economic science is the host's attitude toward resources, and the need to study logistics and supply chain management is considered imperative.*

Keywords: study program, academic practice, information system, logistics, supply chain management

1. INTRODUCTION

Higher education is part of a marketplace. Education is a subjective, natural, people-centric, and societally driven process. The role of higher education in sustainable economic and social development increase year by year, and this will continue over the next decades. With this in mind, universities engage in wider network to capture ideas and embrace best practice. This aims to inspire students in improving their own futures [1]. Quality higher education, enriched with modern practices and skills, is an essential need for any society. Higher education is broadly defined as one of key drivers of growth performance, prosperity and competitiveness. Higher education can be considered an imperative and focal point of knowledge, and its application will make a great contribution to the economic growth and development of any country by encouraging innovation and increasing knowledge and higher skills.

Quality education is seen as a way to improve the quality of life and solve major social and global problems and challenges. Therefore, higher education is given a special place in the agenda of the world's higher institutions. It stands out as one of the key drivers of performance for growth, prosperity and competitiveness.

In practice, universities must keep abreast of business and entrepreneurialism. However, within a university's own portfolio, how they design and deliver practical education programs can differ. Only academic programs with productive and valuable educations form can be competitive and relevant to market offer. What real change can occur, dependent of symbiose of study programs and business needs.

Today we stand on the cusp of a fourth industrial revolution; one which promises to marry the worlds of production and network connectivity in an "Internet of Things" which makes "Industrie 4.0" a reality. "Smart production" becomes the norm in a world where intelligent ICT-based machines, systems and networks are capable of independently exchanging and responding to information to manage industrial production processes [2]. The currently ongoing 4th Industrial Revolution called Industry 4.0, is setting new standards of life and work, which as a result, cause new requirements for education. That cause new challenges.

Industry 4.0 has been defined as "a name for the current trend of automation and data exchange in manufacturing technologies, including cyber-physical systems, the Internet of things, cloud computing and cognitive computing and creating the smart factory" [3].

Universities need to cooperate with companies in shaping competences. In Industry 4.0, having the proper competences is crucial also for specialist profession, such as logistician [4]. In today's new information order, the smart industry or Industry 4.0 unites, coordinates, manages and controls processes, data and services, unites the real and virtual worlds, which is a new dimension of production and the market. This new dimension of the technological environment, radically transforms

the management of the supply chain and final products, which in logistics creates the dimension of smart logistics systems.

The needs of advanced logistics skills are greater than ever. Companies exposed to the global competition are increasingly involving outsourcing partners to meet imposed market needs. In the current business environment, especially in transport and logistic sector, characterized by dynamic and volatile conditions, employees must be able to address obstacles faced by the firm. The application of robotics, modern tools in information technology impose profiles of employees who have high knowledge of information and communication technology. Although there is a tendency to knowledge and practice to rely on software tools to support problem-solving efforts, managerial input is critical. Therefore, companies must focus on selecting the most qualified, best suited managers to work in what frequently involves a somewhat unique and isolated environment. Analytical and creative abilities of managers, as well as the communication skills necessary to convey problem-solving techniques, will influence firm performance [5].

As we move toward a more competitive global economy, there will be an increasing demand for highly qualified people to create and manage more efficient logistics systems and supply chains [6] As businesses are beginning to recognize the importance of having knowledge in this area they also are beginning to recognize that there will be a shortage of qualified talent: "A growing number of companies have recognized the need to develop this expertise. However, companies face a giant obstacle in achieving this goal: the shortage of trained supply chain management professionals at all levels" [7]. Businesses needing expertise in these areas should have access to well-educated managers with the necessary skills to make responsible and effective decisions.

Most of the students graduating from accredited academic institutions in the Northern Republic of Macedonia probably have little or no knowledge of the area that is vitally important to industry and our economy. Academic knowledge in Logistics and SCM discipline is simply not large enough to provide an adequate number of graduates to meet the managerial needs of business activities, which are made even more acute by increasing global competition. The needs for practical knowledge that will be well defined with the practical teaching in the study programs and will provide the minimum skills for working in these activities are inevitable. A small number of major programs still dominate the discipline, but they are generally found in the same schools that run after many years. Inevitably, the practical segment in academic programs must be predominantly represented, but not in form, but by activities that will be evaluated by companies or practitioners in the relevant fields.

Although the number of programs is gradually increasing, there is no large-scale commitment to the development of this discipline, especially enriched with contemporain and advanced informatics contents. The number of programs, courses, students, and faculty must increase at a faster rate and in more academic disciplines. In the interest of strengthening the business competitive orientation of the Macedonian economy, and to meet the needs of companies with sufficient professional staff and skills in the field of transport and logistics, changes in academic programs with content in the field of logistics and information systems will be necessary.

2. ANALYSIS OF THE REAL SITUATION HOW GRADUATES FIT INTO THE LABOR MARKET

Two main factors influence how young higher education staff "cope" with the labor market. The first factor mainly refers to the needs of the labor market and the current development of the economic situation of the country, the employment needs (or unemployment rate) of higher education staff, certain professions that are deficient or surplus, knowledge and skills required, etc. and more. Then, the situation of higher education in the country, primarily professional profiles offered, interest in certain profiles by students, flexibility of educational institutions, aimed at improving certain knowledge, expertise, etc.

According to the data of the State Statistical Office obtained on the basis of received reports, there were 53.677 enrolled students in the Republic of North Macedonia in the academic year 2018/2019, a decrease of 5.7 % compared to the academic year 2017/2018. The number of enrolled female students was 30.352 or 56.6%. The majority of students, 87.0%, were enrolled in public tertiary institutions, while 12.4% were enrolled in private tertiary institutions. In the academic year 2018/2019, there were 13.931 students enrolled in the first year of studies, which is 26% of the total [8].

Only for comparison, in the academic year 2010/2011 enrolled 61.148 students, while enrolled in 2015/2016 the number of students were 58.896. According to the data of the State Statistical Office, obtained on the basis of received reports, the number of graduated students is 7874 at higher vocational schools and faculties in the Republic of North Macedonia. The number of graduated students in 2019 compared to 2018, increased by 2.2%. Of the total number of graduates, 85.5% were full-time students, while 14.4% were part-time students. The share of graduated female students was 57.7%. Of the total number of graduated students, 36.4% have graduated on time, while 63.5% have graduated later than the official duration of education.

The next big problem is the number of unemployed labor force, where Macedonia is counted with a high unemployment rate in Europe. According to the data of the State Statistical Office, in the I quarter of 2020, the labour force in the Republic of North Macedonia numbered 967.733 persons, of which 811.106 were employed, while 156.627 were

unemployed persons. The activity rate in this period was 57.4, the employment rate was 48.1, while the unemployment rate was 16.2 [9].

According to age groups, most of the unemployed (62.9 percent) are between the ages of 25 and 49, while 17.3 percent are in the age group of 15 to 24 and 19.9 percent are in the age group between 50 and 64. Youth unemployment (15-29 years old) remains the biggest problem in the country and the youth unemployment rate of 45.4% is still one of the highest in Europe. This suggests that reducing youth unemployment must be set as a priority and a basis for co-operation between key stakeholders, such as government bodies, educational institutions and businesses / employers.

The situation is worrying with the fact that most young people have been waiting for the job market for more than two years. This results in the obsolescence of their knowledge and qualifications, which makes them less competitive in comparing new "fresh" staff to the labor market. The real risk is that these people cannot find a suitable job at all or have to settle for a position for which higher education is not mandatory, which is a demotivating factor, especially if one knows the time and money these young people spent on studies.

The experience provided by the labor market shows another problem. It is a form of disinterest or rejection towards the new "Bologna" students with 180 ECTS credits. So these young people are at a crossroads, whether to continue their studies and obtain a Master's degree, or to be persistent in their search for a job. Due to the high unemployment rate, an increasing number of these young people are seeking enrollment in master study, especially as they see it as one option for a temporary way out of an unfavorable employment situation.

Due to certain shortcomings in the overall organization of the educational process in the past, certain inadequacies in the transformation of curricula, the readiness of students for a quick entry into the labor market is called into question. On the other hand, many higher education institutions are opening up, which is considered to affect the general decline in the quality of higher education. Certain systemic measures must be found to accept such a critical analysis and aimed at improving the quality and competitiveness of future students.

2.1. Practice and academic programs in high education system in R. N. Macedonia

A very important issue in the educational process in the Republic of Northern Macedonia is the attendance of practical classes by students. In each student year, the student must attend practical classes, which cannot be shorter than 30 days per academic annum, and is a condition for enrollment in the next academic year.

Practical teaching and training of students and their hesitation during the educational process and its application after the completion of a certain cycle is a pillar of new changes in the educational process of the Republic of North Macedonia. Involving students in practical classes is also a form of testing the quality of theoretical and practical knowledge, assessing the competitiveness of certain higher education institutions (public and private), as well as a way of assessing the ability of students to enter the labor market. A lot of feedback is analyzed and focused on improving study programs, the content of certain subjects and the connection with current events and market needs.

It should be borne in mind that if the Law on Higher Education is thoroughly implemented, all these students must go through practical classes in one of the institutions that are related to the academic environment of the students. 7874 students graduate annually (academic 2018/2019), which means that these young people should be ready to apply practical knowledge to the labor market.

With such statements, two important questions arise: Are the institutions (state, public and private) capable and willing to accept such a large number of students for practical classes, and by which they are obliged by law. Usually, institutions do not have the space and physical possibilities to provide the minimum conditions for accepting students. This is a very bitter issue in the real implementation of the legal norm in higher education institutions. The positive thing in the implementation of this legal norm is that a good part of the students, who performed practical classes, were engaged by these institutions even after the completion of the study, and even included in a permanent employment relationship.

2.2. Striving towards the entrepreneurial and practical programs universities

Another important question is how the institutions have responded to such higher education reforms. Undoubtedly, the numerous ways in which institutions can be seen to promote student employable and enhance the student experience with transferable, real-world activities are required. The goal of this analytical situation is to adjust educational and market policies.

Universities of today now aim to promote strategically, and consistently, present themselves as entrepreneurial institution for the future. For all students, the practical focus of what is needed to start up and grow your business is both motivating and practical [10]. This is through developing vibrant programs, encouraging influential researchers and educators in the field, and voicing enduring rhetoric which endorses entrepreneurial education.

According to Iacobucci and Micozzi [11] one of the ways to stimulate start-up in high-tech sectors could be the spread of entrepreneurship courses in engineering and science faculties. Even in this case they should not exclusively be focused on business plan development (entrepreneurship skills) but

rather on enhancing entrepreneurship attitudes and awareness among students. The aim of stimulating start-up in high-tech sectors could be better fulfilled by post-graduate training programs and structures, which can be addressed to more specific targets and be focused on more specific fields.

At the heart of such reforms are the growing commitment of spin-off companies. What is a spin-off company?- is it a frequently asked question. The most common interpretation for this term is related when a company creates a new independent company by selling or distributing new shares of its existing business, this is called a spinoff. A spinoff is a type of divestiture. A company creates a spinoff expecting that it will be worth more as an independent entity. A spinoff is also known as a spin out or starbust. The spin-off company is defined as: a company that employs employees, students, alumni who immediately after graduation start running a business, with the help of professional experience and business knowledge of the university staff. Newly formed companies are joining the university program, which allows them to further develop their products / services with the help of university resources.

In conditions where it is difficult to find interested industry partners to commercialize the scientific and technical results obtained at the University, the spin-off company founded by academics and researchers is usually the best way. The formation of spin-off companies means that its owner, in a sense, can be separated from the university, and this can be a difficult and often risky decision. Therefore, teachers working in such companies are usually offered some additional options such as: part-time work, parallel teaching position and work in the company, but without the opportunity to return to the previous position of the university, if the company fails.

In general, a spinoff tries to take advantage of several purposes, such as retaining talent, developing and exploiting new services and technologies discovered at the institution or company and seeking new business opportunities. Three facts about spin-off activities are undeniable. In developed countries with positive experiences, a private company created at the university must leave the university premises if its owner can no longer be hired full time at the university and the university receives a certain percentage of the value of the company. These private companies only pay for utilities and space rentals at best. In this regard, the company cannot be treated as a result of real spin-off activity. This is due to the fact that there are no clear regulations that define the financial and other relations between universities / faculties and companies formed technology parks.

Based on economic indicators such as: consumer confidence, economic climate and purchasing power of the population, economic trends show that the number of spin-off companies is increasing in conditions of expansion. This is logical and expected, but their formation is even more significant when the economic cycle is in recession. Spin-off companies have contributed to the formation of the overall value at the national level - participation in GDP, which in countries with a large number of technology parks, such as the United Kingdom, Germany and Japan reaches a significant level. This is due to the fact that spin-off companies usually come from the high-tech sector, IT sector, biotechnology, logistics and similar activities that create high added value of the final product.

The number of export-oriented spin-off companies that contribute to improving the trade balance of the home country is also significant. But of all the positive impacts, the most significant (especially for countries with higher unemployment rates, such as the Republic of Macedonia) is the hiring of high-quality staff and increased employment. Namely, the spin-off companies usually employ new graduates from the university that formed the technology park and hiring the young educated potential of a country for national benefits is especially useful. This trend can affect the minimization of "brain drain" from the state, and ultimately, it is based on the development of a country.

It’s important to make the students understand the problem’s true environment during education. Contemporian study programs must tackles with the issue of technology transfer and commercialization, based on the experience and conclusions drawn from the design and ongoing implementation of the above mentioned entrepreneurial applied model, and relates it to the literature on the subject. Speed-to-market is considered in relation to the type of organizations involved in implementing technological innovation.

Today's companies have the opportunity to apply e-business in all business processes. In practice, most companies are gradually introducing certain components of e-commerce into individual business processes. The main reason for the gradual introduction of electronic operations in companies is the gradual development of automation of business processes. In order for a company to introduce an electronic business process, the appropriate business process in the company must be automated in advance.

The use of information technology to exchange data between buyers and suppliers is in fact the creation of a virtual supply chain, which is always based on information rather than real stock.

Success in sharing specific information between supply chain partners can be enhanced through joint customer and seller collaboration, joint

product development, and information system development.

This is also the case with large transnational companies that put the demands of large users of their services in the first place, with which they strive to reach multi-year cooperation agreements. The advantage of the electronic supply chain is in reducing cycle time, closer relationships with partners, revenue growth, cost reduction and production time, optimized inventory management, efficient distribution and collaborative process.

3. MEANING OF LOGISTICS AND SCM FOR ECONOMICAL STUDY PROGRAMS

Students of high business schools and faculties of Economics and Information Technology must have a clear idea of what logistics is today for a company, a nation, a region, the enormous dimension in running the businesses of logistics information systems and what the complexity of supply chain management is. Logistics/SCM is a broad field of study, and people see it from different perspectives and view it as having differing needs.

Logistics and supply chain management are not new ideas. From the construction of pyramids in ancient Egypt to military doctrines and the supply of military units with a variety of equipment, to the supply of hungry people in Africa, the principles of supporting the effective flow of materials and information to meet customer requirements have changed little historically. Over time, the term logistics began to be applied in the field of industry, in the discipline known as "Business logistics". Its significance could be briefly interpreted as the ability to deliver materials and products to maintain the stability and continuity of delivery.

Logistics has always been considered one of the central and essential expressions of economic activity, but lately it has begun to attract serious attention in both theoretical and practical work.

According to Ozment and Keller [12] as we move toward a more competitive global economy, there will be an increasing demand for highly qualified people to create and manage more efficient logistics systems and supply chains. Businesses needing expertise in these areas should have access to well-educated managers with the necessary skills to make responsible and effective decisions. According to Tseng [13] at all logistics services comprise physical activities (e.g. transport, storage) as well as non-physical activities (e.g. supply chain design, selection of contractors, freightage negotiations). Most activities of logistics services are bi-direction. Information systems include modelling and management of decision making, and more important issues are tracking and tracing. It provides essential data and consultation in each step of the interaction among logistics services and the target stations. The information flow interlaces between different stakeholders within the system. Each stakeholder can communicate with the others directly to maximum their profitability. Reverse logistics will be adopted in various modes and applications in the future due to its efficiency and benefits in environment protection.

We can find many study in the literature on the conceptual definition and scope of logistics information systems. Some authors treat this issue as „Interconnected hardware and software systems design to support logistics elements"; e.g., coordination of logistics activities, material flow, and inventory replenishment. Logistics information systems are a subset of the firm's total information system, and it is directed to the particular problems of logistics decision making. There are three distinct elements that make up this system: a) the input; b) the database and its associated manipulations; and c) the output.

Supply chain performance has never been as important as it is today because in an economy where supply chains companies, competes with one another, it is the performance of supply chain that determines who will win the competition. Many companies are still not aware of the performance of their supply chains or they even don't know what kind of supply chain they have [14].

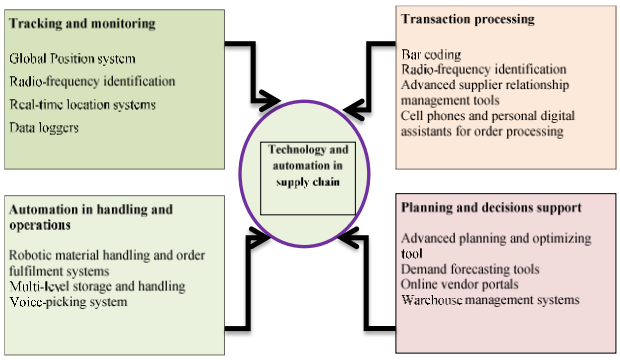

Figure 1. *Areas of technologies and automation adoption in supply chain*

But today companies expanded their activities outside of logistics systems, fully entering into the dimension of the management of the supply chain. Purchasing chain management is a very complex activity, due to the increasing volume and intensity of global movements, complex company structures, increasing the number of partners, suppliers and functional teams. This number will continue to rise as the global market continues to expand. In order for companies to keep pace with this expansion, supply chain management will require systemic change, a step that will contribute to even more operational activities. (Temjanovski, 2020).

In today's economics, supply chains play a key role. The most critical element of the supply chain, as well as the logistic process is production and serving the production. This means that serving modern production lines with determined elements significantly affects the turnaround time and costs. In today's economic environment – especially thanks to unique mass production – the modern production systems require flexible and effective production solutions. This is especially true in the

case of small scale producing of different unique products. The distribution of tasks to individual (flexible) production lines even today is often based on experience. This can lead to increased turnaround time, which leads to increases in logistical expenses, and thus decreases the company's profits. [15]

According to Michael Porter, Purchasing Chain Management consists of a chain of activities, from which each member of the chain adds value to the company's products or services. The model shares the organization's tasks in core activities (inbound logistics, operations, output logistics, marketing and sales, and services) and support activities (administration and management, human resources, technology and procurement).

Finally, experts have concluded that the supply chain management covers the entire process of production and distribution of physical goods, from supplier to customer. The business functions that fall within the scope of supply chain management include: forecasting and planning, procurement and purchasing, manufacturing and installation, storage and distribution, transportation and transportation, and management inventory. Or, simply put, supply chain management includes the following functions: planning, buying, giving, storing, moving, selling, and returning.

4. ARTIFICIAL INTELLIGENCE AND LOGISTICS SYSTEMS

We are witnessing numerous articles about artificial intelligence (AI) in daily newspapers and information of numerous companies. Despite the great benefits of these technological advances, mentioning the terms artificial intelligence in scientific circles is nothing new. The term was coined in 1956 by John McCarthy, a Stanford computer science professor who organized an academic conference on the topic at Dartmouth College in the summer of that year.

AI is like a system, that is based on the ability to estimate and categorize the multitude of data obtained, process it, and then draw conclusions from this. The output of this process is insight, decision, projection or conclusion.

AI is a branch of information technology that deals with the automation of intelligent behavior. AI is the attempt to program a computer so that it is able to process problems independently, similar to the way a human with the appropriate training would. On the one hand, artiicial intelligence could form the basis for huge productivity gains and improved quality of life. On the other hand, as with all new technologies, it could lead to a radical change in the world of work, comparable to the introduction of the conveyor belt. That is to say nothing of the ethical and societal issues that we must consider if machines acquire greater and greater intellectual capacity.[16]

Artificial intelligence can be defined as human intelligence exhibited by machines; systems that approximate, mimic, replicate, automate, and eventually improve on human thinking. Throughout the past half-century a few key components of AI were established as essential: the ability to perceive, understand, learn, problem solve, and reason [17] According to Hofmann S., Knell T**.** [18] the term Artificial Intelligence refers to the ability of machines to interpret different problems and to independently develop suitable solutions. Instead of working through rigid algorithms AI-Machines make their decisions afterwards and can therefore acquire a well-founded wealth of experience. With its help, they can develop ever better solutions and even make predictions.

Artificial information systems function as neural networks to solve complex problems in which a large amount of information is collected. Nervous networks reveal this knowledge through the use of hardware and software that is analogous to the processing of biological or human brain. Application of such sophisticated neural networks is in medicine, financial business, logistics, which covers problems in the field of template classification, forecasting, financial analysis and control and optimization of commodity turnover**.** [19]

Artificial intelligence is very much present in today's logistics operations. The main goal of these systems is to use computer programs to broadcast people's behavior in the decision-making process, but also to perform the most complex digital processes.

In the global, macro and microeconomic systems, there are and continue to be a number of specialized logistics systems, which at various levels, more or less successfully, effectively and rationally, produce special types of logistics products. The structure of the general logistics system consists of numerous interconnected, compatible, complementary, complex, stochastic and dynamically specific (sweat) systems. Some of the (general) systems of the general or universal logistics system are larger and some smaller, others are more complex, and still others are simpler, but some are more important than other subsystems [20]. The general logistics system is a system of interconnected and interconnected subsystems and elements that, through logistics infrastructure, over-structure and intellectual capital in a highly sophisticated industry, enable successful and efficient production of logistics products. The structure of the logistics system is made up of a number of subsystems, some of which are larger, some more important, more complex.

A lot of enterprises like Google, Amazon, and Intel start to invest their resources into AI. Actually, this technology allows saving time and money because it offers to automate various time-consuming processes.

Benefit of artificial intelligence in the logistics field: [21]

- Automated Warehousing – AI transform warehousing operations such as collecting and analyzing information or inventory processing. As a result, AI assists in increasing efficiency and getting profit. Artificial intelligence is used to predict the demand for certain products. After that, the company delivers demanding items to the regional warehouses reducing the transportation costs.
- Autonomous Vehicles - There is nothing more exciting than the field of autonomous transport for SCM. We've all known for many years that driverless trucks have major potential to affect supply chain management and logistics.
- Smart Roads or route optimization. The customers drivers and vehicles submit data to the machine, which then uses algorithms to creates the most up-to-date optimal routes depending on road conditions and other objective factors.
- AI algorithm can forecast when orders will arrive and leave a warehouse - The AI algorithm can forecast when orders will arrive and leave a warehouse, which means employees can put the pallets in the right position.
- Artificial Intelligence of the Back-Office Operations - AI and RPA (Robotic Process Automation) allow employees to speed up the working processes. For example, there are some data-related tasks that repeat every day. They can be automated. The companies with supply chains can save time and money since back office automation.
- AI to Predict the Demand and Improve Customer Experience - Artificial intelligence allows following the necessary factors to increase the accuracy of demand prediction. After that, this information can make warehouse management easier. Additionally, AI improves customer experience. Due to the implementation of this technology, clients can get a more personalized experience and, as a result, trust the company more.

Furthermore, logistics needs to predict consumer needs, goods demand, simplifying and speeding up daily administrative processes and streamlined workflow to remain unhindered and profitable. According to Blake Morgan [22] AI combines historical delivery information with customer feedback, weather reports and logistics to give an accurate prediction of when products will get to customers. The result is a more cohesive company that is able to make decisions faster and satisfied customers who knows just when their products will arrive.

AI provides for increasing process efficiencies, supplies most accurate prediction models and enables an unprecedented ability to adapt to changing markets - no surprise that last year more than $ 40 billion were invested in the research of Artificial Intelligence globally. Many people regard it as one of the most important growth drivers for logistics over the next few years and as the most important key to competitiveness. [23]

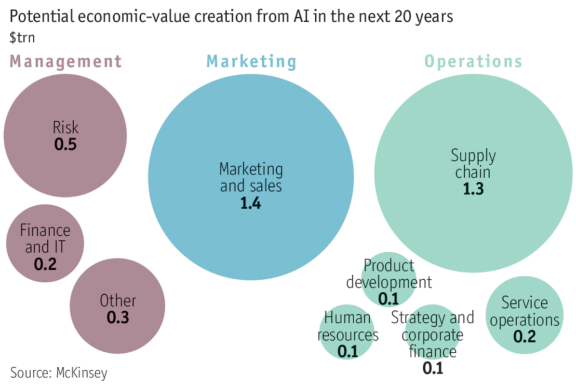

Figure 2. *Potential economic-value creation from AI in the next 20 years*

Undoubtedly, integrating AI into the complex web of production and distribution—the supply chain—will have a bigger economic impact than any other application of the technology and affect a larger number of businesses. McKinsey [24] estimates that firms will derive between $1.3trn and $2trn a year in economic value from using AI in supply chains and manufacturing. Many firms are already using robots powered by machine learning to improve the running of their factories and warehouses. But AI will transform several other aspects of supply chains as well.

5. CONCLUSION

Quality higher education, enriched with modern practices and skills, is an essential need for any society. The roles of higher education in sustainable economic and social development increase year by year, and this will continue over the next decades. In practice, universities must keep abreast of business and entrepreneurialism. However, within a university's own portfolio, how they design and deliver practical education programs can differ. Only academic programs with productive and valuable educations form can be competitive and relevant to market offer. What real change can occur, dependent of symbiose of study programs and business needs.

As we move toward a more competitive global economy, there will be an increasing demand for highly qualified people to create and manage more efficient logistics systems and supply chains. Students of high business schools and faculties of Economics and Information Technology must have a clear idea of what logistics is today for a company, a nation, a region, the enormous dimension in running the businesses of logistics information systems and what the complexity of supply chain management is.

Nowadays, AI uses the full potential of data to better predict a multitude of processes, events, and threats. In its algorithmic portfolio it focuses on avoiding risks and creating optimal solutions. This allows organizations to better manage their resources to optimize resources for maximum benefit. AI brings efficiency to the supply chain and logistics technology. Its advantages can be employed for end-to-end solutions. From planning, tracking, control procedures, and implementation,

logistics improves current operations and make the best business solutions. Data collection can be a by-product of other activities, eliminating the need for effort in form filling. It is also highly desirable for high-end costly items such are specialized engineering parts that require enhanced tracking given the value of items. It also finds opportunities that may exist in production, storing, distribution, and transporting. Forecasting engines with machine learning offer an entirely new level of intelligence and predictive analysis of big data sets that provides an optimal loop of forecasting, overhauling the way we manage inventory and the way we create new strategies for our industries.

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Professional paper
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A Chance for Engineers – Technology Entrepreneurship

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Abstract: T*echnological inventions are often results of thorough research. Identifying inventions' market potential and preparing them for market commercialization are critical tasks, but they require development of entrepreneurial mindset and skills, knowledge about market, finance, how to start a business venture. Entrepreneurial education is necessary in order to get students of technical and engineering faculties involved in entrepreneurial activities. Technology entrepreneurship education requires introduction of entrepreneurship content in the curriculum of existing engineering study programs. Technology entrepreneurship could be a chance for engineers' self-employment, as youth unemployment and inactivity are serious problem especially in developing countries.*

Keywords: *technology entrepreneurship, engineers, skills and knowledge*

1. INTRODUCTION

Entrepreneurship is vital for economic growth in especially in developing countries. Entrepreneurship makes the economy more competitive and more innovative. Commercialization of new ideas improves productivity and creates wealth. New companies, especially small and medium, are great source of new jobs. Unemployment of youth and their inactivity at labor market are major problems, especially in transition economies. In order to exploit advantages of entrepreneurship business model, diverse skills and knowledge about entrepreneurship are required, so faculties are encouraged to introduce entrepreneurial competences in curriculum of almost all areas and courses of study [1]. Entrepreneurial education helps to unleash the entrepreneurial potential of young people. The exposure to entrepreneurship courses increases the intention of university students towards entrepreneurship, compared to the entrepreneurial intention of those who have not taken any courses related to entrepreneurship [2].

Development and implementation of information and communication technology (ICT) resulted in new products and services which created a chance for new form of business venture – technology entrepreneurship. Technological inventions are often results of thorough research and technology entrepreneurship could be a chance for engineers' self-employment. Identifying inventions' market potential and preparing them for market commercialization are critical tasks, but they require development of entrepreneurial mindset and skills, knowledge about market, finance, how to start a business venture. Entrepreneurial education is necessary in order to get students of technical and engineering faculties involved in entrepreneurial activities.

2. ENTREPRENEURSHIP

Key factor of economic development based on innovativeness in European Union (EU) is considered to be entrepreneurship. Schumpeter (1934) explained entrepreneurship as a key process through which the economy as a whole is advanced [3]. European Commission defined entrepreneurship as an individual's 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 objectives [4]. Entrepreneurship also refers to creation of new values through creative combination of business resources.

There are different types of entrepreneurship, which differs depending on the primary motives used for conducting of entrepreneurial venture, used resources, concepts apllied in the relevant sector of economy. In recent years, the phenomenon of technology entrepreneurship has attracted the interest of researchers and policy makers that recognized its positive effect on economic development [5].

3. TECHNOLOGY ENTREPRENEURSHIP

Over the last three decades, technology entrepreneurship / technological entrepreneurship / technoentrepreneurship has become an increasingly important global phenomenon [6]. It is

important for growth, differentiation and competitive advantage.

Technology entrepreneurship is an investment in a project that assembles and deploys specialized individuals and heterogeneous assets that are intricately related to advances in scientific and technological knowledge for the purpose of creating and capturing value for a firm [7]. European commission defined technology entrepreneurship as forming new ventures and transforming existing businesses by developing new digital technologies and/or new usages of such technologies [8]. Some authors defined technology entrepreneurship as the interface of two well-established, but related fields—entrepreneurship and technological innovation [5]. Technology entrepreneurship is critically concerned with technical innovations and the nascent markets and new products they often enable. It exists when developments in science or engineering constitute a core element of the opportunity that enables the emergence of a venture, market, cluster, or industry [9]. Technology entrepreneurship involves a process of industrial innovation, technology transfer and the commercialization of innovative ideas [10].

Technoentrepreneurship is about [6]:

- Operating small businesses owned by engineers or scientists
- Finding problems or applications for a particular technology
- Launching new ventures, introducing new applications
- Exploiting opportunities that rely on scientific and technical knowledge
- Working with others to produce technology change.

Technology entrepreneurship is a future trend in the era of the industrial revolution. It requires innovation and individuals who understand ICT. Changes in technology produce opportunities where entrepreneurs or entrepreneurial organizations can properly exploit and explain how entrepreneurial behavior can be a driver of change in adopting business technology. It talks about the combined concepts of creativity, innovation, entrepreneurship and technology [10].

Technology entrepreneur/ technopreneurs can be defined as an adult entrepreneur who has hybrid competence and who uses technology to create something new for modernization or some innovation [11]. They are individuals who have expertise in mastering technology so they can see business opportunities in the field of technology. They must succeed at two major, but fundamentally different, tasks: ensuring that the technology actually works and satisfy customers' needs, and that it can be sold for profit and provide benefits economically, socially and environmentally [6].

Technology entrepreneurs have more technical skills and competences than non-technical ones. One important step in the new venture success is the transformation of the entrepreneurial mind into managerial one. Technology entrepreneurs have to understand how their businesses will evolve and the importance of managerial skills, and the most important strategic oriented mindset [12]. They are motivated not only with an opportunity to earn, but also by an opportunity to launch an innovative product or solve social problem [13].

Technology entrepreneurship that necessarily deals with implementation of technological change in organization, implies [14]:

- Activities of research and development directed towards the development of new technology products, services and processes, modification and improvement of existing products (vertical technology transfer)
- Activities of acquisition of already developed, new technologies through different business arrangements and transactions (horizontal technology transfer).

Technology entrepreneurship in some point is wider concept from the concept of entrepreneurship, because it refers to entrepreneurship in vertical and horizontal technology transfer, not only horizontal where entrepreneurs see the opportunity (new technology) and bring it to the market [14]. Vertical technology transfer refers to the whole chain of activities which lead to development and implementation of new technology, which means that it involves activities of research and development. In order to monitor and analyze progress of technology entrepreneurship, some indicators must be identified. The most important technology entrepreneurship indicators are research and development expenditure (for vertical technology transfer) and gross fixed capital formation/investment (for horizontal technology transfer), both given as a percentage of gross domestic product (GDP) [14].

The indicators of technology entrepreneurship and the position of Serbia, comparing to the EU, the world and former Yugoslav countries, were analyzed for the period 2008-2018. Data was collected from World Bank reports [15, 16] for the period from 2008 till 2018.

Research and development (R&D) expenditure in Serbia, as percent of GDP, was given at Table 1 – part 1 and part 2. A trend of this indicator was given at Chart 1. This indicator was compared with figures in EU and in the World.

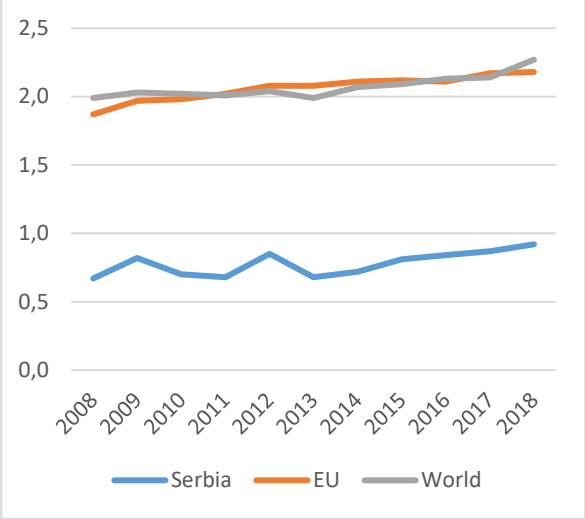
Table 1. R&D expenditure (% of GDP) in Serbia, EU and World during 2008-2018 (part 1)

	2008	**2009**	**2010**	**2011**	**2012**
Serbia	0,67	0,82	0,70	0,68	0,85
EU	1,87	1,97	1,98	2,02	2,08
World	1,99	2,03	2,02	2,01	2,04

Table 1. - part 2

	2013	2014	2015	2016	2017	2018
Serbia	0,68	0,72	0,81	0,84	0,87	0,92
EU	2,08	2,11	2,12	2,11	2,17	2,18
World	1,99	2,07	2,09	2,13	2,14	2,27

Chart 1. R&D expenditure (% of GDP) in Serbia, EU and World



From Chart 1 it could be concluded that Serbian R&D expenditure were lower than 1% of GDP, which puts Serbia in the group of countries with smallest expenditures in R&D, in the world and in the EU. Serbia was far behind in EU when it comes to investment in R&D, but encouraging fact was that these investments were constantly growing since 2013 and that they were almost 1% of GDP in 2018.

Countries, that invested the most in R&D, had dedicated more than 4% of GDP for R&D (Israel and Korea). In Europe, Austria, Germany, Denmark and Sweden invested more than 3% of GDP in R&D.

Comparing to the countries that used to be part of Yugoslavia, Slovenia invested more than double amount in R&D than Serbia, and Croatia was almost at the same level. Other countries were far behind Serbia. Research and development expenditure in former Yugoslav countries are presented in Table 2 – part 1 and part 2.

Table 2. R&D expenditure (% of GDP) in former Yugoslav countries (part 1)

	2008	2009	2010	2011	2012
Bosnia and Herzegovina	0,02	0,02			0,27
Croatia	0,88	0,84	0,74	0,75	0,75
North Macedonia	0,22	0,20	0,22	0,22	0,33
Montenegro				0,31	
Serbia	0,67	0,82	0,70	0,68	0,85
Slovenia	1,63	1,82	2,06	2,42	2,57

Table 2. – part 2

	2013	2014	2015	2016	2017	2018
Bosnia and Herzegovina	0,32	0,26	0,22	0,22	0,20	0,20
Croatia	0,81	0,78	0,84	0,86	0,86	0,97
North Macedonia	0,44	0,52	0,44	0,44	0,36	0,36
Montenegro	0,37	0,36	0,37	0,32	0,35	0,37
Serbia	0,68	0,72	0,81	0,84	0,87	0,92
Slovenia	2,58	2,37	2,20	2,01	1,87	1,94

The second analyzed indicator of technology entrepreneurship was gross fixed capital formation/investment, as percentage of GDP. This indicator is relevant for horizontal technology transfer. This indicator was presented in Table 3 – part 1 and part 2 for the period 2008 – 2018. The data showed the value of investments in Serbia, EU and in the world. The trend of these investment was given in Chart 2.

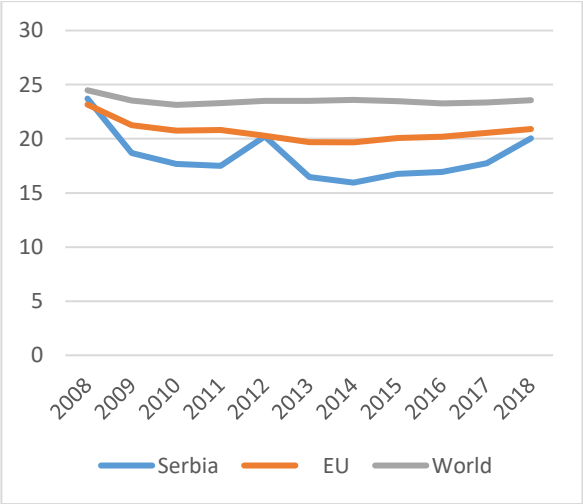
Table 3. Gross fixed capital formation (% of GDP) in Serbia, EU and World during 2008-2018 (part 1)

	2008	2009	2010	2011	2012
Serbia	23,71	18,69	17,68	17,51	20,21
EU	23,16	21,25	20,75	20,82	20,29
World	24,48	23,52	23,13	23,29	23,51

Table 3. – part 2

	2013	2014	2015	2016	2017	2018
Serbia	16,47	15,95	16,77	16,95	17,75	20,05
EU	19,68	19,67	20,06	20,19	20,54	20,89
World	23,49	23,59	23,48	23,26	23,36	23,56

Chart 2. Gross fixed capital formation (% of GDP) in Serbia, EU and World during 2008-2018



From Chart 2 it could be concluded that gross fixed capital investments in Serbia were growing since 2012, and that they are close to European average. This indicator is a good sign of conditions improvement of for technology entrepreneurship

development. Comparing to former Yugoslav countries, the level of gross fixed capital investments was almost equal in all countries, except Montenegro where these investments were significantly higher than in all other countries.

4. THE ROLE OF UNIVERSITIES IN TECHNOLOGY ENTREPRENEURSHIP DEVELOPMENT

An important element of engineering education is the use of laboratories and workshops in the development and application of technical products and systems. This part of the problem-based focus of engineering education is essential in the development of engineering-related desired learning outcomes [17]. The use of laboratories and workshops, creates a reference to real-world problems and contextualizes learning content and objectives in application-oriented scenarios. For instance, this could happen through the use of new technical equipment, software development, and exercises in prototype development that imitates the activities and tasks of potential future engineering professions. For example, professional engineers could give important feedback and support for development of a technical prototype which creates an in-depth learning experience for students that goes beyond classroom learning. Actual hands-on experience is especially important in the development and application of tangible products and services, which is often a shared focus of engineering education and technology entrepreneurship [17]. Thus, the interaction with appropriate spaces and practice is essential in the development of capabilities for technology entrepreneurship. This applies not only to the development of technical products and services, but also to the process of identifying and evaluating market opportunities for the respective products and services.

Collaboration between universities, research centers, start-ups, corporations, small and medium enterprises and other regional entities is very important to foster innovation, know - how transfer and human resource development [12]. The benefits characteristic for science and technology would not be exploited until they are transformed to products and services through innovation and diffusion.

Start-ups can be used as a tool for actualizing students' professional competencies, but there are several conditions for its success. The university should take the initiative to create a regional start-up ecosystem, create a university entrepreneurial network that includes students and graduates, open its own funding platform, and launch a start-up factory [18]. Start-up firms which start as small and medium sized enterprises are considered to be the driving force of the economy, both in developing and developed countries [10].

Universities also have an important role of spin-off generators. Students can play a significant role in the activation of academic spin-offs that commercialize university research, so there is a need for development of students' skills and capabilities for technology entrepreneurship. Many times innovation dies because of lack of supports. Many engineering students are doing so many innovative things but most of the time they end up as a certificate on a piece of paper as they do not find any support to commercialize their ideas [19].

Engineering students can play a major role in developing new technological firms. However, entrepreneurship courses are not well spread in the engineering schools, the courses should not focus solely on business plan development, but they should also enhance the entrepreneurial attitudes, intentions, and awareness among students [20].

Universities can also support entrepreneurship education by providing extra-curricular activities such as the participation in entrepreneurial competitions and associations in addition to internships. It could be wise to create teams consisted from students from different departments, engineering and management for example, so the team could have more perspectives in problem solution and creating a venture. That way all students will be given a chance to become entrepreneurs.

While engineering education had a clear focus on the development and application of technology without any relation to market contexts, entrepreneurship education pursued the objective to create new products, services, and ultimately ventures. Technology entrepreneurship education aims to bridge this gap between the disciplines with the objective to develop entrepreneurial knowledge and competences along in-depth understanding of technology [17].

Entrepreneurship education has to be integrated with the normal curricular being taught to engineering students.

5. TECHNOLOGY ENTREPRENEURSHIP EDUCATION

Technology entrepreneurship education combines concepts from technology commercialization and entrepreneurship. It directly connects the development of the technology with its commercialization and thereby suggests a path towards effective technology transfer of promising research developments [21]. While engineering education in the technical faculties had its focus on technology creation and development, entrepreneurship education in the business and management faculties promoted the commercialization of products or services through the creation of new ventures. Cooperation between universities and companies is important, because it

allows to explore and test innovative knowledge transfer. Such cooperation will allow students, at the educational level, to become more familiar with work at enterprises or to see their functioning from the inside, which in the future can help them to start their own business.

Four characteristics are necessary for an effective teaching model in technology entrepreneurship education. The teaching model need to be real, intensive, interdisciplinary and iterative [21]. *Real* means that students' projects can become new ventures by the end of the education; *intensive* means there is exposure to several experiences (including setbacks and failures) in a short period of time; *interdisciplinary* implies a diversity of skills not only in the teams, but also in the tasks that need to be accomplished; and *iterative* as in offering opportunities to revise and learn through multiple iterations of the process activities.

Technology entrepreneurship education focuses on increasing the entrepreneurial engagement and mind-set of students that had previously none or only limited experience with entrepreneurship [17]. This way an option for technology transfer and commercialization could be made.

Technology entrepreneurship education occurs either through the introduction of entrepreneurship content in the curriculum of existing engineering programs or the creation of entirely new programs that focus on competences that utilize the intersection between engineering and business [17]. That way development and application of technology are provided, but also it puts the respective technologies into a market context.

6. THE NECESSITY OF ENTREPRENEURSHIP EDUCATION

Entrepreneurship education provides new knowledge, skills and attitudes relevant for self-employment, active citizenship and new jobs creation. It empowers people with capabilities to transform ideas into actions, which requires creativity, initiative and risk taking, planning and project management in order to fulfill defined goals [22]. The main aim of entrepreneurship education is to develop all necessary entrepreneurial skills for establishing the performance specifics of big, middle and small companies that will be from the risks and will generate an expected level of profit on annual basis [23].

In the pursuit of their goals, entrepreneurs commonly use competences like creativity, innovation, problem-solving, risk-taking and pro-activity; these competences can generally be acquired and developed [24]. Entrepreneurship Competence study (EntreComp) defines entrepreneurship as a transversal competence, which applies to all spheres of life: from nurturing personal development, to actively participating in society, to (re)entering the job market as an employee or as a self-employed person, and also to starting up ventures [25]. Flexibility, innovatinveness, negotiation, among other competences, become necessary, so education of engineers needs to prepare students for economy where they will be working [26]. Entrepreneurial competences enable individuals to develop their own personal development, to find their own place at labor market, to start own entrepreneurial ventures [27].

Entrepreneurship education should raise students' awareness of entrepreneurship as possible career options, as well as provide specific business skills and knowledge about starting and running a business. Entrepreneurial orientation can be affected greatly by the education process. Entrepreneurship should improve graduates' attitudes towards self-employment, risk taking, creative thinking, as well as the skills necessary to manage newly created business projects, and not just to train students in the functions and roles of entrepreneurship [28].

Entrepreneurial education should be a part of all forms of education (formal and informal and non-formal) in order to spred entrepreneurial initiative at all forms of life and work of people, because the benefits from entrepreneurship education are multiple [27].

7. CONCLUSION

The importance of entrepreneurship increases the responsibility of universities in providing students with adequate entrepreneurial skills and mindset.

Technology entrepreneurship could be a chance for engineers' self-employment. In 2019 the unemployment rate of youth age 15 – 24 was 27,5%, but even bigger problem was the youth inactivity rate which was 70,4%, which was almost the same and the year before [29]. National Youth Strategy of Serbia 2015-2025 promotes entrepreneurship education at all levels of formal education and development of programms for teaching entrepreneurship competences and financial literacy as part of educational plans and programs [30]. Also, there are recommendations for creation of business development support centers at universities and local business incubators for start-ups that could help commercialization of technology inovations.

Technology entrepreneurship represents a promising option for universities to commercialize technology research and contribute directly to communities. More interactions between research groups, technology venture and support organizations such as university incubators, accelerators and science and technology parks are necessary in order to help students achieve first commercial success with their innovations.

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An Impact of the Application of the Lean Concept to Improving Industrial Engineering Education

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Abstract: *This paper emphasizes the importance of applying the LEAN concept in higher education of Industrial Engineers. The purpose of this paper is to present some possibilities of applying the Lean concept as an aid to the industrial engineering sectors in universities to develop better Lean thinking and the application of Lean education in this field. The paper presents Lean approaches that contribute to the improvement of teaching curricula and teaching processes, such as Lean Learning, Lean Thinking and Lean approach to online distance learning. Also, the new modified 7P Lean concept was presented, modeled on the manufacturing Lean concept, where the advantages of Improving Industrial Engineering Education were highlighted. Each of these approaches offers practical solutions and suggestions to highly educated institutions for the improvement of traditional and existing processes, and raises the world of teachers for continuous needs for improvement, which is the essence of the Lean philosophy.*

Keywords: *Lean concept; Industrial engineering education; Lean learning; Lean thinking*

1. INTRODUCTION

Over the past few decades, industry underwent phenomenal and revolutionary changes. With tools and techniques such as Lean Manufacturing, Six Sigma, Total Quality Management, business process reengineering, and concurrent engineering, the manufacturing industry made radical changes in the way it conducted business [1]. Using Lean principles, many organizations, not just from the industry, have significantly improved their business results. The Lean concept is multidisciplinary integrated at several universities as part of educational programs, with special emphasis on the education of Industrial Engineers. The organizational environment of highly educational institutions has changed dramatically in recent years and requires constant change and user orientation. The application of the Lean concept in the education sector is a completely new approach to improving education. But in previous years, a large number of researchers began to deal with this topic, so as a result of research, many Lean methods emerged. Lean concepts have helped many educational institutions to increase the number of students enrolled in courses. Sunder [2] emphasized the importance in finding new and improved ways of teaching, redesigning institutional infrastructure, and processes in order to survive and compete in the educational environment.

Lean Higher Education (LHE) Balzer [3] has enabled post-secondary institutions to seek similar improvements in response to the demands of the higher education marketplace: exceeding the expectations of students, faculty and other constituents; reducing expenses in an age of rising costs and declining financial resources; meeting demands for public accountability in terms of efficiency and effectiveness; and, most importantly, strategically leveraging all available institutional resources to fulfill the educational, scholarship and outreach missions of higher education [3, 4, 5].

Building a programme of education that reflects and keeps pace with industrial practice is difficult. We often hear of a skills shortage in the software industry, and the gap between what people are taught in university and the "real world" [6].

Lean concept is an organizational development program that strengthens the work performance and job satisfaction of each individual in the education system and forces him to constantly improve. Lean's task is to add value to teaching processes by eliminating unnecessary activities that affect the efficiency of teaching. In order for these Lean approaches to be successfully implemented in highly educated institutions, mutual cooperation in the teacher-student relationship is necessary, as well as a lot of joint work. The requirements of the labor market and industrial companies also have a great influence on

the definition of the concept, for the needs of which, with the ultimate goal, future Industrial Engineers are educated.

2. APPLICATION OF LEAN CONCEPT IN EDUCATION OF INDUSTRIAL ENGINEERS

Compared to all other industrial disciplines, Industrial Engineering offers the widest opportunities in building and developing a career. Graduated engineers have opportunity to work in a variety of jobs, from production, through management, to maintenance and quality control, not limited to the manufacturing sector, but also to other related engineering fields. Years ago, Lean became an important topic in the curricula of almost all academic educational institutions of Industrial Engineering.

In order to become competitive on the labor market, it is necessary for Industrial Engineers to be well acquainted with the Lean principles, which enable them to acquire the necessary modern and efficient LEAN skills. The JELA student union for industrial engineering and management conducted a research on this topic [7], where, among other things, the role of the Lean concept in bringing students closer to the labor market was presented. In modern industry, there is a constant need for mutual harmonization of acquired university knowledge of students with the needs of industry. Thus, it is necessary to develop numerous professional competencies during studies and their thorough application in practice. The approaches used in the Lean instruction have been carefully examined leading to a number of relevant findings, including end-customer identification and value-added competence development activities, as well as a number of strategies that promote continuous improvement and enable withdrawal and equalization of competence development [8].

2.1. Lean Learning approach in the education of industrial engineers

Lean Learning is a process of learning and development in order to achieve a high level of education in a quality and efficient way, in a timely manner and in the right amount, with a constant striving for change and waste minimization. Lean Learning aims to develop an innovative program for engineers on the Lean concept, as a successfully applicable alternative to current traditional methods in courses. Lean Learning is a process of learning and development in order to achieve a high level of education in a quality and efficient way with a constant striving for change and waste minimization. This efficient process emphasizes the comparative ratio of inputs or outputs (input-output ratio), viewing them as a return on investment and learning.

Lean Engineering learning should be compulsory on engineering curricula, and, particularly, on the Industrial Engineering field. Prior to the integration on the Industrial Engineering curriculum, Lean Engineering was already implemented by many organizations and, often, fostered by consulting companies. For this reason, if engineering students were taught about Lean Engineering, they would be better prepared to assume a leadership role in their organizations and/or to better communicate with Lean consultants [9].

This approach is based on the Lean approach used in Lean manufacturing in industrial systems. Educational institutions that want to move to the process of lean learning, when educating future industrial engineers, must work on the following 3S concept:

- **Support of team working on continuous development and training, including research**. First, all complicated and insufficiently reasonable activities, which are imposed on students, must be eliminated. Such as bulky equipment, travel from one classroom to another, workload with teaching materials, complicated tasks, requirements for faster learning than usual, etc. Overload during education can lead to student fatigue, which further implies underutilization of student potential. All of the above reasons can lead to certain variations, so management is suggested to eliminate the shortcomings in order to increase the performance of the process.
- **Simplification of curricula**. Curriculum updates are made systematically or over the years of individual updates made by faculty members [5]. Emiliani in his research expressed certain opinions that the curriculum should be constantly developed and improved [10, 11]. Program managers must eliminate shortcomings during the training, starting from the schedule of subjects, to the coordination of the dates of lectures and exercises, in order to avoid unnecessary waiting. This approach is based on smooth flow and aims to eliminate variations and unnecessary waiting caused by the schedule. Therefore, it is necessary to clearly and concisely define all the steps within the curriculum and ensure smooth and efficient work, using various techniques. Fliedner & Mathieson [12] conducted surveys in their research that suggest several implications for curriculum design for undergraduate and graduate business schools, lean education, and a broader systemic approach to vocational education.
- **Simplification of the teaching process and assessment process**. The teaching process and the assessment process certainly contribute to the education of Industrial Engineers. This approach requires greater engagement of educators and much more work and time, unlike the previous two, because it is

necessary to keep these processes under continuous supervision and control. It also requires a much greater experience of educators, as simplifying the teaching and assessment process is a very sensitive topic, and can very easily cause resentment among students. Emiliani, believes that the feedback, received from students in connection with the teaching process, is necessary to improve the concept of the course [13, 14]. Dei [15] in his paper claims that the acquired knowledge of graduates has significantly increased by improving and continuously updating the teaching process by applying the Lean concept, which has greatly contributed to increasing their value in the labor market. M. El-Sayed, J. El-Sayed, Morgan & Cameron [16] have demonstrated in their work how the Lean concept can improve assessment processes where "objectives, outcomes and performance criteria for all courses in the program should derive from and harmonize program-level specifications". To meet these challenges, realistic practical learning facilities closely resembling real-life scenarios that are able to provide effective and efficient backstopping to theoretical instruction are necessary - meaning that there should be minimal abstraction in teaching and learning methods [17].

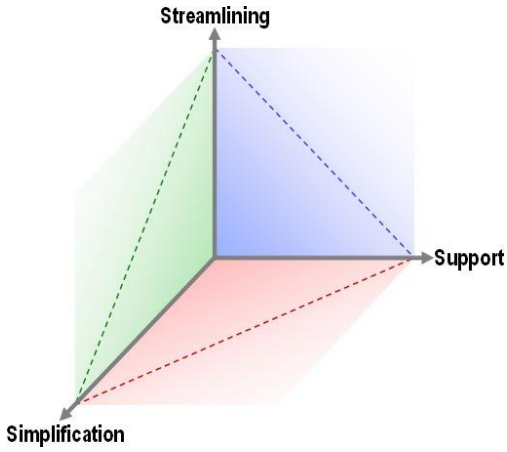

Figure 1. *Dimension of the 3S concept Lean learning approach [24]*

According to Veza, Gjeldum & Mladineo [18], Lean learning can be integrated not only into the education of Industrial Engineers, but also into the education of employees at all levels in the institution. Lean learnig shows that the Lean concept, can make a very big contribution to the improvement of the higher education process through an innovative learning experience during education.

2.2. Lean Thinking approach in the education of industrial engineers

Today, all large industrial companies require graduate Engineers to have the competencies to solve large and complex engineering problems. For this reason, it is very important that students recognize the importance and significance of their studies in a timely and appropriate manner. They do not initially see a direct link between the knowledge and skills acquired during their studies and what industrial companies require during their professional careers. These shortcomings can be corrected by applying different methods of learning lean thinking.

We can single out two very important factors when defining methods. First, at the same time we must work on the education and training of young Industrial Engineers, combining teaching and practice, and secondly, during the learning and training process, students must develop the most important skills and competencies required by the labor market, such as innovation, flexibility, creativity, entrepreneurship. etc.

Garay-Rondero, Rodríguez Calvo & Salinas-Navarro [19] in their research present a model of learning lean thinking that expands the availability of resources for training and development of professional skills in the field of Lean production. This model offers a number of very successful methods that can be applied when improving curricula and teaching processes, while improving and developing competencies in the field of Industrial Engineering.

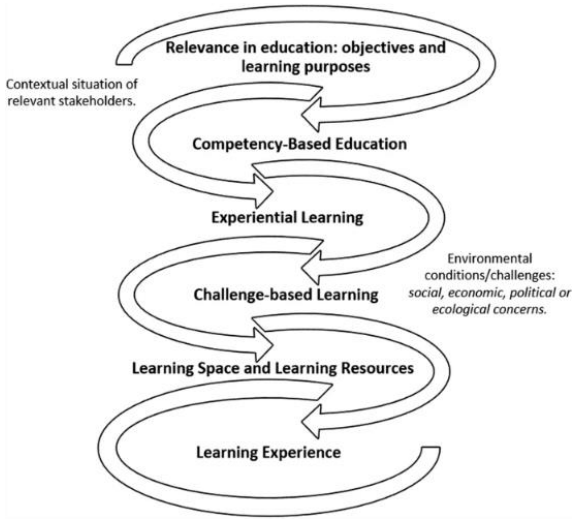

Figure 2. *Proposed model of learning lean thinking [19]*

The solutions offered by this model must be flexible in relation to the variability and transformation of primarily production processes. Frequent changes in product specifications, variable delivery times and unstable supply-demand ratios, etc. must be taken into account.

2.3. Lean approach to improving online distance learning

Distance learning has always been accepted with a certain amount of uncertainty and concern, both among teachers and students. There is a constant fear that this type of learning could reduce the

quality of education. Usually refers to the area of education that includes the redesign of teaching processes intended for students who are not able to physically attend classes in the classroom. Important influence on the implementation of this method of learning has the Internet and the application of information technology, which enable uninterrupted communication between teacher and student.

The contribution of this method of learning is reflected in the possibility of attending these courses, even for people with disabilities, people who are employed or busy with other obligations, people who are stationed in locations where these types of courses were not previously available. This method of teaching brings significant cost savings, both for the educational institution and for the students. Belanger & Jordan [20] in their book list certain advantages of applying online distance learning methods.

Table 1. *Expected benefits of Lean online distance learning* [20]

Learners	Instructors	Institutions
• Increased flexibility • Increased access to learning • Increased choice of institution • Lifelong learning • Access to remote experts • Increased performance • Increased promotion potential • Increased compensation • Better marketability	• Increased participation • Broader time frame to deliver courses	• Increased number of learners • Increased variety of learners • Competitive advantage • Decreased costs • More scheduling flexibility • Less classroom requirements • Increased employee satisfaction • Reduced turnover • Shorter training time

The importance of applying online distance learning is also reflected in the increase in student enrollment in such courses. Checking the effectiveness of the implementation of the online distance learning method can be done by conducting a survey or through a comparative analysis of the performance of each student after completing the course. Also, the goal of this learning method is to increase internal and organizational efficiency, then to encourage and empower teaching staff to improve previous teaching experience.

3. APPLICATION OF THE MODIFIED 7P LEAN CONCEPT IN THE EDUCATION OF INDUSTRIAL ENGINEERS

The Lean 7S concept, intended primarily for production processes, can also be used in Improving Industrial Engineering Education. The lean principles and practices used in industry can be successfully applied to improve the administrative teaching processes of higher education through an innovative approach to education. This paper will present a new modified concept based on Lean principles adapted to education. This modified concept is based on the following 7 principles (7P):

- **Waste elimination –** Educational institutions have an important task to use Lean techniques to eliminate waste in the form of shortages, in order to improve efficiency and efficiency in teaching. These performances, according to Maguad [21], Imply individual and organizational learning that takes place and then spreads throughout the organization. The first step in implementing this concept involves identifying and spotting flaws, and then eliminating them. All activities that do not affect the setting of results can be considered as waste, and as such they should be immediately eliminated from the program. The purpose of this principle is to point out unnecessary activities to educators and to keep them to a minimum, as much as possible.
  Practice has shown that the most common shortcomings that every higher education institution must eliminate: excessive bureaucracy, inconsistency of teaching materials with the planned curriculum, lack of coordination and mutual misunderstanding in the teacher-student relationship, inefficient use of all teaching aids, frequent overlapping of teaching contents, etc.
- **Enhance learning intensity –** This principle is reflected in the mutual harmonization of the requirements of industrial companies and the basic knowledge acquired during the studies. The acquired knowledge and skills provide students only with a starting point when looking for a job. During the implementation of this concept, both teachers and employers are required to make great efforts and joint cooperation in order for graduate students to acquire appropriate competencies.
  Practice has shown that attending the professional practice of students and going to large industrial systems during their studies gives the most effective results in improving learning. Also, this principle achieves that the most successful and most experienced employers from industry and economy can be included in the teaching process and thus contribute to additional education of students.

This type of cooperation requires a cumulative effect of education. This type of cooperation requires a cumulative effect of education.

- **Making the right and as soon as possible decisions –** Every decision-making process begins with identifying problems, gathering as much information as possible, generating alternatives, and ending with making a final decision. Making a decision on choosing an educational institution requires some caution, since students do not have the opportunity to test the chosen course. When making a decision, it is necessary to analyze all possible criteria, as well as the influence of many factors. The most common factors influencing the decision when choosing an educational institution for future students, based on many years of experience, are: the influence of the environment, especially family members and the environment, then the academic reputation of the institution, availability of teaching and non-teaching resources, location of institutions, tuition fees, curriculum, cooperation with industry and industry, etc.
  In practice, it has been shown that the most important criteria that students use when making a decision are those concerning a promising career and better advancement in employment. Students therefore see the possibility of career advancement as a priority in decision making, as well as whether they will continue their studies by attending master's or doctoral studies or not. This principle offers a range of activities that can be undertaken to help students make a decision as quickly as possible, such as: adequate marketing of the institution and its study programs, organizing "open days" where prospective students get acquainted with teaching and non-teaching resources offered by the institution, maintaining creative workshops, which would be organized in one day of the weekend and where direct cooperation between teachers and future students would be achieved, etc. Higher education institutions need to be aware of the influential forces that affect students when they enter this intricate decision-making process and gain an understanding of these variables if they are to meet the needs of students effectively [22].
- **Fast gaining of education –** This principle aims to provide students with the most efficient way to acquire knowledge and skills by attending Industrial Engineering courses. By applying this principle, higher education institutions have the opportunity to reduce the course program to the shortest and most comprehensive teaching units. This directly achieves more efficient learning and faster communication and cooperation between teachers and students. Unfortunately, practice has shown that a large number of teachers do not attach too much importance to the way students learn. Some of them still apply outdated methods of realization of teaching processes, which existed at the time of studies. However, the task of all teachers is to follow the fast pace of change in higher education and to adapt to it as quickly as possible.
  The purpose of this principle is to facilitate learning and to make it quality and efficient, continuously improving the curriculum and the teaching process and at the same time adapting it to the needs of students. After each lecture, the teacher must have an insight into the level of acquired knowledge and perform certain analyzes in order for the lecture to be successful. This principle also achieves flexibility in the way of learning, as well as in teaching, which can also be achieved by the method of distance learning. Teachers quickly receive feedback on the education of graduates, which gives them the opportunity to update and improve the teaching process for the next generation of students.
- **Continuous team empowerment –** This principle is based on the continuous strengthening of the educational team, which consists of teachers. The most important role is entrusted to the team leader, who is usually an experienced leader of the study program, and whose task is to gather around him teachers who are motivated and enthusiastic to improve teaching competencies in the field of Industrial Engineering. This team has the task to improve the efficiency of teaching processes, but also to motivate all other teachers to raise their teaching processes to a higher level. Team members should not be burdened with a list of specific tasks and responsibilities to fulfill, but should be encouraged to do their job as best they can. In this way, the awareness of all teachers is raised and over time an increasing number of them become part of the educational team. Teachers must also be able to maintain consistently high levels of performance to continually strive for better professional performance. It is necessary for them to improve using professional literature, analyzing periodical scientific publications, as well as by participating in expert and scientific conferences in the field of Industrial Engineering.
  Venkatraman [23] in his research lists the key areas that can be identified as a paradigm that everyone will adopt:

  1. Self-development to meet the requirement of the profession
  2. Self-study and reflection
  3. Training programmes
  4. Research and Development and Innovation

5. Collaborative Learning approach with the help of peer/experts/mentors

6. Awareness of Institutional, National and International goals of education

Increasingly frequent changes in higher education require continuous improvement and self-development of the educational team. This principle requires setting goals related to the development of teachers' competencies, continuous involvement in development activities and defining and delegating clearly defined tasks, as well as constant monitoring of progress. In practice, it has proven to be a very useful way for teachers to get feedback on which to determine which outcomes are most favorable.

- **Building integrity –** This principle refers to strengthening the integrity of higher education institutions and teaching processes. It came in response to, unfortunately, the increasingly inappropriate behavior of certain teachers and the abuse of their positions. Teachers and students as a whole must work together to build and strengthen integrity, establishing flexibility, sustainability, efficiency and responsiveness. To begin with, they must first examine their behavior and approach to education, and then compare them with traditional education and codes of ethics.
  Teachers have a key role in building the integrity of the teaching process, as well as in the ethical development of students. They must provide the conditions and resources to meet the goals, i.e. make educational and ethical preparation, which includes developing students' sense of ethics, encouraging students to think critically, establishing sincere awareness, strong character and developing ethical habits of behavior during education. This principle requires teachers to significantly increase the level of social responsibility in education and to find effective strategies and methods that will be based on basic ethical values. The ethical values that are most applicable in practice are highlighted:
  - Building moral values: to establish trust among students with exemplary behavior in all situations;
  - Building human values: establishing respect and honesty, both towards students and colleagues;
  - Building professional values: establishing a high level of excellence, efficiency and impartiality.
- **Perception of the whole –** This principle is reflected in the interaction of all the above principles, which is the task of all Lean methods, including this modified concept. The success of this 7P Lean concept directly depends on the interaction and coherence of all the above Lean principles. The implementation of this concept eliminates the shortcomings and achieves the division of the task into smaller units, which gives much better results and raises the quality of education.

Figure 3. *Phases of 7P Lean concept in the education of Industrial Engineers*

All participants in the process must have a good understanding of this modified concept of slimness in order to be successfully applied in practice. This concept also requires the interaction of all the above 7P Lean principles, and its success depends on the way the principles are implemented, the willingness of all participants to cooperate and the work environment.

4. CONCLUSION

The paper discusses how the application of the Lean concept can positively affect the improvement of teaching processes, especially in the field of industrial engineering. The paper presents a new modified 7P Lean concept in the education of industrial engineers. The possibilities of applying the Lean concept as an aid to the industrial engineering industry at universities for the development of better lean thinking and lean learning, as well as the application of the Lean concept in distance learning online are presented. 7 Lean principles were presented, as well as a series of practical solutions based on the experience gained during many years of teaching in the study program Engineering Management. Also, constructive proposals were offered to highly educated institutions in order to improve traditional and existing teaching processes. This modified 7P Lean concept is defined on the model of the Lean production concept, which aims to constantly improve and perfect the curriculum, as well as teaching processes, which is the essence of the Lean philosophy.

ACKNOWLEDGEMENT

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Session 1: *Teacher Professional Development and General Education Topics*

Professional paper
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Reliable and Automated Recognition of HE Qualifications and More – A New IT Approach

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Abstract: *The importance of learning outcomes and qualifications frameworks during the evaluation of credentials, regarding the processes of recognition of foreign qualifications are tremendous, especially according to the documents and regulations that are in phase of establishment in Europe nowadays, such as Lisbon Recognition Convention. However, more evidence and guidance on practical use of learning outcomes in recognition would be necessary in order to ensure that learning outcomes are considered when evaluating qualifications. The aim of this paper is to provide recommendations for a methodology on how learning outcomes and qualifications frameworks may be used during the recognition of qualifications, thus, fostering easier and simplified recognition procedures leading towards automatic recognition in future.*

Keywords: *National Qualifications Framework*, European Qualification Framework, *Learning Outcomes, Higher Education, Higher Education Institution, European Higher Education Area*

1. ROLE OF NATIONAL QUALIFICATION FRAMEWORK AND LEARNING OUTCOMES IN HIGHER EDUCATION AND RECOGNITION OF QUALIFICATIONS

1.1. Educational Systems

The results of many studies conducted in the near past indicated that no critical or substantial differences may be found in the education systems and National Qualifications Frameworks (NQF) among countries in European Union. Of course, there are chances of significant differences, especially with countries outside EU or countries applying for EU membership, but this seems to be reduced with the accessing processes and compliances of the domestic regulations with the ones from EU. Higher education (HE) is organized mainly in the structure of three cycles (European Qualification Framework – EQF levels 6-8) as defined by the Bologna Process (there are slight differences in some systems, such as Latvia and UK, having EQF level 5 – short cycle of HE program (120-180ECTS), more focused on the acquisition of professional skills needed in labor market. In general, the workload of first cycle (EQF level 6) studies varies from 180 to 240 ECTS credits, known as Bachelor level studies. Holders of first cycle qualification have access to the second cycle studies in any field of study. Universities (Higher Education Institutions - HEI) may set up additional admission requirements to the applicants or the access is direct (to the same field of master studies/when field is close, differential exams are required to be passed for accessing the study program). The workload of second cycle (EQF level 7) studies varies from 60 to 120 ECTS credits, and the titles of awarded qualifications varies. To obtain a Master's level qualification in most of the countries in Europe, total workload of studies in first and second cycles should be no less than 300 ECTS credits (5 years of full-time studies). Graduates of the second cycle have access rights to doctoral level studies. Additionally, in most of the countries, long cycle study programs are provided in specific fields such as medicine, dentistry, veterinary medicine, pharmacy etc. (specifically regulated professions). These programs lead to EQF 7 level qualifications (which is practically master level of degree – 300 – 360 ECTS) with direct access rights to doctoral studies (of course, there are some domestic regulations that differs from this, as in UK – the HEI decides about the third cycle students' applications on a higher level). The third cycle (EQF level 8) qualifications are awarded on the basis of original research. Although the nominal length of doctoral studies is three to four years, workload also can vary by country.

1.2. National Qualification Framework Systems

All the countries have developed their NQF and practically have already harmonized their NQF systems to the EQF. In almost all of the countries, higher education qualifications are located on EQF 6-8 levels. The scope of all NQF is pretty comprehensive and includes the specific levels of qualifications that are conducted within the education and/or training process of the student. For indication of the particular qualification, level

descriptors are used. They help learners, education and training providers, and employers to position and value a specific qualification in relation to other qualifications. Also, this applies to those awarded in another education and training subsystem or country. Most of the European countries have designed level descriptors for a comprehensive national qualification framework, covering multiple types and different levels of qualifications. This allows the level descriptors to embrace a wide range of institutions, stakeholders and their interests, traditions, cultures and values. Used in terms of fundamental level descriptors are:

- Knowledge (knowledge and understanding and its application, understanding and level of practice);
- Skills (generic cognitive skills communication numeracy and ICT skills);
- Competences (personal, professional, autonomy and responsibility, learning skills etc.).

1.3. Learning Outcomes Roles

Learning outcomes (LO) describe what students are able to demonstrate in terms of knowledge, skills, competencies and values upon completion of a course, a span of several courses, or a program. Clear articulation of learning outcomes serves as the foundation to evaluating the effectiveness of the teaching and learning process. As already known, the Bologna Process is focused on pushing students in the process of acquiring knowledge, skills and competences incorporated in their study program, that meet their self-development goals and social needs (professional and personal in the same time) in the best way. Therefore, learning outcomes are the main tool of the Bologna Process for improving mobility, transparency and recognition in the European Higher Education Area (EHEA). Certainly, in this direction are the familiar tools used in the process of mobility and awards recognition years backward, such as ECTS system of evaluation, Diploma Supplement (DS) and quality assurance processes. Practically, LO can be taken as a basis for a common understanding when comparing, assessing and recognizing qualifications offered in different education and qualification systems, needed for HE harmonization at international level.

There are several important aspects regarding learning outcomes, that need to be met in terms of possible comparison:

- How visible are the learning outcomes – necessary information about all the sources (online or others) where the provided learning outcomes are published or are available to be seen and examined;
- How the learning outcomes are defined – necessary information about the author who defines, body that approves and/or owns the provided learning outcomes;
- Information whether the learning outcomes are subject to quality assurance – positive or negative reply;
- Information about the terminology of learning outcomes – concepts or categories used when formulating the provided learning outcomes.

Learning outcomes have an important role not only in education process giving precise information about all the qualities that the graduate will earn, but also in the recognition procedures (mobility). There are two categories of learning outcomes that can be analyzed: generic and specific. Researches have shown that generic learning outcomes have broader usage than the specific learning outcomes. Generic learning outcomes are referred to being transversal, soft or social knowledge, skills or competences whereas specific learning outcomes are more related to the particular field or subject of qualification. The most significant differences may be observed in terms of cases when learning outcomes are used and sources of learning outcomes differ by different countries and different education systems. Thus, the conclusion may be drawn that more attention should be paid to clear identification of sources for learning outcomes that may be used in recognition.

2. CHALLENGES IN KNOWLEDGE MOBILITY

The recognition of learning across boundaries is urgent and challenging for multiple different stakeholders in the process of knowledge mobility, as shown in figure 1.

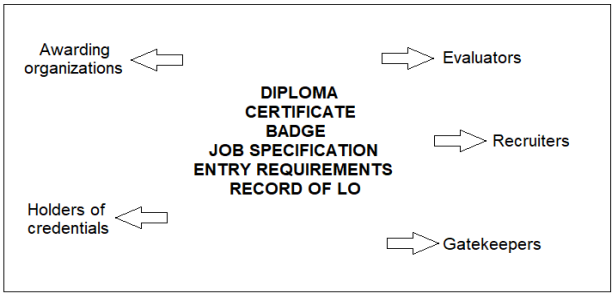

Figure 1. Knowledge mobility stakeholders

The largest goal to be achieved is automated (as it can be) international recognition, that embraces the need to work with different categories, types and levels of achievement, such as:

- life skills;
- application and responsibility;
- practicing knowledge gained;
- personal autonomy;
- context and systems;
- knowledge;
- skills;
- competences;
- learning;
- know-how etc.

So, this clearly goes above the concept of only knowledge, skills and competencies, into a broader (as it can be) picture of the person, both personal and professional, giving clear information about his ability to respond as qualified for something. Not only the specific skill or knowledge or competence is important, but also the level of achieving it, leading to the measurement of the difference between intended learning outcomes (what a learner is expected to know, be able to do and understand after having completed the learning process) and achieved learning outcomes (represented by the set of knowledge, skills and/or competences the learner has achieved and/or is able to demonstrate after completion of the learning process).

Two different recognition concepts can be analyzed:

- Recognition for the purpose of continuation of education (academic recognition), and
- Recognition for the purpose of professional engagement / employment (professional recognition).

Usually, authorities responsible for the different types of recognition differs on a state level, as well for the process of recognition of professional qualifications.

3. NEW IT APPROACH OF KNOWLEDGE MOBILITY AND RECOGNITION

The main purpose is to combine all the data that one study program offers, in terms of learning outcomes, general and specific, together with the gradation system or more general, levels of achievements specific to the countries, into concept that will offer unique way of awarding the learner with a report that will clearly show the quality and quantity of the learned and gained through the learning process, which will be base for further recognition. Since different countries still deals with a tremendously big set of different terms and levels describing the "skillset", there is a need of a translation system (black box) that will give the answer about the quality and quantity of the learner being subject of recognition process.

Thus, countries need an international system (tool) which will be broad enough in the following aspects of functioning:

- Establishment of a common (unique) path for comparison between the achievements and requirements (what we have vs. what we need);
- Detailed enough to be able to match any descriptors and different kind of levels;
- Must be combination of factual information, professional judgements and supporting evidence;
- Has to produce uniform format (for example, report) which will not require any alterations in terms of regional, national or local arrangements (enabling not regulatory).

For this purpose, several broad fields need to me examined in order of creating convergence between the data specific for each field, regarding the need of recognition:

- National qualification frameworks;
- Regional qualification frameworks;
- Sectoral qualification frameworks;
- Competence frameworks;
- Job evaluation systems;
- Job specifications;
- Program entry requirements.

As a result, this system should translate any descriptors (learning outcomes) into internationally recognized form. This is in parallel with the global growth regarding the need to be able to measure everything, such as the kinds and levels of achievement. It should be able to work with any outcome-based structure (qualification, credential, study program, job specification or even framework level). The system should translate them into an internationally recognized form of description which can be used to compare achievements and/or requirements.

UNESCO has developed solid starting system regarding this issue, named World Reference levels (WRLs). It is consisted of:

- 11 (eleven) different ways of describing achievement, which are elements of capability, and
- 8 (eight) different levels of describing the stage of progression, regarding each element of capability (A1 – D2).

The system deals with 51 (fifty one) different indicators of progression.

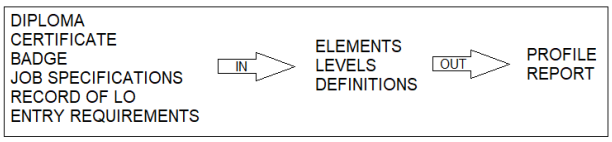

Figure 2. WRL conversing LO inputs in WRL outputs

Because of the common intention for broad usage, the system (should) offers big support to the users in terms of credential descriptors, job specifications or entry requirements in a common and understandable language. Based on the input data, the system produces profile based on the elements of capacity and stages of progression (levels). Also, the system produces a specific report, that contains vital information about any quality assured credential. The way of representation of the outcomes is pretty standardized.

3.1. Process Specifics

At the very beginning, starting data for the subject being profiled need to be entered, because of the profiling process. The user needs to make precise parallel between the subject of profiling and the system. Thus, some elements may not be relevant, so they will not be selected. Only the appropriate elements regarding the subject of profiling needs to be selected. The subject of profiling (for example, study program with its structure of qualifications) needs to converge into one or more of the following elements:

- Accountabilities:
  - Activities;
  - Responsibilities;
  - Working with others;
  - Quality;
- Capacities:
  - Skills and procedures;
  - Communication;
  - Data;
  - Knowledge and know-how;
- Contingencies:
  - Context;
  - Problems and issues;
  - Values.

After selection of the elements regarding the subject, for each element the user will have to provide answer to a specific series of questions, each of which is accompanied by a list of possible answers. Many of the terms in the options are linked to a WRL definition in the WRL directory. The appropriate answers should be selected by the user (one or more). The possible answers contain one or more of 51 terms which indicate changes of technical difficulty, scope or autonomy. Practically, they form the final picture (profile and report) of the system. The final report is as shown in the following figure, containing the stage of progress of every different element chosen to represent the subject of profiling.

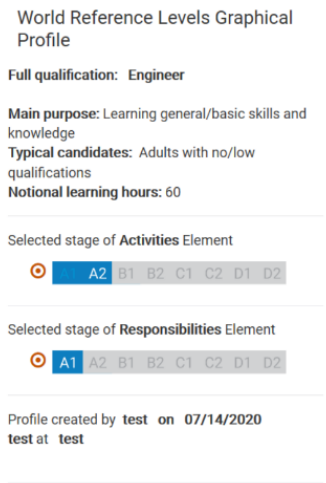

Figure 3. Final report

4. CONCLUSIONS AND RECOMMENDATIONS

Conducted analysis on the use of learning outcomes in the process of recognition indicate that states/institutions use generic learning outcomes (more), but not specific learning outcomes. However, the issue of how the learning outcomes of qualifications are used in recognition should be explored in more detail. Therefore, several challenges are identified as regards the use of learning outcomes in recognition, e.g., poorly articulated learning outcomes are subject to interpretation, variety in terminology and phrasing (including the issues of translation of learning outcomes), as well as lack of trustful sources of learning outcomes.

The following recommendations about learning outcomes are provided:

- The structure, formulation of learning outcomes should be improved by creating common guidelines on how higher education institutions (HEIs) should write learning outcomes in relation to the recognition practice. The content of the learning outcomes (topics, themes) would remain at the discretion of each provider.
- The availability of learning outcomes and its sources should be at a high level (and their translation into a commonly language).
- Permanent update relevant institutions and HEIs about the relevance and importance of learning outcomes of qualifications to ensure comparability and recognition of qualifications.
- Permanent level descriptors of NQFs.
- Regular trainings and methodological guidance for credential evaluators about learning outcomes and their use in recognition should be provide.
- Implementing and presenting standardized learning outcome analysis methods and tools to relevant institutions included in the recognition process for their use of analyzing the learning outcomes in recognition.

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Lifelong Learning in Pandemic Situation – Challenge and Need

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Abstract: *End of 2019 and beginning of 2020 year bring a global pandemic caused by new disease named as COVID-19. This pandemic has huge impact not only on healthcare system but also on the global economic, political, technological, social and educational system. This paper considers effect of pandemic at lifelong learning, chance and motives for education of adults. The sample consisted of 67 adults who are completed or started some available form of additional education in first half of 2020 year. Questionnaire with mostly closed questions was used for the survey. The research shows that pandemic caused actions for lifelong education through avilability of information (79%) and through free and discounted educational programs (73%). The most significant motives for learning within this group of adults are connected with professional needs and career (39,7%) and 27% of answers indicates at desire to learning and self-development. This research covers only a small number of motives and factors that have influenced lifelong learning in a pandemic situation. In future research, this area should be investigated from more different aspects.*

Keywords: *lifelong learning; education; pandemic; COVID-19*

1. LIFELONG LEARNING

The concept of Lifelong Learning refers to idea that any individual can learn whole life regardless of age or professional status. That is a form of self-initiated education that is focused on continuous personal development. The aim of this kind of education is improving knowledge, skills and abilities of adults to become more competitive in the labor market and/or for personal fulfilment. This type of learning implies all forms of knowledge acquisition, through formal, non-formal and informal learning [1, 2]. According to [2], Lifelong learning contains: (1) learning from home, (2) education of adult or the acquisition of formal qualifications and skills later in life, (3) continuing education through seminars and courses, (4) professional knowledge acquired through professional development and on-the-job training, (5) learning from a personal environment or self-learning using different sources and the Internet application. Useful prerequisites for lifelong learning are the desire for change, curiosity and the desire for knowledge, as well as self-centeredness, metacognitive awareness and tendency for lifelong learning [3].

Significant impact, at lifelong learning, have globalization and technology development (especially Digital technology). New technology constantly changing context of life and work. New professions are developing and existing professions are expanding, this require update of existing and acquisition of new knowledge and skills (qualifications). At the same time knowledge and information growth accelerates and make it necessary to update qualifications in shorter cycles [4]. This is challenging situation for educational system and for individuals. There is at least 2 reasons for this: (1) It does not exists educational system or program which can teach people everything that they may need to know in the future. (2) No one can predict what specific knowledge someone will need or not need in the future [5]. To answer on challenging time, school learning and workplace learning need to be integrated toward a lifelong learning. This is a responsibility of educational system and individuals. Educational system needs to foster flexibility in curriculum, teaching method, adoption of new technologies, and sharing information [4,5]. Individuals need to awake inner curiosity, desire for learning and critical thinking.

2. WHAT ARE EFFECTS OF COVID-19 PANDEMIC?

Since December of 2019, new disease, named COVID-19, spread out of worldwide and change every segment of life and work [6].

The biggest impact of pandemic was at health care and health services in affected countries. The most of hospitals needed reorganization, work and infrastructure adjustment to new situation because

it was not designed to deal with unknown and unpredictable disease such is COVID-19.

For the purpose of virus prevention, some countries, including Serbia [7, 8], declared state of emergency for whole or part of country, sometimes it included a curfew, and some countries lockdown their borders [9].

Governments of affected countries also gave recommendation for conduct in pandemic conditions and whole population needed to accept new rules of conduct, protection and physical distance [10].

As consequence of pandemic, global economy are facing with the largest global recession in history. In economic senses this relate to the loss of Gross Domestic Product (GDP) in the countries affected by the epidemic, the growth of the unemployment rate in them, the deterioration fiscal indicators and foreign trade relations [11]. In Serbia, situation is similar as in other countries. Small business and jobs that can't be done from home are the most affected by pandemic and recession [12]. A lot of business entity are temporarily reduce or completely stop their production in first wave of pandemic. Some people had lost or have risk to lose their job. If pandemic would last a long time it may cause deterioration of human capital, competence and skills of workers who do not go to work. Are people aware of all this? How people will develop new skills and in what field of interest? Where they can retraining for some new jobs and new conditions of work? How all this will affect on lifelong learning?

Under curfew and isolation measures people had more free time for family, relax, learning and personal development. To help people to get through this difficult time on site of Government of Serbia start to work Digital Solidarity portal at https://www.digitalnasolidarnost.gov.rs . On this site there are all the information about free platforms for distance learning, work from home, free online books, courses, movies, music and television content during the COVID-19 pandemic.

As everything else even a educational system needed to transform in a short term. Different countries worldwide have introduced various solutions during the pandemic to continue the education process, some of those are: TV broadcasts, resources, video lectures, online channels [13]. In Serbia, like in other affected countries, after closing schools and universities, students started with online education thought some of available online platforms and web conference tools (Google classroom, Microsoft Team, Zoom, Skype, Viber, Moodle, Cisko Webex, etc). Also started to work TV station for teaching students of primary and secondary school. This TV station was some type of knowledge base, with recorded lessons and instructions, but students had online support from their teacher through email, Viber, Skype or other communication platforms. This way of learning has some good sides, but it is more difficult for both the teacher and the students. Problems existed in practical and laboratory lessons which are not possible to perform online and one part of students did not have all necessarily equipment (smartphones, computer, fast internet connection) for this type of study [14]. As the epidemic progressed, the number of online courses, workshops, and seminars (that were either free or discounted) increased. Changing method of education especially suited to adults who are out of school system. Adult learners need flexibility to contend with competing priorities (work, school, home, family) [15,16], and this situation provided them a chance for acquisition of new knowledge, skills, certificates and diplomas, in any time, everything from their homes.

3. RESEARCH METHODOLOGY

Aim of this paper is to examine motives and needs that drive adults to further education in times of crisis caused by pandemic. Main questions of this research are: (1) Does pandemic of COVID-19 have an influence on the decision and desire for further education of adults? (2) Whether the availability of information and financially affordable courses are a motive for lifelong learning or it is something else? (3) In what area people see chance for their prosperity in next period?

During June of 2020, 67 adults were surveyed anonymously. Every of respondents needed to fulfill the condition that in last six months have completed or started some available form of additional education like course, seminar, training or workshop. The sample is suitable research. It consists of the former students who have attended the Faculty of Technical Sciences in Čačak between 2007 and 2012 year and their friends and family members who participate at some form of education in past period. The questionnaire was distributed via social networks. Participation in research was at voluntary bases.

Questionnaire was divided in 3 parts. First part of the questionnaire provides information about respondents such are gender, age, level of education, income, the connection between current job and previous schooling, number of children and their age. Second part of questionnaire was about courses, training and workshops that respondents attended (number of educational programs, type, price, area of education and teaching method). Third part of the questionnaire is dedicated to the attitudes, motives and factors that influenced at respondents for further education and connection of educational program to current job and previous education.

There are 19 items, of which 2 were double chose questions, 9 were multiple chose questions, 2 were

open question and 6 was assessment scale with 5 level of agreement.

Demographic and socioeconomic characteristics of participants are presented in table 1.

Table 1. *Characteristics of participants*

Gender	Answers	
	N	%
man	26	38,8
woman	41	61,2
Age	**Answers**	
	N	**%**
<24	13	19,4
25-30	30	44,8
31-37	21	31,3
>38	3	4,5
Level of education	**Answers**	
	N	**%**
Secondary school degree	15	22,4
University or high school degree	52	77,6
Income	**Answers**	
	N	**%**
Below average	19	28,4
Average	43	64,2
Above average	5	7,5
Number of children's	**Answers**	
	N	**%**
0	36	53,7
1	11	16,4
2	19	28,4
3	1	1,5

The average age of respondents is 29 years. Average age of surveyed men is 27,5 years and for women it is 30 years.

According to official data [17], in Serbia, the average salary without taxes and contributions (net salary) calculated for May 2020 was 58,892 dinars (about 500 eura). 64,2% of respondents describe its income as average. Interesting is that 61,5% respondents with diploma of university describe its income as average and that only 7,7% respondentes with diploma of university have income above average. This is related to the fact that most of the respondents (46,3%) do not do the job for which they were educated and 16,4% does not work at all. Conection of income and type of job (does someone work job for which he were educated?) is confirmed by signigicant negativ correlation between these variables (rho=-0,59).

Most of respondentes (53,7%) does not have children's. Majority of childrens (72,7%) are younger then 6 years; 19,3% of childrens belong to group 7-11 years and rest (8,0%) is older then 12 years. The author's assumption is that some of characteristics of respondents have influence on characteristics of courses that they attended (this will be explaned in the next part).

4. RESEARCH RESULTS

The author's assumption is that the number and age of children affect at the number of attended courses because it reduces the available time for learning because children need care and attention, which decreases with the age of the child. In total sample, this cudnnot be proven, but at sample of only women there is negativ corelation (rho=-0.367) between variables number of children's and number of educational programas. Women who have children's (mothers) have less time, chance, posibility and energie to attending courses and educational programs. The correlation between children's age and the number of attended courses cannot be proven. Also, the correlation between income and amount of money spent on educational program cannot be proven.

Table 2 presents information about form, cost and area of additional education that respondents attended. Question about Area of education had an open form, the responses are grouped by similarity. Category Other covers: make-up, hairdresser, groomer, geronto housewife, tailor, electrical working and construction. In pandemic situation large nummber of courses was discounted or free, in this questionare, and in Table 2, price is the total amount of money spent for all courses.

Table 2. *Characteristics of courses*

Number of attended educational programs	Answers	
	N	%
1	47	70,1
2	18	26,9
>2	2	3,0
Price of course *summary for all programs	**Answers**	
	N	**%**
<100 Eura	37	55,2
100 – 200 Eura	28	41,8
>200 Eura	2	3,0
Learning method * multiple answers possible	**Answers**	
	N	**%**
Online	67	84,8
Practice	7	8,9
Combination of online learning and practice	5	6,3

Type of education * multiple answers possible	Answers	
	N	%
Course	60	59,4
Training	13	12,9
Workshop and seminar	28	27,7
Area of education	**Answers**	
	N	**%**
Economy, accounting, business	60	31,6
Work on computer, web design, graphic design	36	18,9
Languages and communication	33	17,4
Marketing and Consumer psychology	25	13,2
Other	13	6,8
Programming and coding	19	10,0
Education	4	2,1

55,2% of respondentes spent less then 100 eura on education in last 6 month. No women would spent more then 200 eura on courses, but men would (7,7% of men paid educational program over 200 eura).

Most of respondents are educating in area of economics and bussiness (31,6%), programming and ICT (cumulative 28.9%), then in learning language and marketing (Table 2). Those proffesiones and area of education are popular in last few years and could not conected with pandemic. Proffesiones related with ICT, programming and coding are more popular to respondentes who work the job for what they did not educate for (53% of this group of respondentes).

Question about motives that stimulated respondent to learning, was an open question in the survey and respondents needed to put minimum 3 motives for atteding course. The responses are grouped by similarity and presented in table 3.

Table 3. *Motives for lifelong learning in pandemic situation*

Motives that triggered lifelong learning	Answers	
	N	%
Respond to professional needs	41	15,3
Progress in professional career	40	15,0
Possibility to start a firm	8	3,0
Re – qualification	17	6,4
Possibility to lose a job/or already lost a job	16	6,0
Change the family situation	19	7,1
Free courses	30	11,2
Free time	16	6,0
Desire to learn	24	8,9
Development of new knowledge	22	8,2
Restoring forgotten skills	13	4,9
General education and information	15	5,6
Other motives	6	2,2

Most of answers referes on job and professional career 39,7% (cumulative %) 27% of answers indicates at desire to learning and self-development. Low costs of cours is high ranked motive for education (11,2%). 21,5% of respondentes are motivated with their economic situation (cumulative % for Change the family situation, posibility to lose job, re – qualification).

Table 4 presents answers at questions about factors that triggered learning in pandemic situation. Mean values and standard deviatin for those factors are presented in table 5. Every listed question had the same scale for answering but in the table empty answers are ommited.

Table 4. *Factors for lifelong learning in pandemic situation*

Pandemic of COVID-19 had an influence at my decision about education	Answers	
	N	%
Absolutely not true	9	13,4
Not true	1	1,5
Maybe, I am not sure	7	10,4
Yes	23	34,3
Absolutely true	27	40,3
Free time and monotony had an influence at my activity about education	**Answers**	
	N	**%**
Absolutely not true	15	22,4
Not true	9	13,4
Maybe, I am not sure	15	22,4
Yes	12	17,9
Absolutely true	16	23,9
Availability of information and courses affected at my activity about education	**Answers**	
	N	**%**
Maybe, I am not sure	18	26,9
Yes	28	41,8
Absolutely true	21	31,3
Discount price of course affected at my activity about education	**Answers**	
	N	**%**
Maybe, I am not sure	14	20,9
Yes	17	25,4
Absolutely true	36	53,7

Table 5. *Factors for lifelong learning in pandemic situation – mean and standard deviation*

Factor	Mean	Std. Deviation
Pandemic of COVID-19	4,28	1,012
Free time and monotony	3,07	1,480
Availability of information and courses	4.33	0.805
Discount price of course	4.04	0.767

From tabels 4 and 5 can be seen that pandemic affected at need for education and triggered some actions about lifelong education (74,6% vs. 14,9%) but it has great diversity in answers. More unified attitude of respondents is about impact of price (73,1% vs. 0%) and avilability of educational programe (79,1% vs. 0) at lifelong learning. Interesting is that free time and monotony has slightly influence at lifefong learning (41,8% vs. 35,8%). 26% of only women had neutral attitude on this factor, and 41,5% said that this factor did not have any influence at their educational activity.

Resoults about connection of educational program with job and previous education are presented in Table 6.

Table 6. *Characteristic of new knowledge*

Scale 0 -100 %	Answers %	
	Connection of course with current job	**Connection of course with formerly education**
0	25.4	13,4
25	0	1,5
50	16,4	10,4
75	14,9	34,3
100	43,3	40,3

25,4 % of respondentes used pandemic situation for learning somethig what is not related with curent job and 14,9% what is not connected with previous education. 43,3% of respondentes used pandemic for developing skills related to curent job and 40,3% had only updated professional skills and knowleges.

Most of respondents who do not work job for they educated for (49.2%), used pandemic situation for expanding knowlege about curent job and 38,7% of them continiue education in same area as before. 45% Respondents who does not work at all attended courses which does not connected with their formal education.

5. CONCLUSION

Pandemic of COVID-19 change contest of life and work. People need to follow new rules of conduct (hygiene, protection and the most difficult – isolation and physical distance). This situation accelerated transformation of educational system and influenced at concept of lifelong learning – New programs for education of adults, Requalification, courses, training programs and seminars started to be online and available to a wider audience.

The presented findings emphasize the positive side of digital technologies (their involvement in the lifelong learning) and affordable education. Digital technologies have given adults the flexibility they need (to manage place, time and tempo of learning), access to resources (information) and chance to learn (if they want it).

This paper has various limitations: small sample size, limited information about educational program and learning method. Also there is no information about: satisfaction with educational program, contributions of educational program and barriers and obstacles to learning. For future research need to supplement the questionnaire with those items and repeat the survey on a larger sample.

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The Use of Anglicisms in Speaking and Writing Among IT Students

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Abstract: *The evolution of IT has influenced the development of many other fields including language itself. This paper investigates the rate to which information technology students use original English terms from their domain compared to the transcribed versions (anglicisms) or translations in Serbian. The sample consisted of 96 first-year undergraduate IT students at Faculty of Technical Sciences, Čačak. Students' propensity towards the use of various forms of specific IT terms was analysed with the questionnaire specifically designed for this research. The results indicate that students prefer anglicisms in oral communication while they mainly use original forms of specified terms in written communication.*

Keywords: *borrowed words; loan words; English; preferences; IT.*

1. INTRODUCTION

Throughout the world, people tend to use modern and newly forged words in everyday speech. They also borrow words and terms from foereign languages.

Like many other phenomena, borrowing words from other languages can be observed from two points of view. Molnar [1] states that „a large quantity of borrowed words is considered as a positive phenomenon since it makes terminology systems in different languages understandable for specialists regardless of their nationality, enabling cooperation and development". Her other point of view is that this phenomenon „leads to the loss of distinctness of national languages, which causes anxiety for many people".

While older generations in Serbia in the past used Turkish terms, younger ones are oriented towards English. These borrowed words and terms are nowadays mainly recognized and applied in the field of information technologies (IT).

The advances in the realm of IT have had an impact on the development of many other fields including language itself. The absence of Serbian words for some IT terms or the lack of knowledge about official translations, results in the adoption of original English words without translation, called anglicisms, which also include idioms recognizable in English by pronunciation, morphology or spelling but are accepted in the dictionary of the target language [3].

IT vocabulary is standardized by International Organization for Standardization (ISO) in ISO/IEC 2382:2015 [2]. The vocabulary is defined by Technical Committee ISO/IEC JTC 1 however, standardized IT words in english are not the main subject of concern in this paper. The authors were primarily aimed to the extent of use of anglicisms as compared to official serbian equivalents.

2. RELATED WORK

There are many research papers focused on examining topics alike. The following ones are presented for the sole purpose of providing an insight into the variety of nations and domains dealing with this issue.

Molnar's research centres on the issue of English borrowed words used in the discourse of French Information Technology [1].

By presenting the role and position of English language in international criminal law Ristivojević [4] observed that determined speech characteristics also affect the judiciary.

In his paper which compared the use of Anglicisms in economic terminology in Serbian and Croatian, Silaški [5] speculates that "some of the domestic terms seem to have become *determinologised*, while new terms are introduced in a chaotic manner, according to personal preferences of authors".

Ariyati [6] states that society in general should be aware of the practical use of English loan words in Indonesian observing thereby that IT people spell and write all the English borrowed words correctly.

Ćirić-Duvnjak [7] demonstrates the means and the extent to which anglicisms are integrated and incorporated in Serbian sports terminology. She also clarifies that our national identity is not at risk by an inflow of new, foreign words into the language ie its sports terminology.

Francuscki [8] analyses the influence of English on the Serbian language in the domain of electronic media and informatics pointing up the absence of adequate equivalents in Serbian language in respective domains.

In their paper, Milanović & Milanović [9] suggest that names of the most wanted occupations published on the Internet appear as anglicisms.

Mavrić [10] points out that borrowing words from another language can lead to "narrowing of the semantic field in relation to the semantic possibilities of the lexeme in the original language". In addition, the author highlights the fact that borrowed words may develop new meanings different from the original ones in English.

In his paper, Stojkanović [11] analyses linguistic metaphors in computing in Serbian and English. The author describes similarities in metaphors in both languages and explaines the procedure giving the example of malicious software terminology in both languages. He also argues that "English as IT language influenced the conceptualization of computer virus in Serbian as well".

The main goal of this research was to determine IT students' preferences in oral and written communication in terms of the use of english and serbian words in their respective domains.

3. METHODOLOGY

Based on the above stated goals of the research proposed, the following hypotheses were established:

- Students tend to use foreign terms in the field of IT as well as in general (everyday) communication.
- There is a positive correlation between the frequency of use of foreign terms in the field of IT and the use of IT in leisure time.
- There are differences in the frequency of use of anglicisms between students who attended different educational profiles in high school.

The sample consisted of 96 first-year undergraduate IT students at Faculty of Technical Sciences, Čačak, University of Kragujevac. Out of this number, 74 were male and 22 female students. Table 1 shows the structure of the sample according to previously completed high school. Less than 10% of students did not provide data about their previous education.

The research was conducted at the beginning of March 2020.

Online questionnaire, specially designed for this research, was used to gather the data. Besides questions about preferences of use of serbian or english IT terms, it contained questions about gender and previous education, as well as those about the use of IT in leisure time. There were 2 main parts of the questionnaire which served to analyse the topic in 2 different manners – propensity to use english or serbian IT terms in oral and written communication. Each part consisted of 12 questions – 12 offered words from IT domain in english and their appropriate serbian translations.

Table 1. *Educational profiles which students attended in high schools*

Educational profiles	**% of students**
Information technologies	15.6
Economy	12.5
Gymnasium	16.7
Electrical engineering and computer science	24
Road traffic	1
Tourism	3.1
Medicine	3
Mechanical Engineering	5.2
Mehatronics	4.2
Architecture	2.1
Computing Gymnasium	3.1
Computer networks	1

4. RESULTS AND DISCUSION

To determine the percentage of students that use anglicisms in the field of IT and in general communication, descriptive statistics was applied. The majority of students stated that they use anglicisms in everyday speech (95.8%). Table 2 shows the percentage of use of IT terms in oral and written communication.

Table 2. *Representation of IT terms in oral and written communication*

IT term	Oral communication	Written communication
	% of students	
computer	71	43.8
file	93.8	100
folder	97.9	97.9
browser	76	79.2
online	96.9	93.8
screenshot	96.9	94.8
screencast	26	41.7
string	91.7	91.7
taskbar	83.3	86.5
desktop	99	97.9
display	16.7	18.8
pointer	31.3	54.2
N = 96		

The results from Table 2 indicate that the use of anglicisms is very common in oral and written communication among IT students. Certain

expressions such as "screencast" and "pointer" are more used in written communication. In contrast, the word "computer" is more frequently used in oral communication, while the term "display" is the least used in both types of communication. This may be due to the fact that this term has an adequate and very commonly used Serbian word.

Most popular anglicisms in the field of IT in German-speaking area are computer, link and tool [12]. In order to determine general frequency of use of anglicisms in the field of IT, one of the questions was an assessment scale with offered answers in range from 1 (very rare) to 5 (very often). The results are given in Table 3.

Table 3. *Frequency of use of anglicisms in the field of IT*

Grades	% of students
1	1
2	13.5
3	37.5
4	33.3
5	14.6
N=96	

Most students rated the frequency of use of anglicisms with grades 3 and 4. The percentage of students who use anglicisms very rarely, rarely and very often is almost equal.

Frequency of use of IT in general language is presented in table 4. It can be noticed that the largest percent of students often use IT in general language (57.3%), while 15,6% of students use it rare.

Table 4. *Frequency of use of IT in leisure time*

Grade	% of students
1	1
2	14.6
3	27.1
4	40.6
5	16.7
N=96	

Pearson's test determined moderate positive correlation (r = 0.55 **, p = 0.00) between the frequency of IT application in general language and use of anglicisms in this area.

Table 5 shows the results of comparison of IT terms used in written communication between students whose previous education was in areas of information technologies (IT) and electrical engineering and computer science (CE) and all other areas listed in table 1. Every term was offered in three forms: (1) original english word, (2) anglicism, (3) serbian word, whereas several anglicisms are written the same way like original english words. Those terms are written in italic.

Table 5. *IT terms used in written communication – comparison of different previous education*

IT terms (1. english word, 2. anglicism, 3. serbian word)	IT/CE (%)	Other fields	Pearson Chi-Square value	p	Phi/Cramers' V
1. Computer 2. Kompjuter 3. Računar	21.1 52.6 23.3	24 58 18	0.886	0.642	0.1
1. File 2. Fajl 3. Datoteka	94.7 5.3 0	98 2 0	0.059	0.576	-0.089
1. Folder 3. Direktorijum	94.7 5.3	100 0	0.844	0.184	-0.175
1. Browser 2. Brauzer 3. Veb-pregledač/čitač	60.5 15.8 23.7	61.2 20.4 18.4	0.542	0.762	0.079
1. Online 2. Onlajn 3. Na mreži	57.9 26.3 15.8	76 24.4 0	8.979	0.011	0.319
1. Screenshot 2. Skrinšot 3. Snimak ekrana	26.8 35.1 8.1	46.9 53.1 0	5.864	0.053	0.261
1. Screencast 2. Skrinkast 3. Video-snimak ekrana	39.5 2.6 57.9	26.5 16.3 57.1	4.996	0.082	0.240
1. String 3. Niska	92.1 7.9	90 10	0.000	1.000	0.036
1. Task bar 3. Traka sa zadacima/Linija poslova	78.9 21.1	90 10	1.309	0.225	-0.154
1. Pointer 3. Pokazivač miša	44.7 55.3	58 42	1.037	0.282	-0.132
1. Desktop 3. Radna površina	94.7 5.3	100 0	0.844	0.184	-0.175
1. Display 3. Ekran	18.4 81.6	20 80	0.000	1.000	-0.020

No statistically significant differences between two groups of students were established (all p values are greater than 0.05) for almost all the terms in sense of written communication. The only statistically significant difference was noted for the term "online" ($\chi 2$ (2, n = 96) = 8.98, p = 0.01, Phi = 0.32). Students from vocational schools other than IT and CE major more often use English word "online" compared to another group of students. It can be concluded that previous education has no influence on the use of various forms of IT terms.

The reason for this may be due to the fact that the offered anglicisms are in wide use in everyday speech. It can also be noticed that students tend to use words in original english form rather than their transcribed (anglicism) version. Exceptions are words "computer" and "screenshot" which are more used in their transcribed forms by both groups of students.

Vuletić et al. [13] also discovered that dentistry students prefer the use of anglicisms in their respective domain.

Table 6 shows the results of comparison of IT terms used in oral communication among students whose previous education was in areas of information technologies (IT) and electrical engineering and computer science (CE) and all other areas listed in table 1. Since there is no difference in pronunciation between anglicisms and original terms in english, every term was offered in two forms: (1) anglicism and (2) serbian word, whereas several terms have more than one translation in Serbian.

Table 6. *IT terms used in oral communication – comparison of different previous education*

IT terms (1. anglicism, 2., 3. serbian word)	IT/CE (%)	Other fields	Pearson Chi-Square	p	Phi/Cramers' V
1. Kompjuter (engl. Computer) 2. Računar	78.9 21.1	68 32	0.811	0.335	0.122
1. Fajl (engl. File) 2. Datoteka	94.7 5.2	92 8	0.006	0.695	0.054
1. Folder (engl. Folder) 2. Direktorijum 3. Fascikla	94.7 0 2.6	98 2 0	2.811	0.354	0.154
1. Brauzer (engl. Browser) 2. Veb-pregledač 3. Veb-čitač	76.3 18.4 5.3	74 26 0	3.931	.203	.190
1. Onlajn (engl. Online) 2. Na mreži	97.4 2.6	96 4	0.000	1.000	0.037
1. Skrinšot (engl. Screenshot) 2. Snimak ekrana	92.1 7.9	100 0	2.041	0.077	-0.215
1. String (engl. String) 2. Niska	89.5 10.5	92 8	0.001	0.722	-0.044
1. Taskbar (engl. Taskbar) 2. Traka sa zadacima 3. Linija poslova	68.3 7.9 5.3	80 14 6	0.878	0.654	0.098
1. Desktop (engl. Desktop) 2. Radna površina	100 0	98 2	0.000	1.000	0.093
1. Displej (engl. Display) 2. Ekran	15.8 84.2	18 82	0.000	1.000	-0.029
1. Skrinkast (engl. Screencast) 2. Video-snimak ekrana	18.4 81.6	32 68	1.419	0.221	-0.153
1. Pointer (engl. Pointer) 2. Pokazivač miša	31.6 68.4	30 70	0.000	1.000	0.017

The results indicate that students mainly prefer anglicisms in oral communication. Terms „screencast" and „pointer" are rather used translated which is in line with findings for written communication (table 5). The same finding goes for the term „display".

No statistically significant differences between two groups of students were established (all p values are greater than 0.05) in terms of use of anglicisms in oral communication.

5. CONCLUSION

The hypothesis which suggests that students tend to use foreign terms in the field of IT and in general communication was confirmed, which is undoubtebly due to the influence of media, social networks, and persistent immersion in English language.

Accordingly, the hypothesis about the connection between frequency of computer use in leisure time

and propensity of students to use anglicisms and english terms in the field of IT was also confirmed.

Differences in the frequency of use of anglicisms between students who attended different educational profiles in high school were not established. Thus, the last hypothesis was not confirmed. It can therefore be concluded that the examined terms are widely used in everyday communication.

The future work on this issue will be aimed towards detailed analysis of means by which anglicisms are integrated and incorporated into Serbian IT terminology. Additionally, it would be useful to examine the impact of professional environment of respondents in several fields with broader list of specific IT terms.

It should be noted that the sample for this research was made up of first year students only which implicates that studies could not influence the results in a way if the sample was made up of students from higher study levels. This fact will also be included in the plans for the future work.

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Foreign Language Learning (FLL) as Influenced by Social Media platforms: Facebook, Twitter, and YouTube

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Abstract:*At the turn of the past decade,researchers highlighted the promising role of the fast emerging forms of ICT, predicting its potential use in education. At the turn of the current decade, social software is here and is doubtless about to stay. In modern ambience, education has seen the new opportunities offered by the new technological model. With generations of 'digital natives', having technology at the core of their identity, and with the rapid development of social software technologies the building blocks of a new educational paradigm have been firmly laid providing a solid basis for the implementation of unprecedented pedagogies. The objective of this paper is to present potential academic uses of social media – Facebook, Twitter, andYouTube,eitheras the instruction or supporting tools, for augmenting students FLL competences. Comprehensive studies performed so far clearly suggest the huge potential of social media platforms for the development of students' receptive and productive FLL competences. In that line, this paper providesaliterature review of possible uses of YouTube videos inasocial networking context, touching on the advantagesofits use as well as current issues regarding the full implementation of Web 2.0 social software into the education system.*

Keywords:*Social media, Facebook, Twitter, YouTube, FLL competences*

1. INTRODUCTION

It goes without saying that the current decade has seen tremendous growth of social networks such as Facebook, Twitter, YouTube, etc. These networking platforms are involved in a wider context known as Web 2.0 technologies [1] which presupposes a more social and participatory environment. Some of them are media-sharing websites such as YouTube and Vimeo, others, e.g. Facebook, are social networking websites, while Wikis, blogs, and microblogs (Twitter) are closely related to user-generating content being distinguished as user-producing environments [1].

Modern technological setting has influenced all areas of life with the Social Networking Software (SNS) becoming a ubiquity which can no longer be ignored in the realm of higher education. The internet is a huge repository of information wherein an enormous corpus of data can be seen as relevant from the scientific and academic standpoint therefore it stands to reason that academia should make use of affordances that social software tools provide for educational purposes. This particularly holds as students enter university with a "strong command of competences to communicate via Information and Communication Technology (ICT) tools" [2]. On the other hand, literature also provides evidence of the unfavorable trend among faculty where the vast majority of teachers feel reluctant to enter this new digital setting preferably sticking to the wellestablished textbook-based teaching methods. In their study, Aijan and Hartshorne [3] investigated knowledge and perception of faculty concerning the Web 2.0 potentials for education. The results of their study suggest the existence of educators' awareness of advantages of the SNS tools over traditional teaching techniques however the main obstacle is the lack of interest of educators to adopt this new digital paradigm and incorporate it into the traditional academic classroom [4]. Twenty-first century students are fully aware of the advantages of the web 2.0 environment, and aptly expect to be technologically prepared to embrace new opportunities of the digital world after graduation. The fact places the oust on the academic community to observe these fast evolving trends and propose strategies for implementing ICT reality into the higher education system by fundamentally altering traditional learning and teaching pedagogies and transforming them to suit modern learning styles.

1.1. Web 2.0 Revolution

Establishing a new Web 2.0 paradigm presupposed the call to users to leave the passive position and

enter the public domain as content creators and contributors. This call was accepted by the vast majority of social media users, organizations as well as individuals, who have unawares turned the public sphere into a new structure which can afford ample and potentially effective opportunities to enhance students' learning in the university environment. This modern social media ambience involves immanent congruity which, by being transferred into the e-learning environment of academia, could transform higher education [5].

In the essence, the Web 2.0 revolution-based academic learning relies on students and their peers as active participants of knowledge creation who by employing the social networking tools change the flow of information from "unidirectional to multidirectional" [6] thus defining a novel Learning 2.0 paradigm [4]. In this user-created process, social media primarily ensure a psychologically favorable ambience – a more relaxed setting for students in which they learn and gain knowledge in a more leisurely style. Studies have shown that knowledge acquired in this manner is a real knowledge resulting from "deep student learning", according to Richardson, cited in [7]. A plethora of case studies reveals "multiple benefits for using social networking software, including retention, socialization, collaborative learning, student engagement, sense of control and ownership" [5].The sense of community closely linked to collaborative work is fundamental to successful learning along with students' motivation which has been reported to be the primary building block of successful social media interaction in an academic context.

2. SOCIAL MEDIA IN FLL – LITERATURE REVIEW

The Web 2.0 social software cannot be said to be learning environment *per se* – social networking sites are not explicit learning environments, but they could become an important learning support [2]. They cannot solve all learning problems [8] however they could be able to eliminate common barriers in FLL classroom and open up new perspectives.

Researchers report on the major impact of conversation-based interaction among second language learners [9]. Carmean and Haefner point up that real learning happens when it is social and student-centered [10]. In this line of thought, Waters highlights the fact that only in enjoyable surroundings, with minimal stress, 'meaningful understanding of material and content' [11] occurs. Other studies emphasize the value of discussion within social groups and the significance of learners' feedback during discussion for gaining confidence in communication. Discussing the effects of Facebook in educational settings, Schaffhauser observes the absence of constraints among students in the communication [12], which helps them single out information relevant for conveying a message or opinion in the community. Positive effects on students' motivation to do exercises in online surroundings of Facebook, for example, were also considered [13]. In her study, Kroonenberg revealed that foreign language learners who lacked confidence in speaking in class were found to express themselves more freely in the social media environment [14]. Finally, social media reinforce the sense of community and collaboration which projects social networks as an alternative to traditional course management system [15]. The studies mentioned above are just a few going on in academia, a discussion which has begun to examine this new paradigm with increased scrutiny and formality [4].

3. DEVELOPING FLL COMPETENCES WITH SOCIAL MEDIA

There is a burgeoning discussion going on about what social media tools can be integrated into higher education for building students' FLL competences. As not all social media can be successfully used for developing the entire set of FLL capacities, there have been a growing number of studies in recent years exploring how the different social networks can be effectively incorporated in the learning environment of higher education. Some social platforms are appropriate for augmenting receptive capacities – listening and reading, while others are useful for developing productive abilities – speaking and writing.

3.1. Facebook-based foreign language learning

Besides allowing the development of some FLL skills such as vocabulary extension, reading, summarizing or spelling, the primary field of Facebook application is its significance as a platform for developing collaborative work in which all the students – not only the ones proficient in a foreign language – are activated, given the pervasive notion that all members of the community are equally important.

As inferred above, Facebook is a very useful tool for improving interaction between teachers and students. The teacher creates a dedicated Facebook community and sets common learning objectives. In this environment, the learning process occurs beyond time and space constraints, which facilitates interaction involving multiple content exchanges, i.e. sharing files, videos, and texts among students. A more relaxed setting, 'innate' to students' digital nativity, makes them motivated to have more interaction without much concern about making mistakes, e.g. in spelling, focusing only on the assignment completion. A central topic assigned by the teacher should be diversified and involving multiple related topics

dedicated to each student individually. In this manner, a discussion and collaboration-based environment is provided wherein all students function as independent systems moving towards a common goal. With the individual objectives set, students strive to be as productive and collaborative as possible. Such atmosphere ensures learning through inquiry while knowledge gained in this manner guaranties long-term retention.

One aspect which calls for attention in the Facebook setting (but also in other social networking communities) is the role attributed to the teacher. The network structure might come in conflict with the hierarchic structure of traditional teacher-centered learning where the flow of content is typically one-directional [2]. Specifically, in a traditional classroom, the teacher is a primary guide, while in these new social surroundings they are expected to coordinate students' individual, pair, or group activities. In a social media environment, with the assignments set, it is of utmost importance that the teacher allows students to establish "their own rhythms and methods, keeping a close watch on them, without interfering and always ready to assist" [2].

Activities of teachers who tend to use social networking platforms only for conveying information are doomed to failure. Such educators could be said to have completely missed the target, overlooking the very nature of the social media context, and face the danger of being aptly recognized as 'digital immigrants' [16].

3.2. Twitter-based classroom

From its original goal of answering the question 'What's happening?' Twitter has evolved rapidly to discuss a wide array of topics. In the learning environment, Twitter has recently been incorporated to promote a fast exchange of ideas, brainstorming, or reflective thinking [17], which can be considered as Twitters central applications in the educational environment. Asin the case of Facebook, the key word describing Twitter's contribution to the learning process is the vast number of users participating simultaneously on the platform and the underlying sense of community.

One aspect of using Twitter for enhancing FLL competences that has been the focus of academic debate is the limitation of characters on sentence production [17]. This word constraint might be seen as a disadvantage of this social networking tool however some researchers consider this as Twitter's twofold strength. Firstly, short tweets, as the answers are called, are favorable from the aspect of peer reviewing, as students prefer reading shorter essays of other students [18]. Secondly, Twitter's character constraint requirement is an extraordinarily favorable feature for developing some important academic skills, such as summarizing and note-taking. This particularly goes for students proficient in a foreign language. On the other hand, according to Ruiperez Garcia, Castrillo de Larreta-Azelain & García Cabrero cited in [19]. This brevity requirement can be discouraging for students with poor knowledge of a foreign language and contribute to their anxiousness in summarizing ideas within a constrained environment

Research into the Twitter's usefulness in education suggests its undisputable contribution as a learning tool however Wang and Vasquez propose that further research is needed to fully determine the pedagogical application of Twitter [20].

4. YOU TUBE AFFORDANCES IN FOREIGN LANGUAGE LEARNING

Consensus exists as to YouTube as the most effective tool for both learning and teaching within different realms of science. With the ever increasing number of users visiting this social platform (2+ billion viewers) [21] and even more increasing amount of content uploaded daily (500 hours uploaded to YouTube every minute) [22], YouTube is the largest video portal and the second largest video search engine globally. Variety of videos covering all topics, posted both by individuals and institutions, represents more than a solid corpus of knowledge which can be used or referred to as both supporting and instruction tool in modern FLL classroom.

The reasons for teachers 'opting for this social networking tool are obvious and can be easily accounted for. In his research into multimedia and video clips, Berk [23] sees the potential effectiveness of video technology as a mode of instruction, as it arouses the senses in ways that other media cannot. Video can grab students' attention, create anticipation among them and increase memorized content, among other outcomes. The more senses are involved in the learning process the greater the reception of the content, which implies that contemporaneous usage of visual stimuli, written texts, sound effects, and dialogue seems to be the ultimate learning tool to stimulate the brain [24]. This phenomenon is in close correlation with Blended Learning and Information Processing Theories.

Garrison and Kanuka [25] describe blended learning as "thoughtful integration of classroom face-to-face learning experiences with online learning experiences". This definition could be expanded to include the stance that the two segments present a complementary mixture [26].

The hypotheses put forward by the Information Processing Theory can also be applied in the case of YouTube and account for its popularity both among students and educators. Deffenbacher and Brown [27] argue that "to create a memory,

individuals are exposed to information via sensory input that is either visual (icon) or audio (echo). These initial pieces of information are only held in the sensory memory for a brief moment, unless the individual focuses attention to the stimulus and the object of interest is moved into the working memory. The working memory has a limited capacity, holding only pieces of information at a given time. If the individual maintains attention, the theory dictates that working memory will encode the information for storage in long-term memory. The long-term memory is an unlimited storage space in which one must recall or recognize information to bring it back into working memory for conscious awareness."

Considering aspects of cognition and information processing above, the key word is *attention*. Providing meaningful – and long-lasting learning requires 'attention grabber', thus any media representing a simultaneous blend of video, text, dialogue and audio stimuli is a promising tool for gaining real and long-term knowledge. This might be the answer to the question why educators most frequently, quite unawares, choose YouTube as an instruction or supporting tool in the classroom.

4.1. Enhancing FLL competences with YouTube

As a unique specificity of the 21st century culture that supplies limitless opportunities for maximizing the effectiveness of the FLL process, YouTube has encouraged a considerable number of teachers to adopt it as a teaching tool in their classrooms. YouTube is a viable option as a means of modeling strategies, providing additional context on education trends as well as assessing student learning through student-created videos [28].

YouTube is the essential social networking platform for developing the majority of FLL competences, both receptive and productive ones. In view of the fact that the incorporation of YouTube into the learning process is a relatively novel phenomenon, foreign language teachers still find its use rather challenging in the absence of a more comprehensive and institutionally established strategy for developing students' FLL competences.

YouTube enables the teacher to use its various supporting features within different segments of the teaching process. It can be used as a primary instruction tool, essential for the lesson organization or it can be applied as a supporting technique helping the teacher to place relevant information into the students' working memory before it is processed and recognized as knowledge. Finally, YouTube can be successfully used for recapping the learning material covered in the closing section of the lesson.

Research conducted so far imply that language learning skills can be effectively developed by the use of YouTube. Receptive competences, listening and reading, can be substantially boosted in video-rich YouTube environment. Developing *listening* needs to be teacher-guided, both in respect of the selection of appropriate videos and the learning material, usually created and organized by the teacher. This is due to the fact that YouTube abounds in videos considered irrelevant from an academic standpoint. They might be unreliable in respect of the video content, non-academic vocabulary (containing slang), or poor pronunciation of the speaker. Having reservations about video content and quality, some teachers feel more comfortable to use an official educational channel on YouTube [28]. *Reading* can be activated simultaneously with listening given the transcript provided in almost all video clips on YouTube as well as via reading viewers comments, especially in videos created and 'consumed' by academic/scientific community. Especially beneficial video clips aimed at augmenting students' listening and reading competences are TED talks which always come with transcript [28]. Activation of transcripts can be constructive, especially when a speaker presents too quickly or unintelligibly, which is usually frustrating for students with poor command of a foreign language. Productive competences – speaking and writing, based on actual knowledge, require the foreign language teacher's involvement in particular. Developing *writing* necessitates teacher's and students' full commitment due to the complex nature of writing skills and their acquisition. Using YouTube for developing writing competences cannot be reduced to writing comments on a YouTube portal – commenting is a good platform for exercising the knowledge already existing. Students proficient in a foreign language can, however, gain good results in individual efforts to develop their writing skills via YouTube, given the multitude of YouTube video clips on this topic.

As for enhancing *speaking* via YouTube, it usually relies on discussions in class within a projected thematic frame typically organized by the teacher. In regards to developing this language competence, one aspect needs to be particularly observed in the YouTube ambience. The leisurely style which a video context essentially ensures, promotes both students' and teachers' confidence. Be it an instruction or a supporting tool in the teaching process, YouTube videos add to the dynamics of the lecture by stimulating discussion in class. Studies have shown that even students that lack confidence due to the poor knowledge of a foreign language (and rather choose to listen in a traditionally-based class), are instigated to speak their minds in video-based classes. As remarked earlier in the paper, discussion is triggered among the majority of students whenever there is a keen sense of community – "real learning happens when it is social and students centered" [30]

Given the fact that pronunciation is of ultimate significance in developing speaking competences another aspect to be noted within the context of enhancing speaking is the teacher's careful selection of videos that feature native speakers.

Besides major language competences addressed above some other skills can additionally be acquired and enhanced with YouTube videos as an instruction or a supporting tool. Making Power Point presentations and giving presentations have become ubiquitous at all education levels, from elementary to academia. YouTube's TED talks mentioned earlier in the paper have proven to be very useful to that end. By following the talks of prominent members of scientific and academic community, students can learn how to organize a presentation, get to know tips to apply when creating a Power Point presentation and analyze the entire process to find the way to giving a successful presentation. The teacher's relevance as a guide that highlights particular aspects of a presentation and makes students aware of the importance of presentation segments is unquestionable. Additionally, TED talks are an exceptional material for distinguishing between the oral language used in presentations and the one specific to academic writing. Developing this skill also needs to be teacher guided.

Differentiating between oral and written language, as well as learning to identify the different language registers, is the part of extending vocabulary technique which requires theoretical and practical framework provided in advance.

The list of favorable aspects of YouTube use in a foreign language classroom is by no means exhaustive. Although primarily teacher-centered, the development of the skills above can be effectively promoted by using social media, YouTube in particular, as valuable tools for maximizing foreign language learning gains.

Apart from the positive aspects of YouTube application in the classroom, possible disadvantages may include content inaccuracy, poor video and audio quality, intellectual property rights, bad pronunciation, unavailability of YouTube clips, as a great number of videos are deleted on a daily basis, etc., however, positive aspects of YouTube application by far outweigh constraints and challenges which can be easily managed bearing in mind the enormous corpus of the YouTube material. Having YouTube as the incentive tool for creative work, 'millennials' are inspired to create videos of their own, be it entertainment or education thus motivating them to expand their productive capacities.

5. CONCLUSION

Social media have become ubiquitous in the 21st century society to the extent to "entail new conditions and opportunities for teaching and learning" [2].As the Net Generation has a strong command of competencies to communicate via ICT, the introduction of online resources as learning supports in an academic context is a viable alternative to the traditional course management system [2].

Informal learning of social networks has great potential to bridge the communication gap between digital natives and their digital counterparts. Application of social networking software, e.g. Facebook, Twitter, and YouTube have proven to be highly effective in augmenting FLL competences, both receptive and productive ones. Three important affordances of social media for students' learning, i.e. fostering active learning, enhancing students' collaboration, and increasing their community connections are the desirable outcomes of the teaching process [31]. Studies have shown that social media-based learning encourages students to extend their engagement beyond the classroom assignments and prompt them to enhance their knowledge in the realm of their learning interests. Transforming current academic learning environment greatly depends on the openness of faculty to accept and incorporate pedagogies which facilitate and maximize learning gains in the social media environment.

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Some Corpus Linguistics Tools for Adequate Reading Comprehension of Instruction Books for Electro Technical Officers

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Abstract: *The development and arising of new Englishes for specific purposes imposes great challenges to language teachers and course designers. Nevertheless, the ever boosting information technologies bring new possibilities in terms of abundant corpora collection and analysis and production of relevant and profession-oriented course materials. Considering this specific research, contemporary corpus linguistics tools enabled us to obtain precise results on the vocabulary load and complexity of instruction books for Electro Technical Officers, aiming to reach the adequate or ideal threshold of reading comprehension. The paper results provide comparative analyses, leading to a clear call for a word list creation to suit the vocabulary needs of Electro Technical Officers in the most efficient way.*

Keywords: *reading comprehension, corpus, word list, instruction books*

1. INTRODUCTION

The technological development after the World War II influenced all areas of human endeavors. The new era of informatics brought new possibilities to the regular life of people, but especially to all fields of science. Following the accelerated development of cross-border scientific and business activities, the need for a common language and the economic and military superiority of the USA have imposed English as the *lingua franca* of the modern world. This especially became the case in maritime affairs, formally effective as of the establishment of International Maritime Organization in London in 1948.

The ever growing and multiplying scientific and business activities have been generating a multitude of branches and sub-branches of English for Specific Purposes (ESP). This has imposed new challenges and requirements on English language teachers in their effort to develop course materials and methodologies according to the needs of the (English) language learners.

Fortunately, the development of information technology has also provided for new tools and methodologies, such as corpus linguistics methods and software, enabling easier access to the abundance of real-life material and its multiple analysis.

2. THEORETICAL BACKGROUND

Although corpus linguistics methods had been known and applied earlier, no sooner than in the 60s of the previous century, the new array of linguistic research was opened, owing to new possibilities brought by information technologies. This has brought many benefits to language teachers and course designers, and consequently the language learners as well.

Bearing in mind the fact that specific, technical vocabulary is considered the main meaning predictor in reading comprehension, the renewed interest in vocabulary has led to the development of modern computer tools for lexical analysis of written or spoken texts. The programs and software such as AntWordProfiler, AntConc, Wordsmith, Sketch Engine, LancsBox and many others, have been used to provide data on the quantity and type of vocabulary and its various elements and patterns in a certain text type (genre). In addition, some of them can be used for extracting key words and word lists according to word frequency values. The idea behind this kind of analyses and produced word lists is to achieve the adequate reading comprehension with less learning effort, which would be especially useful with our target learners.

2.1. Reading Comprehension

In trying to answer the question on the quantity of needed vocabulary, two thresholds have been mostly used in the lexical profiling of texts. The level of 95% of known words in a text was set as desirable by Laufer [1], while Nation [2] advocates for 98% of known vocabulary for achieving appropriate reading comprehension. Thus, the threshold of 95% has been used as the adequate,

and 98% as the ideal coverage of a text, whilst the remaining 2–5% are expected to be understood from the very context.

3. METHODOLOGY AND CORPUS

The method we used for our corpus/vocabulary analysis and research is called Lexical Frequency Profiling [3]. It will enable us to answer the question on the quantity of certain types of vocabulary within our referent corpus. The software that we have found most useful and convenient for this purpose is AntWordProfiler 1.4.0w developed by Laurence Anthony [4], as an upgraded version of the previously used RANGE program [5].

In our analysis, we used the relevant and available word lists of general English (GE), academic English and ESP. An additional program – Familizer + Lemmatizer [6] was used to expand the available word lists into all-family-members form, so that they can be used by the software for lexical profiling of the text. Word family is the most commonly used unit of measurement in this type of research, meaning that a "word" would anticipate the headword with all its derivatives and inflected forms.

For the preparation and conversion of the corpus into the "plain text" format, we used AntFileConverter [7], after which we additionally "cleaned" the text from tables, lists, references, typos and graphical errors, in order to make the analysis as precise as possible. These efforts can often be very demanding and time-consuming, but are still very important for the relevance of the results obtained [8].

3.1 Word lists

Following the previous research of the area, we tested our corpus against the most used general English word lists, the academic word list and available and relevant ESP word lists.

General Service List (GSL) was produced by Michael West in 1953 [9]. It comprises 2,000 most frequent words from a 5-million-word corpus of the English Language. It is far from a contemporary one, but it is still commonly used for general English coverage testing, especially with Academic Word List [10] which was built upon it. They have been used together in this kind of analysis, so, we are going to use them in the same way for comparison reasons.

Concerning more contemporary general English, Paul Nation extracted 25 general English word list (each of 1,000 word families), with additional four covering some most frequent proper names, abbreviations, transparent compounds and marginal words [11]. This set of GE words (known as BNC/COCA word lists) was derived from the British National Corpus (cc.100 million words) and Corpus of Contemporary American English (cc. 450 million words).

After mastering the first 2,000–3,000 general (English) words, it is recommended that language teaching/learning should be more field oriented, the first step towards specialized word lists would be an academic word list of vocabulary common to various scientific and academic fields. The most used one is the Academic Word List by Averil Coxhead [10], comprised of 570 word families and expected to cover about 10 % of academic texts.

More and more specialized word lists have been produced in order to achieve significant coverage in relevant texts and adequate reading comprehension in the most efficient and least time-consuming way. To the best of our knowledge, only two available word lists of those [12] [13] developed to this date are applicable to our research, considering the scientific field, student level and software requirements. Both Ward's and Hsu's lists belong to more general engineering English and have been extracted from undergraduate textbooks (25 and 100 of them, respectively) for engineering students of various engineering fields.

3.2 Corpus

Our target (English) language learners are the students of marine electrical engineering, but also seafarers undergoing trainings for Electro Technical Officer (ETO). Considering their most practical language needs in terms of their onboard duties and operations, we came to the conclusion that adequate reading comprehension of ship's instruction books are of utmost importance to their daily duties. In particular, from the day of signing on, all marine engineers need these "tools" to familiarize themselves with the ship systems and devices, and their daily duties anticipate regular maintenance and monitoring, but also repairs and overhauling as required. This is especially relevant for cruise ships where Electro Technical Officers are more numerous than on other types of vessels, having a hierarchy of their own. Following this fact and some expert advice, we collected instruction books for a very common and popular Voyager class of cruise ships, selecting their contents with reference to electrical installations, maintenance and repairs. This class of vessels has the carrying capacity of 3,800–4,000 persons and the gross tonnage of about 138,000. Bearing in mind the systems and devices maintained by ETOs, the corpus comprises instruction books for diesel-electric propulsion, power generation and distribution systems, various automation systems, switchboards, dynamic positioning systems, engine room machinery (electrical part), as well as those related to cooling and ventilation systems, steering equipment, signaling, radio and safety equipment, lighting and other numerous ancillary services. The

final corpus amounts to 176,491 running words (tokens) extracted from 44 electronic (scanned) files of varying volume.

4. RESULTS

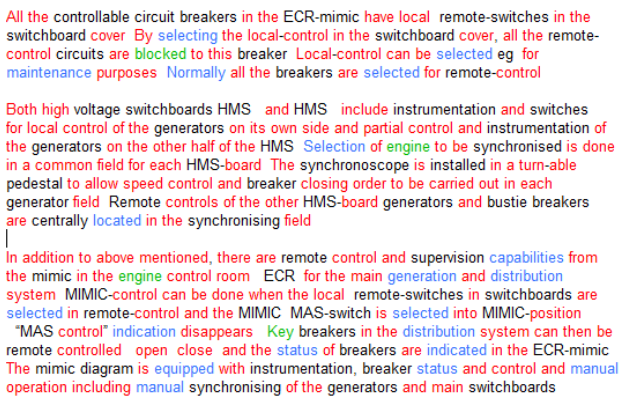
In order to test the vocabulary types in our referent corpus, we first analyzed it against the General Service List [9] and Academic Word List [10], 2000), as these are usually used together in this kind of research. The obtained results (Table 1.) show a significantly lower GSL coverage (66.95%) compared to the usual coverage of 78 – 98% reported for various types of written texts [14], and somewhat closer coverage to that in various academic texts of up to 76% [10], which points to the extremely technical nature of this professional type of texts.

Table 1. *The coverage of GSL and AWL in the corpus of instruction books for ETOs*

Word lists	Tokens	Coverage (%)
GSL	118,165	66.95
AWL	12,898	7.31
-	45,428	25.74
Total	176,491	100

The coverage of AWL is also lower than the average of 10% in various academic texts [10]. In other words, knowing the first 2,000 general English words and the most frequent academic words would leave the reader with about a quarter of the unknown vocabulary, or every fifth word unknown, which would make the reading and understanding of this type of text extremely difficult.

For the purpose of illustration, we can present another possibility of the AntWordProfiler software. In the excerpt below (Figure 1.), vocabulary types are given in different colors, i.e. the words marked red belong to the first 1,000 GSL words, the second 1,000 are marked green, whilst the words colored in red belong to AWL. More colors are available for additional lists, whilst the words remaining outside the referent lists remain black.


All the controllable circuit breakers in the ECR-mimic have local remote-switches in the switchboard cover By selecting the local-control in the switchboard cover, all the remote-control circuits are blocked to this breaker Local-control can be selected eg for maintenance purposes Normally all the breakers are selected for remote-control

Both high voltage switchboards HMS and HMS include instrumentation and switches for local control of the generators on its own side and partial control and instrumentation of the generators on the other half of the HMS Selection of engine to be synchronised is done in a common field for each HMS-board The synchronoscope is installed in a turn-able pedestal to allow speed control and breaker closing order to be carried out in each generator field Remote controls of the other HMS-board generators and bustie breakers are centrally located in the synchronising field

In addition to above mentioned, there are remote control and supervision capabilities from the mimic in the engine control room ECR for the main generation and distribution system MIMIC-control can be done when the local remote-switches in switchboards are selected in remote-control and the MIMIC MAS-switch is selected into MIMIC-position "MAS control" indication disappears Key breakers in the distribution system can then be remote controlled open close and the status of breakers are indicated in the ECR-mimic The mimic diagram is equipped with instrumentation, breaker status and control and manual operation including manual synchronising of the generators and main switchboards

Figure 1. *A corpus excerpt with GSL and AWL coverage given in colors*

Aiming to determine the specific amount of general English vocabulary needed to reach the adequate reading comprehension (95 – 98%) we tested our corpus against the BNC/COCA word lists [11], including the additional lists of the most frequent proper nouns, abbreviations, marginal words and transparent compounds.

Table 2. *The coverage of the BNC/COCA lists in the corpus of instruction books for ETOs*

BNC/COCA Word lists	Tokens
2,000 + proper n., *abbrev. and marginal words*	77.3
3,000 + proper n., *abbrev. and marginal words*	85.48
4,000 + proper n., *abbrev. and marginal words*	88.5
5,000 + proper n., *abbrev. and marginal words*	90.71
6,000 + proper n., *abbrev. and marginal words*	91.15
7,000 + proper n., *abbrev. and marginal words*	91.56
8,000 + proper n., *abbrev. and marginal words*	91.97
25,000 + proper n., *abbrev. and marginal words*	93.58

The results (Table 2.) show us that the first 2,000 general English words (BNC/COCA) cover 77.3% of our corpus, which is significantly higher than GSL coverage (66.95%). This is understandable, considering that the BNC/COCA word lists are much more up-to-date in terms of their age and selection of texts, as well as the contemporary nature of our referent corpus. Another advantage of the letter type of general English word lists is that they can show us higher levels of GE coverage. In our case, we can see that not even the adequate threshold of 95% of needed vocabulary is reached with general English words, not to mention the ideal coverage of 98%. This would mean that this kind of texts would be a hardly attainable task even to a native speaker not involved in (marine) electrical engineering.

As illustrated before, the classification of the vocabulary by referent lists can be presented with the aid of different colors. On the example of the same short excerpt, the first 1,000 is given in red, the second 1,000 in green, the third 1,000 in blue, the fourth 1,000 in pink, the fifth 1,000 in violet, the sixth 1,000 in orange, the seventh 1,000 in brown, the eight 1,000 in dark blue, etc., and the remaining vocabulary is given in black.

All the controllable circuit breakers in the ECR-mimic:have local remote-switches in the switchboard cover By selecting the local-control in the switchboard cover, all the remote-control circuits are blocked to this breaker Local-control can be selected eg for maintenance purposes Normally all the breakers are selected for remote-control

Both high voltage switchboards HMS and HMSO include instrumentation and switches for local control of the generators on its own side and partial control and instrumentation of the generators on the other half of the HMS Selection of engine to be synchronised is done in a common field for each HMS-board The synchronoscope is installed in a turn-able pedestal to allow speed control and breaker closing order to be carried out in each generator field Remote controls of the other HMS-board generators and bustie breakers are centrally located in the synchronising field

In addition to above mentioned, there are remote control and supervision capabilities from the mimic in the engine control room ECR for the main generation and distribution system MIMIC-control can be done when the local remote-switches in switchboards are selected in remote-control and the MIMIC MAS-switch is selected into MIMIC-position "MAS control" indication disappears Key breakers in the distribution system can then be remote controlled open close and the status of breakers are indicated in the ECR-mimic The mimic diagram is equipped with instrumentation, breaker status and control and manual operation including manual synchronising of the generators and main switchboards

Figure 2. *A corpus excerpt with BNC/COCA coverage given in colors*

Not being able to reach the adequate reading comprehension with general English words only, we tested the coverage of available and applicable engineering word lists.

The coverage of the Ward's basic engineering English word list (BEEWL) is somewhat lower than in his original corpus of engineering textbooks (16.4%), but is still substantial and could be of good use to marine (electrical) engineers, as well (Table 3.). In our analysis we used it without the first 2,000 most frequent GE words, since Ward did it the same way due to the poor vocabulary skills of his students.

Table 3. The *coverage of BEEWL in the corpus of instruction books for ETOs*

Word lists	Tokens	Coverage (%)
BEEWL (Ward)	25,550	14.48

Hsu, however, first excluded the most frequent English words in her analysis, so we followed the same methodology (Table 4.). The coverage of her engineering English word list (EEWL) is significantly below the coverage in her original corpus of textbooks from 20 various engineering areas (14.3%).

Table 4. *The coverage of EEWL in the corpus of instruction books for ETOs*

Word lists	Tokens	Coverage (%)
BNC/COCA 2,000	120,685	68.38
EEWL (Hsu)	16,677	9.45
Total	137,362	77.83

5. CONCLUSION

Using some of the most contemporary corpus linguistics software and programs, we were able to provide data on vocabulary type and load of our referent corpus. Not surprisingly, the results point to the extremely technical and demanding nature of the texts vocabulary-wise, the adequate reading comprehension of which cannot be reached with knowing general English vocabulary only. This justifies the general recommendation of upgrading the first several thousands of general English words with more specific and profession-oriented vocabulary, which is a general tendency in English for specific purposes.

The fact that the adequate threshold has not been reached even with the existing word lists of adjacent engineering fields, clearly calls for the creation of a specific ETO word list. Fortunately, the software used here provides us with the very possibility, thus the authors hope to present the target learners, as well as other course designers and authors, with this kind of ESP aid in the near future.

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Application of Textual Analysis in the Context of Vocabulary Teaching for the Marine Electrotechnics Students

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Abstract: *The paper aims to highlight current trends in vocabulary teaching of English for the students of marine electrotechnics studies. Nowadays, the education process includes a variety of teaching materials, the majority of which are found in a digital format. In addition, language teachers have become actively involved in designing language materials and textbooks with the help of the subject experts. With this in mind, the paper presents how language teachers combine textual analysis software with the subject knowledge of the field they teach in order to establish communicative patterns. This approach requires not only knowledge and expertise about the content subject, but it also implies teachers' technical versatility and availability of digital platforms for students. In order to prove the assumptions presented in the paper, we made use of the textual software in the analysis of the specialized reference book in electrotechnics titled "Practical Marine Electrical Knowledge" by Denis Hall. After the texts were converted into textual files and imported in the software, the analysis was focused on the prevalent lexical aspects in teaching English for the marine electrotechnics students at the Faculty of Maritime Studies in Kotor.*

Keywords: *marine electrotechnics, textual software, vocabulary, communicative patterns*

1. INTRODUCTION

Recent years have seen the development of many research papers dedicated to the application of technological tools in teaching professional subjects. The use of technical equipment which educational institutions have obtained, such as sophisticated licensed audio and video materials, professional software, and simulators, helped teachers of English language at the Faculty of Maritime Studies to refresh their language curricula and language course content. In the context of English language learning for students of marine electrotechnics, it can be said that technical innovations enriched the learning environment and brought benefits to English teachers and subject-specific teachers as well. A blended approach where traditional face-to-face learning is complemented with an online learning environment, aims to encourage students to participate in the class actively and benefit more from it [1].

With the increasing need for the electrotechnical officers (ETOs) on the international seafaring market, subject teachers, along with the English teachers at the Faculty of Maritime Studies, have dedicated specific attention to adapting theoretical and practical classes to professional needs. As the focus of this paper is English as the leading language in seafaring and marine electrical engineering, respectively, we shall first focus on the particularities of this professional discourse community. Among many characteristics defining a concept of a discourse community as proposed by Swales [2], the most relevant to the topic of this paper are (1) the fact that members of discourse community use specific genres to achieve their specific communicative goals, (2) the use of specific lexis that the participants of discourse community use, and (3) means of communication that the discourse community members utilize to achieve their communicative goals.

With the subject in mind and discourse communities on one side, one should keep in mind the multidisciplinary nature of science and digital technical benefits. Interaction between people in their professional work settings and the technical environment has been on the rise [3].

Teachers' involvement in the professional subjects is inevitable and requires constant endeavours to grasp the communicative needs of the professional community which is the focus of professional language research and education.

2. COMMUNICATIVE NEEDS OD THE ETO OFFICER

Discourse community formed by the ETOs comprises a variety of verbal and written genres and discourse types. The electrotechnical discourse is vital for the proper functioning of the electrical equipment on board a vessel. These officers use a

range of different discourse styles in daily and emergency activities related to the electrical and technical operations of all the main systems on board ships [4]. As per Model Course 7.08 [5] and in line with Table A/III of the STCW convention, English language competence for operational level implies the use of English in written and verbal form. The level of English language competence is not strictly laid down, but ETOs must have at least good semantic knowledge of the terms used in their daily assignments. However, it may be assumed that the grammatical structure of marine electro-technical genres is not difficult to acquire. Although genres may vary, the learning of grammar includes passive forms and schematic structures found, for instance, in the language of instructions, manuals of the electrical appliances on board ship. However, the narrative component and an appropriate level of verbal competence are of particular importance in those situations where narrative discourse prevails. This particularly refers to the situations when the ETO needs to explain deficiencies, point to problems, suggest solutions, and write reports. Despite various communicative situations that the ETO may tackle, we believe that, compared to deck and engine officers, language requirements of the ETOs are more demanding. The very fact that the ETO is involved in many discursive situations related to the proper functioning of equipment in departments on board ship (deck, engine, catering department), leads to the assumption that the ETO's level of English competence must be high and complex.

Relying on the recommendations pertaining to the English teaching course stated in IMO Maritime English Model Course 3.17, part 2.3 titled "English for Specialized Maritime English for Electro Technical Officers" [6], we concluded that marine engineering discourse blends a variety of communicative situations. Apart from general English competence that these officers need in order to work in a multicultural environment on board ship, i.e. the ability to communicate with fellow mates on board, we will focus on the segment of technical-specific words that the students of marine electrotechnics, future ETOs, will use upon embarkation on board ship.

According to IMO 3.17 teaching recommendations, ETOs are required to verbalize various language skills that are in the scope of the ETO's duties. These include understanding and using engineering books, electronic and electrical publications, deck and bridge equipment, publications related to the main and auxiliary engines, and communication systems on board such as computers and computer networks [6]. Electro-Technical Officers are involved in many professional communicative situations that vary from factual to narrative language competence.

Despite various literature resources and methodologies that we have encountered in the teaching practice so far, we have realized that the most important aspect of teaching English for the marine electrical students lies in semantics. Vocabulary and specialized words in each professional discourse community present the basis for learning [7]. After acquiring a domain-specific vocabulary, learners are then encouraged by their ambition to succeed and upgrade their communicative competence in specialized English.

3. PATTERNS OF SCHEMATA

The concept of schemata is closely related to the learning of different genres. It refers to establishing predictable linguistic means and structures making up a particular genre. As far as pedagogic context is concerned, "content schemata can facilitate not only the learning of generic conventions and rhetorical action but also the linguistic resources to realize them [8]". In our paper, we aim to demonstrate how the concept of schemata reveals dominant linguistic peculiarities of the marine electrotechnics discourse. Learning schemata is particularly convenient in technical studies as it facilitates learners grasping text structure, which they will apply in practical work settings. Technical texts must be concise and clear, which is imposed by the nature of the profession and institutional requirements. Among many norms prevailing in "building up the formal architecture of technical communication [9]" are the need for clarity and brevity.

4. METHOD

The corpus for the analysis in this paper comprises texts from the book *"Practical Marine Electrical Knowledge"* [10], a well-known literature reference used by the marine and electrical practitioners in the education process. The text pages, excluding figures and tables, were converted into the textual file and processed in the textual software AntConc 3.5.8 [11]. One of the options offered by this software is to generate frequency lists. Frequency lists are particularly applicable for the compilation of technical or other field-specific glossaries.

The analysed texts contain 403,999 tokens of which 338,001 are common words that repeat throughout the text (such as articles "a", and "the", and the prepositions "of", and *"with"*). The concept of schemata in this paper was deployed on the semantic level. Namely, after the reading of the specialized texts about the basics of ships electrical systems, electrical distribution, generators, electrical propulsion, we decided to focus on the most frequent concepts and the typical context in which they appear.

We first created the word list and found the most frequent words. After that, we explored the

linguistic exponents denoting how the things operate and what are the cause and effect relationships within the specific domain of engineering and electrical systems. We also identified the examples of nominalization, which is typical of educational and technical texts, as well as the passive constructions used to express scientific facts, such as motor or generators operations (running of the equipment, the relationship between voltage, current, and resistance, spatial relationships).

We analysed lexical and function words. Lexical words are content words, typically nouns and verbs that convey meaning in a sentence, whereas function words express grammatical relationships. In this paper, we found that the frequency of certain grammar words should not be underestimated in these types of texts.

5. RESULTS

Our texts for the most part deal with the technical discourse found in the academic book intended for students and lecturers engaged in the specific field of engineering and electrotechnics. In that light, we focused on the lexical words, prepositions, passive constructions, and nominalization.

5.1. Lexical words

Content or lexical words with more than 100 occurrences in the texts are given in descending order in Table 1.

Table 1. *Nouns (content) words in the texts*

Word	**Number of occurrences**
Motor	765
Current	422
Circuit	390
Voltage	387
Power	385
Generator	281
Equipment	218
Fault	191
Insulation	143
Earth	143
Resistance	111
Frequency	106
Maintenance	102

The search results pointed to the examples of collocations that the antonyms *high* and *low* make with the nouns presented in Table 1. The adjective *high* is found in 187 instances as in: *high voltage* (34 examples), *high power* (33), and *high temperature* (28). On the other hand, the adjective *low* (108 instances) collocates with the same nouns (*low pressure/ current/voltage temperature*).

Identification of the key words in the corpus makes the basis for the preparation of dictionaries or glossaries that can be used in the teaching. For example, students may be asked to find as many words as they know that collocate with the word *motor* as in *motor acceleration, motor action, induction motor,* and *drive/synchronous motor.*

Verbs are also important in our corpus, as some of them occur more than 50 times, such as with *start*, *keep,* and *maintain*. One activity is to establish patterns that the verbs make, as with the verb *maintain* in *maintain safety/equipment,* and *maintain generator operation*.

Nouns derived from the verbs, usually hyphened two-word strings, are also worth investigating in light of technical discourse, as in *start-up delay/equipment/sequence.* Similar examples include *run-up, back-up, pick-up,* and *set-up* as in *back-up fuses/protection/trip/voltage, run-up time/period,* and *pick-up power/setting/current.*

The use of passive constructions in technical discourse provides the objectivity of facts. In our corpus, the formation of passive voice is found in 584 examples formed by the *is/are + past participle* pattern (Fig. 1).

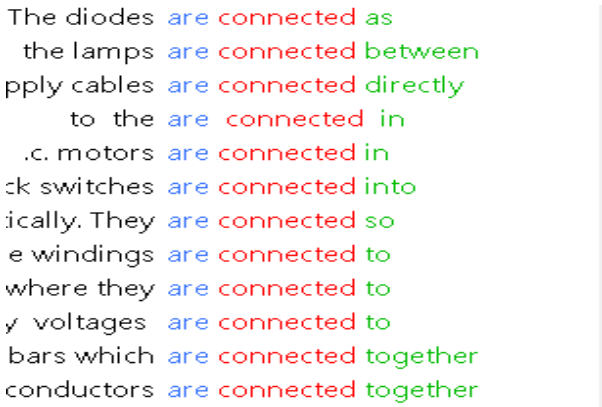


Figure 1. *The examples of the passive voice in the corpus*

The most representative verbs found in the passive voice are: *make, connect, maintain, keep, arrange, use, adjust, design, drive, construct, feed, locate, monitor*, and *require*. The following are the examples from our corpus:

(1) "Emergency suppliers are necessary for loads which *are required* to handle a potentially dangerous situation."
(2) "The other phase of the phase windings *are connected* to outgoing conductors."
(3) "The compressor, air fan and sea water pump *are driven*."

5.2. Function words

Function words such as prepositions *at, which,* and *of* are interesting for language research. They provide grammatical and semantic cohesion within

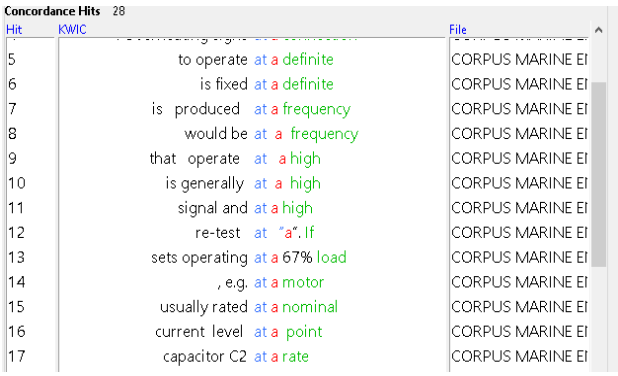
the sentence and text, but in the context of our analysis, they are indicative of the patterns they make with the content words presented in table 1.

In our corpus, the most frequent function words are articles (*a, an, the*), prepositions (*to, at, with, by, in*), determiners (*that, this*), and conjunctions (*and, or*):

Table 2. *Function words in the texts*

Word	**Number of occurrences**
To	1596
At	328
With	477
By	488
In	456
This	345
That	245
A/an	1582
The	4412
And	1687
Or	503

The preposition *at* is the most commonly used function word in the corpus. It denotes place, rate, direction, speed or intensity (Fig.2). The preposition *at* occurs in 328 examples. It is found in the instances: *at speed, at 110 V, at a frequency, at about 4 seconds, at all times,* and *at high temperature*.



Concordance Hits 28

Hit	KWIC	File
5	to operate at a definite	CORPUS MARINE EI
6	is fixed at a definite	CORPUS MARINE EI
7	is produced at a frequency	CORPUS MARINE EI
8	would be at a frequency	CORPUS MARINE EI
9	that operate at a high	CORPUS MARINE EI
10	is generally at a high	CORPUS MARINE EI
11	signal and at a high	CORPUS MARINE EI
12	re-test at "a". If	CORPUS MARINE EI
13	sets operating at a 67% load	CORPUS MARINE EI
14	, e.g. at a motor	CORPUS MARINE EI
15	usually rated at a nominal	CORPUS MARINE EI
16	current level at a point	CORPUS MARINE EI
17	capacitor C2 at a rate	CORPUS MARINE EI

Figure 2. *Concordance of the preposition "at "in the corpus*

Conjunctions *and* as well as *or* occur in the binomial expressions which are commonly found in electrotechnical texts. They occur in binomials and denote opposite relationship as in *outside and inside*, *inlet and outlet*, *input and output*, and in pairs implying direct connection between the two concepts as in *rotor and stator*, *control and safety*, and *humidity and salinity*.

The high representation of the prepositions *in, with, by,* and *to* in the electrotechnical discourse signals the importance of the concepts of time, location, place, and the relationship between the objects, activities and conditions.

Spatial precision when describing places and components is necessary. When interior spaces or the inside of the object are referenced, the preposition *in* is used, for example, *in the boiler, in the generator, in the glass, in the propulsion*. Direction, measurements and accurate values are expressed with the preposition *to* as in *to a level*, *to 1000 A*, *to a maximum*, *to a shaft, to about 750 V.*

The preposition *with* indicates that a specific tool or other means is being used to do something. Examples are: *with a multimeter*, *with power, with a vacuum*, *with boracic powder, with fresh grease.*

Among many language activities used to teach prepositions are those in which students are asked to choose among the offered prepositions. According to our teaching experience, the most common mistakes occur with the prepositions *with* and *to*. For instance, students say *with a speed*, *with a large extent*. Instead, they should say *at a speed*, and *to a large extent.*

5.3. Nominalization

The analysed corpus displays a high representation of nominal expressions. Nominalization is used in technical genres with the aim to achieve accuracy and describe condition, value, and rate. Compared to the verbs expressing dynamic actions or processes, nominal expressions denote activities that have already been completed. The most representative examples in our corpus are formed by the suffix *–ion* as in *generation, classification, production, operation, protection, aeration*, *-ance* as in *maintenance*, *resistance, clearance*, and *-ency* as in *frequency*.

(4) Electrical *generation* on board ship is typically at three phase.

Such nouns are commonly found in a string of three words (trinomials) which are, along with binomials, preferred in marine technology discourse.

(5) Motor and starter *construction, operation, and protection* are explained.

(6) Laundry equipment and cathodic protection are described together with battery *support, care* and *maintenance*.

5.4. Application of the textual analysis in the classroom

In light of the results shown in the previous sections of the paper, it is worth noting that the study programme of the Marine Electrotechnics at the Faculty of Maritime Studies Kotor was reaccredited in 2017. Goals and syllabi comply with the latest trends in the marine electrotechnics domain and follow the increasing demand for the ETOs on the seafaring market. The teaching staff have put much effort into combining the traditional teaching with laboratory and practical work and to use simulators

in the training process (such as the recently acquired high voltage simulator).

In addition to this, the importance of the English language for the marine electrotechnics students has been accentuated from the first year of enrolment. Given the availability of sophisticated digital learning environment, all teaching material is placed on the Moodle platform. Education process has gathered various subject teachers in that they "back-up" each other's efforts in compiling materials and designing practical activities. As far as English classes are concerned, the English teachers have recently implemented collaborative work with subject teachers, particularly in the domain of glossary production. Some samples are already available on the Moodle platform of the faculty and contain basic electrotechnical terms that the student, the future seafarer, will use in his/her work environment on board ship. Despite limitations that exist in terms of the lack of hours anticipated for some specialized courses in marine electrotechnics and the English courses, the attitude taken by our faculty is to increase future interaction between teachers in the subject-specific field and English teachers.

6. CONCLUSION

The availability of materials and corpora which can be a subject of linguistic research is a step forward in the recent practice of English language teaching. Also, many types of textual analysis software can be used to process large segments of general and specialized texts. In this paper, we tried to highlight how software outputs can be used to identify patterns of a specific genre. The focus of the analysis was on the lexical words prevailing in this professional discourse (*motor, generator, current, voltage, maintain, back-up, start-up*), and the way they can be taught in the classroom. We also examined function words (*at, in, by, to*), which are equally relevant for the marine electrotechnics discourse.

In this way, the teacher may select which aspect of language he or she will focus on, and design language activities respectively. There is no doubt that technical vocabulary presents the basis for upgrading communicative competence of the learners.

However, it must be noted that the interpretation of the identified language patterns or schemata requires the knowledge of the context of the domain under investigation. In the context of marine electrotechnics, there is a variety of genres and discourse types that the ETOs will utilize in the future.

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Effects of Teaching Summary Writing Skills on Students' Learning Process in IT field

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Abstract:*Summary writing task is a demanding activity as it foreshadows several other cognitive skills. This paper aims to present the potential effects of the summary writing teaching practice on students' learning process and development. The paper also provides a detailed description of a step-by-step procedure of summary writing skills. The analysis of the teaching practice shows how it affects students' learning process and contributes to students' development, mostly evidenced in the linguistic features of their texts. Summary writing is a part of the course English Language for Information Technology 2 taught in the first year of IT study module at the Faculty of Technical Sciences Čačak.*

Keywords: *summary writing, ESP, writing skills, language learning, linguistic use, grammar features, writing style.*

1. INTRODUCTION

Writing designates a complex activity which not only implies linguistics and semiotics, but also deeply portrays the social and educational level of the writing subject. Some factors which nowadays considerably affect conventional writing are "increasing globalisation, the development of new communication technologies, new approaches to language learning" and multimedia [1].

In general, writing activity in English as a Second Language implies demonstrating students' learning and comprehension of the specific subject. It is also an extremely difficult challenge due to the fact that students are not versed in the requirements of professional writing, and their previous writing experience is usually scarce [2].

As for students an academic context implies "greater formality, impersonality, nominalization, and incongruence of these discourses" [3], a failure to achieve these conditions is more frequent than success. Therefore, writing is designated as "the crucial process by which students make sense not only of the subject knowledge they encounter through their studies", but as a way "how they can make it mean something for themselves" [3].
Having in mind all these factors, the concept of summary writing presents even more demanding activity, as it includes both the skills for understanding the assigned text, and the writing skills, or skills for devising the text based on the read one [4]. Thus, the inferred or background activities in the process of summary writing are reading comprehension, and writing as an outcome of learning. Summary writing can be regarded as a *transferable skill* which can help students "move across different assignments" [3]. In this paper, we shall try to present a students' activity of summary writing in an IT profession and explain the process of teaching the writing skill. This paper aims to present teaching content, conducted procedure and the results in the course English Language for Information Technology 2 at Information Technology bachelor studies at University of Kragujevac, Faculty of Technical Sciences Čačak, Serbia in the school year 2019/20. It will also provide an insight into the impacts of the teaching process onto the overall students' development mainly manifested in the linguistic use in their texts.

2. THEORETICAL BACKGROUND: Summary Writing in ESP

In ESP, writing is perceived as "assisting students towards competence in particular target genres" [3], whereat students are taught specific kinds of writing skills required in particular professional contexts.

Since the language is primarily used for achieving specific purposes, text as a written form of communication is a source of the writer's intentions, the structure of organized information, and "a repertoire of linguistic responses" [3] used for communicating in specific situations.

As evidenced in the research in ESP, learning professional writing presupposes both the linguistic features of a specific professional genre, and the professional values and practices [5]. Written texts are distinguished by the use of the rhetorical

conventions, specific tone of narration, grammatical features and structure of arguments [3]. On the other hand, ESP texts designate language forms acting as a means to accomplish specific purposes. Rather than focussing on parts of language "distanced from both teacher and learner and imposing on them external rules and requirements" [3], ESP practice foregrounds the demands for communication [3] and study of the texts needed for the future target contexts.

Students' native language and prior experience significantly affect ways of structuring ideas and arguments when writing in English [3]. In order to access readers' understanding, texts should be systematically structured, and only then they can be regarded as professional, characterized by its "expert character, its specialized goal orientation, and its conventionalized form" [3].

The assignment to write a summary of a research article and analyze different, sometimes opposing ideas in it seems very demanding for university students. The commonly received feedback is general points of the text expressed through personal observations and attitudes towards the subject [3]. Therefore, the teacher's task is not only to spot grammar errors and improve the style [3], but to help students acquire skills for mastering a wide variety of contexts and practices.

Margaret Hill [2] proposes three key issues related to summary writing. The first one presupposes the definition of summary writing as a "short statement that condenses formation and reflects the gist of discourse" [2]. The second issue addressed relates to the variables implicit in the task of summary writing. The variables are as follows: text complexity and organization, degree of comprehension, text availability, audience, intended purpose, type of summary required, genre, and text length [2]. Finally, the third issue suggests the way of overcoming difficulties with summary writing. As already mentioned, summary writing is very demanding as it "requires the ability to abstract" [2].

Writing summaries usually helps students to comprehend reading materials, organize their writing, develop vocabulary, promote critical reading, and improve learning in general [2].

The type of summaries especially appropriate for content areas are reader-based summaries which are polished, short, concise, and written for an external audience [6].

Summary writing is more demanding than other forms of written discourse as it presupposes several cognitive activities [4], such as distinguishing the main idea of the text, eliminating the less important data, and finally reorganizing the selected information [2] [6].

For summary writing in ESP, common instructions include a few steps [7]. The first step includes differentiating main ideas from irrelevant information [2]. This can be achieved either by using a "linear time pattern" (narrative structure) or by developing "a structural organization from the mapping" [2]. The second step implies the conversion of these ideas into a written discourse [2]. This enables students to proceed towards a more complex and abstract composition such as "cause-effect, compare-contrast, problem-solution" [2]. The final step infers restating in their own words the elicited main ideas.

Some authors suggest that the strongest step-by-step guidance for a successful summary results is the GRASP procedure (Guided Reading And Summarizing Procedure) [8]. In this paper, we shall try to provide a detailed procedure we employ in the classroom in order to help students learn the skills of summarizing.

3. TEACHING SUMMARY WRITING AT THE FACULTY OF TECHNICAL SCIENCES ČAČAK

The aim of including the summary writing activity in the course *English Language for Information Technology 2* is not only to provide support to learning ESP, but also, to a lesser degree, to students' general knowledge of technical sciences.

The study was performed at the Faculty of Technical Sciences Čačak, University of Kragujevac. The study programme within which the research was conducted was Information Technology. The study programme of Information Technology at the Faculty involves four English language courses: English Language for Information Technology 1, English Language for Information Technology 2, English Language for Information Technology 3, and English Language for Information Technology 4. The course covered by this research is English Language for Information Technology 2 which is in the first year summer term. The course covers the required literacy, of which the activity of summary writing plays a vital role. At the end of the course students are expected to be able to summarize academic articles taken from their professional context.

Most students have already gone through the course English Language for Information Technology 1, and acquired knowledge in general English in a specific field of IT. The aim of this course is to introduce students to the basic skills necessary for reading and understanding texts in their professional environment. At the end of the course entitled English Language for Information Technology1, students should acquire intermediate knowledge in English grammar (B2), and learn how to use tenses, passive voice, conditionals, as well as adjectives and adverbs correctly. In the following course, English Language for Information Technology 2, students are expected to develop writing skills in a specific field of IT, as well as skills for successful presentation which they demonstrate orally. The aim of this course is to expand students lexical and grammatical corpus, and develop written and oral communication skills in IT context.

At the end of the course, students are expected not only to produce a summary writing to document their learned skills and understanding of the text, but also to deliver a successful presentation.

Given that the rough process of summary writing has already been mentioned in Section 2, in this section we shall focus on the techniques employed in teaching summary writing at the Faculty of Technical Sciences Čačak.

The guided procedure for summary writing task starts with the reading activity. As the study was carried out during regular ESP classes at the faculty, it was, as usual, preceded by a few questions related to the topic of the class. The assigned text was a text on Maglev trains (shown in Example 1.), and students were asked on their background knowledge on the subject, e.g. what the term Maglev stands for, and how the conventional trains differ from the Maglev trains. This activity introduces students to the topic. The students were asked to skim the article in order to find general information in the text.

Example 1. *Text of the article for summary writing*

Maglev (derived from ***mag***netic ***lev***itation) is a public transportation technology that uses magnetic levitation to move vehicles without making contact with the ground or an electrical pickup. Maglev competes with high speed rail and airlines. A Maglev train does not run along a track in the normal way. Instead, magnetic fields lift it above the track, so that the train "floats" along.

In itself, Maglev technology does away with moving parts, allowing vehicles to move more smoothly and more quietly than wheeled transport. Because they have no wheels, axles, suspension, dampers, or brakes, Maglev vehicles are light and compact. They are also pollution free, as no fuel is burned, and cheap to maintain. A vehicle travels along a guideway provided with magnets to control in-flight stability and create propulsion and lift, eliminating the mechanical constraints of dry friction. In the case of conventional high speed trains, wear and tear of wheels on rails and on the electrical pickup limit highest speeds.

Maglev vehicles hold the speed record for trains (603 km/h). In practice, as with all high speed transport, time for acceleration and deceleration allows fewer stops if higher top speeds are to be effectively utilized. In the case of Maglev, acceleration and deceleration are essentially limited by the wellbeing and safety of the passengers.

The world's first commercial Maglev system was a low-speed maglev shuttle that ran between the airport terminal of Birmingham International Airport and the nearby Birmingham International railway station between 1984 and 1995. Its track length was 600 m (2,000 ft), and trains levitated at an altitude of 15 mm, levitated by electromagnets, and propelled with linear induction motors. All the electrical equipment which powered the cars was situated under the floors or the seats. Each car could take 32 passengers and their luggage, up to a weight of 3 tonnes. The train travelled at the maximum speed of 42 km/h. It operated for 11 years and was initially very popular with passengers, but obsolescence problems with the electronic systems made it progressively unreliable as years passed, leading to its closure in 1995.

The train is lifted from the track by magnetic attraction. This is the force by which two opposite magnetic poles attract each other (just as two of the same poles repel each other). Powerful electromagnets at each corner of the train exert a pulling force which lifts the train upwards so that it floats 15mm above the track. As people get on and off, the weight of the train varies. It may drop closer to the track than the required 15mm, or rise further from it. To keep it at an even distance from the track, the force is varied by a microprocessor.

Each train is driven by an electric motor called a linear induction motor. Electromagnetic windings, or coils, on the train generate a magnetic field in which the magnetic poles shift along the train. The field induces electric current in the track, which in turn generates its own magnetic field. The two fields in the track and the train interact so that the shifting field pulls the floating train along the track.

Maglev systems have been much more expensive to construct than conventional train systems, although the simpler construction of Maglev vehicles makes them cheaper to manufacture and maintain. Despite over a century of research and development, Maglev transport systems are in operation in just three countries (Japan, South Korea and China). The incremental benefits of Maglev technology have often been hard to justify against cost and risk, especially where there is an existing or proposed conventional high speed train line, as in continental Europe, the UK and Japan.

'Inside out: Magnetic levitation train', *Education Guardian* (abridged excerpt)

When the students have read the text, they are asked to share the remembered details from the text, and write them down in their notebooks. The fragmented information will only later attain its full contextual meaning [8]. The next step is to ask the students to read the text again for specific information. At this stage, the students are ready to complete reading comprehension activity in which they should elicit the advantages and disadvantages of Maglev trains. In notes, the students write down the advantages (no pollution, faster than conventional trains, no maintenance cost, light, compact, able to develop high speed), and disadvantages (expensive to build, variable weight to carry). If some of the information previously written was incorrect, students will now be able to correct it. As suggested by the authors in [8], this step of correcting the gathered information is significant for achieving "accurate, critical reading competence" [8]. Example 2. presents the notes and details remembered and jotted down from the article.

Example 2. *Details noted down from the article*

- Maglev is a public transportation technology
- does not run along a track
- uses magnetic levitation to move vehicles without touching the ground

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- Maglev technology allows vehicles to move smoothly
- vehicles are light and compact, pollution free, and cheap to maintain
- vehicles are provided with magnets for in-flight stability control
- magnets generarate propulsion and lift

- high speed of the vehicles
- time for acceleration and deceleration causes fewer stops

- first Maglev system ran between 1984 and 1995
- first Maglev could take 32 passengers and their luggage

- the train is lifted by the force generated by two opposite magnetic poles
- weight of the train varies as people get on and off

- each train is driven by a linear induction motor
- coils on the train generate a magnetic field
- the field induces electric current which generates its own magnetic field

---

- two fields interact and the shifting field pulls the floating train along the track
- Maglev trains are expensive to build compared to conventional trains
- Maglev transport systems are in operation in just three countries

---

At this point students are taught that although every paragraph in the text serves the main idea, it could be regarded as a single section of the text which usually deals with a single theme. Extracting the main idea of each paragraph can be facilitated by the teacher's suggestion that the most important sentence of a paragraph is usually the first one. Around the main idea, there are always major and minor details, thus collapsing the paragraph into the main idea and major and minor details contributes to a clear identification of the text. The following step is the clustering of the information. At this stage, the draft is not perfectly set and structured, but the information is close to being appropriately transformed and organized. As the control over text is gained, and each piece of information is set in the belonging group, the next step of the summary writing maps out the "polishing strategy" [6] which develops through selecting the relevant data, compressing the information, and maintaining the coherence of the entire text [8]. The strategy of compressing the information is only presented to the students, who are then instructed through examples that combining the information is typically conducted by linking sentences using 'linking words' or 'sentence connectors', commonly referred to as discourse markers. As discourse markers bind together pieces of text and contribute to the overall text coherence, the teacher suggests different types of discourse markers that students can use for their summary writing. Discourse markers can be used for emphasising contrast, showing similarity, structuring, adding, generalizing, giving examples, logical consequence or summing up [9]. Moreover, the teacher emphasises that when used appropriately, discourse markers elevate the text and make it seem logically constructed, thereby raising the students' awareness of using discourse markers correctly. The conversion of active into passive sentences contributes to the formality of style which therefore becomes impersonal and concise. As direct instructions seem to be most effective for this type of assignments [2], before instructing the students to use their own words and complete the summarizing, the teacher calls students' attention to the fact that the final text of the summary should be concise, without personal ideas expressed in it, neutral, with quotation marks used. The teacher additionally highlights the rule that the summary should not be a copy of the original, pointing up the brevity requirement of the summary and the essential use of discourse markers.

4. THE METHODS

The sample was constituted by summaries written by a group of 44 students enrolled in the first year of IT study program at the Faculty of Technical Sciences Čačak. As mentioned above, the grammar variables examined in the submitted summaries were: use of personal pronouns, use of tenses, use of passives, use of gerund/infinitive, use of articles and use of modals, while the style variables were: sentence clarity, text condenseness, text conciseness, text impersonality and discourse markers (to name but a few: with reference to,

regarding, as for, on the one hand, on the other hand, while, whereas, however, nevertheless, nonetheless, yet, still, in spite of, despite, similarly, in the same way, just as, on the contrary, first(ly), second(ly), lastly, finally, to begin/start with, in the first/second/third place, moreover, furthermore, in addition, besides, on the whole, in general, in most/all/many/some cases, broadly speaking, to a great extent, to some extent, apart from, except for, for instance, in particular, therefore, as a result, consequently, so, then, in conclusion, to sum up, etc.).

Example 3. *Submitted summary 1 writen by S1 with inserted corrections and teacher's comments*

Maglev Train-Summary writing

~~When we talk about the public transport, there is a Maglev train. This~~ Maglev trains ~~isn't moving~~ are not like ~~the same way as~~ classic trains, ~~but~~ as ~~it's moving without~~ they don't touch the ground ~~contacts with land~~. Maglev ~~train~~ vehicles are simpler and less noisy ~~eless~~ than classic vehicles, because they do not operate ~~n't have anything as a classic cars~~ in the same way. On the contrary, they ~~don't~~ neither pollute the environment, nor ~~moreover they don't~~ use fuel to start the engine, as they are~~. Maglev train starts~~ operated ~~ing~~ by ~~with~~ electromagnets and linear induction engine which ~~and that helps~~ enable ~~him~~ it to move faster and easier.

The speed of 603 km/h which this train ~~amounts~~ can develop ~~, in regarding of trains~~ is the record speed in comparison to conventional trains.

~~For example~~ In past, the first Maglev train ~~has a first shape,~~ was called "Maglev shuttle", ~~but~~ and it worked for only ~~just~~ 11 years. Strip length was 600 m long, ~~and~~ while the train hovered ~~on~~ 15 mm above the ground ~~with the help of~~ due to electromagnets. This ~~one~~ vehicle could take ~~maximum~~ 32 travelers maximum and ~~their~~ 3 tons of luggage ~~of maximum 3 tonnes~~. On the whole, maximum speed of ~~this shape of~~ the Maglev train was 42 km/h, and ~~he~~ it was closed in 1995 ~~because~~ due to ~~of~~ electronic systems problems.

To sum up, ~~my opinion is that~~ even though Maglev trains could be ~~are~~ a perfect example of modern solution to traveling, the cost of constructing them is very high.

Can be better. Pay attention to grammar, pronouns, sentence clarity, style. Both the first and the last sentence of your summary are inappropriate, as you are to summarize an article, and you should not put your own opinion.

The instruments of the study were students' summaries. The qualitative method we employed is case study research, and the analysis included grammar and the stylistic features of the students' texts. The method employed in the research covered textual analysis of students' summary writing. In order to attain a representation of language use in the summaries of Maglev train text, we included one of the submitted summaries in this paper. Example 3 shows a submitted summary with additions and corrections inserted by the teachers. The author of the summary is an IT student at the Faculty of Technical Sciences Čačak.

The submitted summary is the evidence of the original student's text which contained two personal sentences with the first person pronouns used, several grammar mistakes and generally unclear sentences. However, the student in question was able to distinguish the main idea of the assigned text and omit the irrelevant information, so he was assessed as Can be better.

During the course students were assigned to write three summary writing tasks. As forty four students constituted our group, the corpus of 44 written summaries were submitted for this specific task. The students wrote their summaries under the guidance of teachers, and their achievement was evidenced through evaluation of the submitted summaries, and assessed as being "well done", "could be better", "can be better", or "failed". The summaries submitted by the students who were not able to summarize the original text but only copied sentences from the original text were assessed as Failed. Can be better implied another

assessment level whereat students were able to abstract the original text, but their summaries showed the incorrect use of the grammar features such as: tenses, personal pronouns, passive forms, gerund/infinitive, modal verbs and articles, and usually were void of style features such as discourse markers so their texts were not clear, concise and impersonal. Style impersonality was an important variable, as summary writing presupposes the avoidance of personal text. Could be better indicated higher level of skills than can be better, and students' texts assessed as Could be better were overall grammatically correct, but mostly contained incorrect use of articles and some stylistic errors such as incorrect use of discourse markers. Well done presupposed the best assessment level which stood for the correct use of all grammar and the previously mentioned style features. The summaries were evaluated by two ESP teachers at the Faculty of Technical Sciences Čačak.

During the course, through language features of the submitted summaries, we also evidenced the extent of development of the language used by IT students. The analysis of the students' texts and the teacher's feedback shows the students' learning process and contributes to students' progress in their professional environment.

5.TEACHING RESULTS

The analysis shows that more than half of the students progressed through stages as they wrote summaries. We observed students' development by comparing their assessments in each summary writing assignment. More than half of the students with better assessment at the end of the course were able to abstract the original text. The student who progressed from Failed to Can be better was able to summarize the assigned text, but his/her summary showed the incorrect use of the grammar features, while the style features were weakly used: no discourse markers, and the text was not clear, concise and impersonal. The students who progressed to Could be better were able to write grammatically correct texts, with the exception of the incorrect use of articles and some stylistic errors such as the incorrect use of discourse markers. The students who progressed to Well done assessment level were able to write summaries showing the correct use of all grammar and the previously mentioned style features. Initial versions of the students' summaries generally appeared rough, however, it was only later when the style of the writing became concise, impersonal, and refined. The students' assessment during the course is shown in Chart 1.

As evident in Chart 1, not all the students progressed during the course. Yet, the students whose writing skills improved made less grammar mistakes related to tenses, personal pronouns, passive forms, gerund/infinitive, modal verbs and articles, while the analysed style features also confirmed progress, as the texts were clearer more concise and less personal. A number of 18 students achieved better assessment level, another 18 students maintained the same assessment level, whereas 8 students showed lower assessment level in Summary 2 than in Summary 1. However, enhanced students' development was evident by comparing the assessment levels achieved in Summary 1 and Summary 3, since 26 students obtained better results, and 18 students maintained the same assessment level.

The analysis shows that the writing behaviour of 26, out of 44 students, progressed during the course, as shown in Chart 1 (next page). By comparing the initial and the final summary assessments, it is evident that a number of 14 students progressed from Can be better to Could be better, 5 students progressed from Failed to Could be better, 4 students progressed from Could be better to Well done, 2 students progressed from Can be better to Well done, and 1 student progressed form Failed to Can be better. The change in writing behaviour was evident as the students who progressed to Could be better did not make mistakes with the tenses, passive forms, personal pronouns, gerund/infinitive, and modal verbs, while those who progressed to Well done did not make mistakes with the articles, and they used discourse markers as style determiners. In case of students who maintained the assessment level during the course, a number of 10 students were assessed as Could be better, 7 students were assessed as Well done, and 1 student maintained the assessment level as Can be better.

Furthermore, at the end of the course, most students learned how to avoid personal style and were able to write a professional, impersonal and concise summary. As the course progressed, 26 out of 44 students, have developed skills for summary writing through the teacher-student written communication which included texts of the students' summaries and teacher's feedback. Responding to the language use in the summaries, teachers inserted corrections and wrote comments on the content of the summaries.

We also observed that besides strong contribution to the impersonality of the style, the use of the passive forms caused further inevitable linguistic change in the text, such as omitting the use of the first person pronouns from the text, to mention but a few. Thereby, towards the end of the course, students' texts became clearer, more condensed and concise.

Chart 1. *Students' assessment during the course*

Name	I summary	II summary	III summary
S1	Can be better	Well done	Well done
S2	Could be better	Well done	Well done
S3	Can be better	Could be better	Could be better
S4	Could be better	Can be better	Could be better
S5	Could be better	Could be better	Well done
S6	Could be better	Could be better	Could be better
S7	Can be better	Could be better	Could be better
S8	Could be better	Can be better	Well done
S9	Can be better	Could be better	Well done
S10	Can be better	Could be better	Could be better
S11	Well done	Well done	Well done
S12	Could be better	Could be better	Could be better
S13	Well done	Well done	Well done
S14	Well done	Well done	Well done
S15	Could be better	Could be better	Could be better
S16	Can be better	Can be better	Could be better
S17	Can be better	Can be better	Can be better
S18	Can be better	Well done	Could be better
S19	Could be better	Can be better	Could be better
S20	Can be better	Can be better	Could be better
S21	Can be better	Can be better	Could be better
S22	Could be better	Can be better	Could be better
S23	Well done	Well done	Well done
S24	Can be better	failed	Could be better
S25	Well done	Well done	Well done
S26	Could be better	failed	Could be better
S27	Can be better	Can be better	Could be better
S28	Could be better	Well done	Well done
S29	Could be better	Could be better	Could be better
S30	Well done	Well done	Well done
S31	Could be better	Can be better	Could be better
S32	Can be better	Could be better	Could be better
S33	Can be better	Could be better	Could be better
S34	failed	Can be better	Could be better
S35	Could be better	Could be better	Could be better
S36	Can be better	Could be better	Could be better
S37	failed	Can be better	Could be better
S38	failed	Could be better	Could be better
S39	failed	Could be better	Could be better
S40	failed	Can be better	Could be better
S41	Can be better	Well done	Could be better
S42	Can be better	Can be better	Could be better
S43	Well done	Could be better	Well dome
S44	failed	Can be better	Can be better

6. CONCLUSION

This paper presents how IT students at the Faculty of Technical Sciences Čačak summarize an assigned text in their context target field. The aim of the paper is to explore the effects of the summary writing on the students' learning process. Having described the teaching process of summary writing, we analysed the effects of teaching such skills on students' learning process, and noted slow and gradual progress in the language and style of the text of summaries submitted after the students acquired summary writing instructions during the course. We also observed that in summary writing students learned how to opt for the appropriate linguistic combinations affecting the meaning of text. Our results in the research of the summaries written by IT students show that during the course, IT students tend to advance from a personal to a more concise and impersonal style. Also, during the course, summaries are found to evolve through steps from chronology to logical arrangements, while changes in style are observed to take the most time to develop usually occurring at the end of the course.

Few experimental studies covering the developing of summary writing skills have been carried out in the past several years. Marzec-Stawiarska is the author of the quasi-experimental study investigating the effect of "summary writing on the development of reading skills in a foreign language" [10]. The results of the study show that summary writing was highly beneficial for weaker students to their development of reading skills. However, the research results related to the progress in quality of the written summaries, which was insignificant compared to the progress in reading skills [10], oppose the results obtained in the present study. The results of the present study show that the summary writing teaching practice significantly affects not only students' development in reading

skills, but in writing skills as well. Wichadee performed a quasi-experimental study investigating the effect of transactional strategies on undergraduate students' reading and writing abilities [11]. Summary writing was one of the research instruments. The study results show that transactional strategies enhance the development of reading and (summary) writing skills [11]. The results of the study by Wichadee confirm the effect of teaching skills through instructions on development of both reading and writing, which was also shown in the results of the present study. Moreover, both of the studies were conducted among undergraduate students. Another study which explored the effect of summary writing on the reading comprehension of English foreign language learners is written by Shokrpour, Sadeghi and Seddigh [12]. The authors employed pedagogical approach which covered the use of "higher order thinking skills" [12]. The study analysed the effects of summary writing in the field of ESL/EFL on students' reading comprehension ability [12]. The study results show that the summary writing significantly influences the improvement of reading comprehension [12]. As the study focus is only on the reading comprehension ability, it is different from the present study in which the main result observed is the learning development evidenced in the students' texts.

The present study shows the impact of teaching summary writing skills on the students' learning process in a specific field of information technology. Even though summary writing task goes "beyond grammar and vocabulary" [3], our research results show that direct and clear instructions and the subsequent grammar and stylistic corrections inevitably influence students' learning development, and create a solid basis for the professional experiences anticipated in the future.

As ESP teachers working in the information technology context, we would like to point out that providing direct instructions during the teaching process results in successful learning outcomes. The instructions should be provided initially, at the beginning of the course, as they can serve as a model for further stylistic and grammatical choices. The present research of the summary writing suggests that the writing of students is a painstaking process with a slow and gradual advance towards the writing of professionals.

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Multilingual Conversational Communication Tools for Distance Learning

Synchronous & Asynchronous Teaching During the Covid-19 Pandemic

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Abstract: *This paper provides a brief summary of the Aristotle University of Thessaloniki (AUTh) policies for providing solutions and supporting the tertiary education community with good practices and an online catalogue of tools for learning during the Covid-19 crisis. Electronic learning takes place mostly in Greek, but during the Covid-19 pandemic, progressing rather explosively, many resources where made available predominantly in English and other EU languages. In recent years, the AUTh has been expanding its innovation in the fields of e Learning and Distance Learning. The Information Technology Center (ITC) and especially the Academic Activities and Technological Support Office (AATSO) provide integral solutions in the above-mentioned areas. These capabilities are perpetually upgraded and improved, transforming remote education into a more authentic process and providing user learning experience anywhere-anytime. AATSO develops, adopts and manages rich on-premises environments, along with tools and collaboration platforms, either open source or commercial. This gear offers enormous potential for collaboration with synchronous and asynchronous data transmission, strong interactivity through learning flexibility, prodigious new features and options.*

Keywords: *Distance Education; e-Learning; ITC; Web Conferences*

1. INTRODUCTION

The Covid-19 pandemic in a matter of weeks has changed how instructors teach and how students are educated in all education systems around the world. In Greece, after a relevant joint ministerial decision of the Ministries of Health and Education and Religious Affairs[1], it was decided to temporarily ban the educational operation of all educational structures in the country for the period from 11/3/2020 to 24/3/2020 with a margin of extension. This practice had been afterwards extended up to the spring semester end.

This was the first drastic measure to be taken, on the one hand, by taking precautionary measures to raise the bar in the spread of coronavirus, and, on the other hand, to make public health a priority. However, this legal provision does not concern a total prohibition of educational functions but of teaching that takes place in physical presence of the involved class members. Therefore, the aim of Universities is to offer as much Distance Education and work as possible by electronic means remotely, in order not to fail the spring semester; these courses have been *de facto* considered equivalent to the face-to-face ones and will be counted in the provided by legislation teaching weeks length.

Regarding the "Implementation of Distance Education in Higher Education institutions" decree[1], the Ministry of Education and Religious Affairs directs that the conduct of courses is not limited to the asynchronous way of posting teaching material on an electronic platform, but should also be accompanied either way by the provision of synchronous teaching (online courses) and live interactive video lectures or a combination of the last two methods. Therefore, Distance Education, in addition to the appropriate tools needed, depends on elaborating special skills in the administrative and organizational structures of the educational systems involved.

As a productive unit of the Aristotle University of Thessaloniki (AUTh), the Academic Activities and Technological Support Office (AATSO) was summoned to allocate the necessary educational resources as well as to sought after the pressing requirements for the Distance Learning of courses, with the appropriate technological support and the

[1] Decree No. D1a / GP.Oik. 16838/2020 (ΦΕΚ Β '783 / 10-03-2020)

guidance of the teaching staff in any complication that would become apparent.

The AATSO is thus engaged in a wide range of issues in the field of Multimedia Learning, e-Learning and Distance Education. It also supports members of the University's community and trains educators along with students in the use of interactive videoconferencing services and live-streaming systems [1].

With these reference services in perspective, lecturing would be enhanced with innovative tools, introducing novel good practices in the established teaching models, having as ultimate goal to stimulate students' interest by increasing their motivation to learn and improve their performance during tribulation.

1.1. Distance Learning

Distance Learning is defined as an organized form of education where there is separation between teacher and learners and where electronic communication means are used to bridge the "natural" gap that exists. The methods and techniques of its implementation considerably vary depending on the period and the level of technology in perspective.

The "Internet-based Distance Learning" model is part of the new and modern way of life that emphasizes the extensive use of the Internet not only for Education, but also for a variable width of social and consumer practices. Through the use of Information and Communication Technologies (ITC) and the Internet, the conceptual deconstruction of space and time is achieved, resulting in the immediate transfer of information and educational material [2]. In particular, Distance Learning has two sides, the physical and the temporal, which relate to the segregation between:

I) Teacher – trainee

II) Training with each other

III) Teaching and learning processes [3].

As Lionarakis has pointed out since 2001, Distance Education is based on three important axes, the trainer, the trainee and the educational material in contrast to the binary relationship between trainer and trainee that characterizes conventional education. The pedagogical characteristics of Distance Learning do not simply instruct students how to learn on their own but also how to function autonomously in an exploratory course for knowledge acquisition [4].

Based on the above principles, the trainee takes responsibility for his studies and acquires a more accountable role, while at the same time the teacher is called to take on the role of counselor and mediator, with the responsibility to motivate the trainees and organize the training programs ensuring maximum efficiency in the learning process [5].

Indeed, during this survey it was noticed that classes with large audiences recorded more consistent and frequent attendance, as limiting conditions connected with student mobility, availability and amphitheater capacity were annihilated.

1.2. Information and Communication Technologies (ICTs)

Technological tools are *en masse* used in education because they help and support learning, while providing students with opportunities to gain faster new knowledge and learning experiences. In order to be able to properly support educational activities, the deployed technological tools should incorporate various teaching strategies, allowing the student to explore and interact, and be as interdisciplinary as possible.

ICTs are defined as the forms of technology used for the purpose of transporting, processing, storing, creating, presenting, sharing or exchanging information through electronic media [9]. More specifically, the ICTs agenda refers to the use of computers for delivering individual functions through software, usually with the extensive use of Internet or similar resources. Also, the conceptual merit of this agenda is directly related with how successfully machinery, software and equipment are incorporated into the educational process.

ICTs essentially correspond to a subset of media such as New Media, Telecommunications and mainly Multimedia. They may include media with data in the form of text, image and sound combining in parallel synchronous and asynchronous communication and information technologies such as video conferencing, forums, e-mail, blogs, computer software, radio, television, video, telephone satellite systems, portable and mobile gear, and many other devices that allow the interconnection and transmission of any amount of data in a very short time [6].

1.3. Synchronous and Asynchronous learning

Distance synchronous and asynchronous Learning should involve integrated teaching strategies.

Synchronous teaching, re-teaching and learning use communication technologies that require the direct connection and in real time transfer data. Users have the ability to interact with each other during scheduled educational activities. It is usually done after planning the organized delivery of course lectures, focusing on learning through interaction and several times through collaboration. In this way, the teaching and dissemination of knowledge is facilitated and the necessary interaction for learning is supported. Usually in synchronous learning, teleconferencing platforms are operated, either commercial or open source. In the following sections some such tools used by AUTh will be analyzed [2].

Asynchronous is the teaching during which the student cooperates with the teacher at a different time from the delivery process of the course. That means that the creation of the instruction material was created by the teaching staff in previous time and the access to the learning material from students is scheduled through the Internet on specific platforms that are provided [7]. numbers.

2. MULTILINGUAL E-LEARNING IN THE AUTh

Since the beginning of the Covid-19 lockdown, in these extraordinary conditions, the appropriate measures were carried out immediately with the adjustment of administrative services to operating remotely, as possible, and the prompt acclimatization to e-Learning schemes from all the 45 AUTh departments. Educators and students were pushed to ardently work and study from their homes in asynchronous and synchronous electronic platforms. They would have access to information and content that is deployed in multimedia format and may amply interact by teleconferencing in virtual environments. Likewise, students could communicate with teachers and with other students or study on their own in certain platforms, at any place and time.

The technological challenges faced by the ATSSO in Distance Learning were many. Indicatively the most important ones will be pointed out.

One problem was the lack of significant technological skills on the part of both teachers and students. At the same time, many students and teachers could not create or attend the course as they faced network overload issues, especially those with very low bandwidth connections; some faced technical problems with their computers or even crackdowns. To tackle this problem and make it easier for professors and students, AUTh provided them with appropriate e-Learning platforms to refer to, through which the sessions would be recorded and then made available on demand.

Another problem was the copyright issue for the material used by the teaching staff (images and electronic files from books and the Internet) during the on-line lesson and particularly, what material would eventually meet the standards to be uploaded or not.

As libraries where not otherwise available, nor books could be easily delivered to students dispersed all the way throughout Greece and Cyprus, serving the needs for literally published compositions or otherwise intended learning resources, a wide range of electronic records, enriched with scholarly Academic works available over the Internet and video lessons was made available to the students.

In technical subjects it was prevalent to use widespread resources, like TED lectures, animations, or ordinary qualitative electronic learning assets that promoted greater understanding by enhancing neurocognitive appreciation over external sense impressions (Fig. 1).

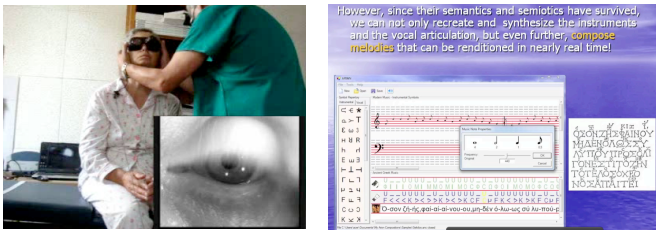

Figure 1. *Electronic resources in English, left, for clinical diagnoses (Dix-Hallpike test) in ENT Medicine, right, for Computer Music.*

Indeed, multimedia learning has endorsed an intensely enthusiastic two-way interaction between learners and the teaching staff, the path of success during the very difficult, in economic and psycho-sociological terms lockdown.

The success of the broadcasting series of learning resources has created euphoria for a transition to more energetic trajectories, in tertiary education instruction, for mass media like productions.

New channels of communication seem to be opening to road ahead to enhanced remote communication between the involved parties. Since such a transformation needs considerable investments in equipment and communications, a temporary option was to designate the on-line course as a closed circuit one, addressed only by authorized students, which could not download the audiovisual material. Class registries and identification codes for access were set, restricting viewing to the pool of registered users for each course.

Nevertheless, this can in no way be a long term solution, since the Greek legislative corpus designates (for the provisions on the protection of intellectual property and related rights) that the material used and uploaded to the University platforms, and consequently on the Internet, should be either property of the instructing team or have the relevant permission from the producers of multimedia content accompanied by the appropriate referral texts.

2.1. Essential Online Tools for asynchronous teaching

For Distance Education, the IT center provided the educational community with alternative schemes for both synchronous and asynchronous teaching. The basic platforms for distance communication with students and for the organization of the educational process (educational material, quizzes, exercises, etc.) were the asynchronous Learning Management Systems (LMS) – Moodle and eClass.

The mission statement of these platforms is to enhance teaching through electronic planning. Moodle and e-Class are collaborative learning management platforms, which are based on free admission, i.e. are provided free of charge. In particular, these two platforms provide access to a personal website-like structure, where students can store their scholarly accomplishments; the same time, instructors access their teaching Learning Objects, instructional material and a variety of tools that support the planning and exchange of information (Figs. 2, 3).

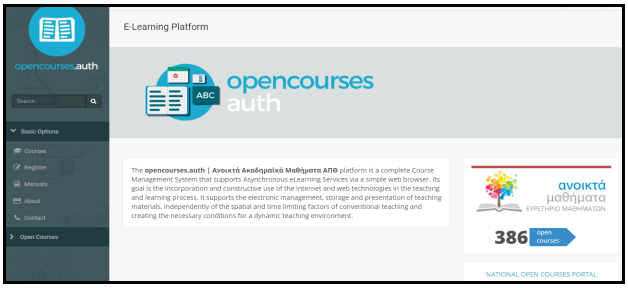

Figure 2. *Learning Management System - eClass*

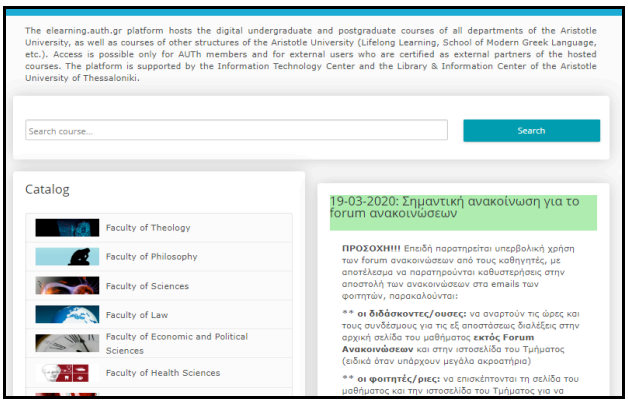

Figure 3. *Learning Management System - Moodle*

The key tool elements of these LMSs are:

- *Information exchange* with various tools such as announcement tables, electronic files, ready-made Learning Objects, multimedia files, agendas with datebooks, schedules and deadlines.
- *Collaboration and communication spaces* such as forums, chats, wikis, emails, blogs, and web conference apps.
- *Feedback space* handling questions, answers, directions, research papers.
- *Evaluations*, either formative or final, linked with assignment submissions and quizzes.

Another AUTh on premise LMS institutional platform is Open Delos, where teachers can record and broadcast the lesson remotely via live streaming or as processed video lessons (Fig. 3).

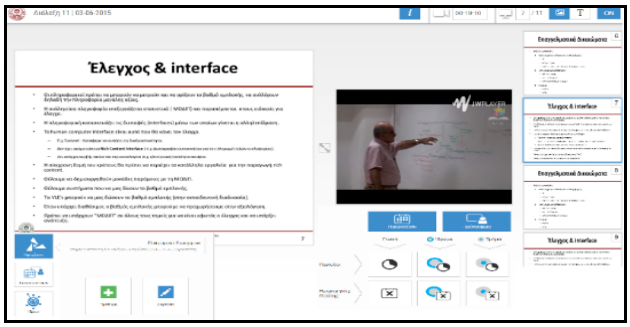

Figure 3. *Teaching Experience with video conferencing tool Open Delos.*

Some 25% of the teaching material on Open Delos is in English, an asset for providing instruction to some 1,000 Erasmus students in AUTh per annum.

In periods of high demand, they may edit the video of the course online and make it available directly on the Internet for their students. Recording and live streaming can be done either from static IP cameras installed in 55 amphitheaters of the University campus or through each users' personal computers and recording paraphernalia.

The management and regulation of this process is done by the lecturers themselves without the need for any additional external technical support. The platform also provides modern features, such as the ability to sync videos with presentation files (Fig. 3). At the same time, it is important that the learning facility does not allow students to download the video sessions and use it in any other way, thus ensuring the copyright of the author. Finally, it uses an "HTML5 video playback" module that runs on almost any operating system, browser or multimedia player.

3. THE NEWCOMERS: ESSENTIAL ONLINE TOOLS FOR SYNCHRONOUS TEACHING

The basic interactive online tools for asynchronous teaching at AUTh are its teleconferencing systems. The main advantage of web conferencing is that it eliminates potential geographical constraints and increases learning opportunities, as it is possible to conduct educational online meetings with a large number of participants, without the need for a class or assembly to flock at a particular point.

The main disadvantages of videoconferencing practices of this kind are related to the use of specialized equipment. Each user should be provided with the necessary equipment such as a headset, quality camera and a high-speed network connection. In addition, the total number of participants depends on the available Internet resources and the computing power of the videoconferencing server. Trainees should also have basic skills in the use of ICT techs and

gadgets. Specifically, ITC provides AUTh lecturers a set of Distance Learning Scenarios that best suit each lesson according to the number of students attending the course.

I. For small audiences up to 100 people, IT supports the on-premise Big Blue Button (BBB) service.

II. For medium audiences, from 100 to 250 people, ITC provides licensed Skype for Business, Google Meet and Microsoft Teams clients.

III. For large audiences ranging from 250 to 500 people, ITC provides the Zoom & WebEx platforms with the corresponding number of user licenses.

The reason behind ITC providing a bunch of alternative platforms for modern telecommunications was the high load and high demand for the use of teleconferencing systems worldwide this period. This stipulation posed the risk of overloading datacenters and consequently collapsing the teleconference systems or preventing them from operating as prescribed at scheduled times. For the effective support of each scenario, the IT center recommended the use of appropriate web conference tools and provided instructions for their use, offering the same time more than one alternate solutions. Indicatively, basic collaboration platforms will be presented; they were used quite successfully in most cases.

3.1. Big Blue Button (on premise) up to 100 users in a session

As of 16/12/2019, the IT center has adopted the new upgraded BigBlueButton 2.2 teleconferencing platform, which is supported through the ITC web conferencing service. The BBB is a reliable, open source web-conferencing system, specifically focused on Distance Learning. It allows remote users to enjoy high quality online services similar to or better than several commercial packages. BBB is being developed dynamically through collaboration with large communities of volunteer developers interested in promoting BBB as an open source gateway. The BBB project plans to eliminate Flash permanently by the end of 2020 so that pure HTML5 may be used instead. BBB has developed an HTML-Client videoconferencing program to work on desktop, portable and the very trendy recently mobile devices, thus providing users with high-quality online learning experiences regardless of their device (Fig. 4).

So far, the BBB comes in two versions, 1 and 2. The latest stable version used was BigBlueButton 2.2. It is based on HTML5 clients that eliminate problems with browsers that no longer support flash player, screen sharing, and portability, regardless of their size and functionality. The BBB program is written in ActionScript and the server components are written in combination with Java, Grails, and Scala. Many developers have devoted their time and experience to developing it, and the source code is hosted on GitHub so that everyone can contribute, by written agreement, to the code. In addition, an API has been developed that enables the BBB to integrate and collaborate with various open source and Learning Management System platforms, such as Moodle, Sakai, WordPress, Joomla, Drupal, etc. [10].

The user interface is consistent and consequent, allowing its users to understand effortlessly how all functions work. As seen in Fig. 5, GreenLight is the preferred BBB front-end web-based interface. It provides users with virtual rooms for videoconferencing, the ability to record videoconferencing in custom pedagogical scenarios with high security.

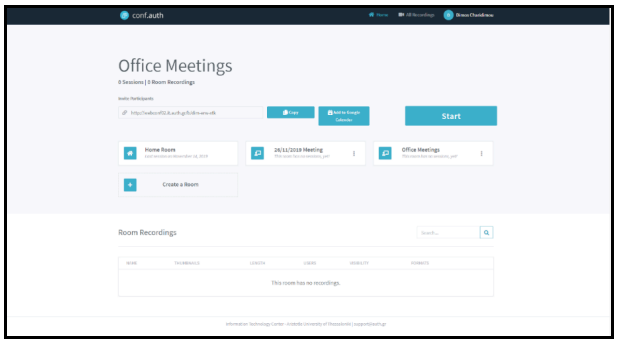

Figure 4. *BBB Interface*

Maximizing the interaction between students and teachers in different communication rooms, which can support synchronous and asynchronous communication and facilitate collaboration and knowledge acquisition, are some of its "value added" characteristics.

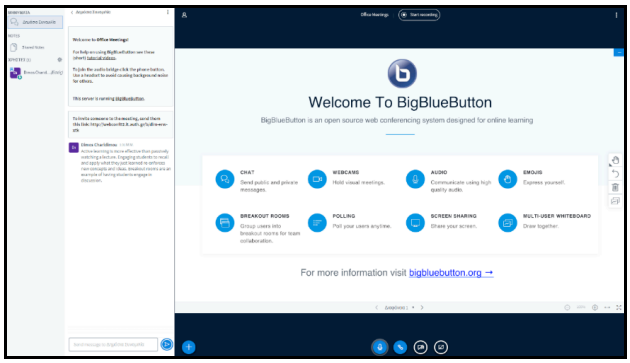

Figure 5. *BBB front-end*

The new BBB also provides enough functionality and features for users to have positive user experiences. In particular, BBB release 2.2 has the following amenities to successfully support collaborative activities:

- Two-way audio and video conferencing, up to 100 participants

- Participation in public / private conversation mode between users
- Ability to present PowerPoint slides
- Application / desktop sharing
- Interactive whiteboard
- Shared notes, capabilities for downloading slides and presentations
- Hand raising function including emoticons (expressing emotions)
- Group chat via text messaging
- Instructor control and management (setting up permissions to users for presentation and sharing, conversation restriction, etc.)
- Responsive and mobile friendly clients
- Easy navigation and accessibility (for people with disabilities).

The disadvantages of using BBB are:

- The small number of users per conference call
- Does not by itself provide Participation Meters and Statistics

In addition, the new BigBlueButton interface has been successfully integrated and is fully functional on the AUTh e-learning platform. BBB in Moodle gives these additional possibilities, so instructors may:

- Incorporate virtual lessons and provide on-line education to their students
- Provide access only to the enrolled students of the virtual class
- Create multi-activity links for online seminars in any course
- Exclude students from entering the virtual room until a moderator monitors the on-line session
- Start BigBlueButton in a separate window
- Create a customized welcome messages that appears at the top of the chat window when users enter a session
- Determine the open / closed connection dates for the session, which appear in the Moodle calendar
- Record access and manage lectures

3.2. Big Blue Button (on premise) up to 100 users in a session

As Zoom facilitates scheduling and participating in high definition (Full HD, 1080p/30fps) video conferences, subject to the users' connection and equipment capabilities. Supported devices and operating systems include iPhone/iPad, Android, Blackberry, MS Windows, Mac OS and various Linux distributions, as well as dedicated video conference terminals (H.323). Each video conference may have a maximum duration of 12 hours and can host up to 500 participants. Participants can share their screens or specific program windows, as well as interact with a whiteboard.

Advantages and disadvantages: AUTh has many times used the Zoom service for official board meetings with 300 users in a single video conferencing room and found it to be generally adequate, reliable and easy to use. It is, however, limited in features useful for classroom video conference scenarios, such as instructor control/management, lesson material sharing, participation meters/statistics and real-time tests/grading. Recently, some security vulnerabilities have been identified, as it transcended the practice of uninvited users intruding into the teleconference room.

3.3. Cisco WebEx – on cloud & commercial up to 1000 users in a session

Cisco Webex Meetings Server is a virtualized, software-based solution that runs on Cisco unified computing system servers and VMware. It uses virtual appliance technology for rapid turn-up of services to end-users. CISCO Webex provides users with the ability to streamline asynchronous video and/or audio communication, as well as display slide presentations to all participants. It offers chatting, collaboration, interactivity, PC screen sharing, presentations, videos, web browsing and more (Fig. 6).

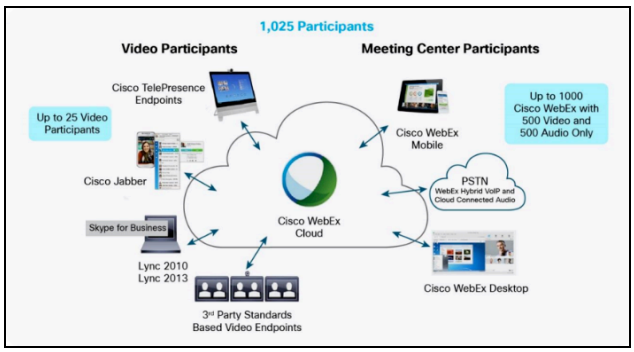

Figure 6. *WebEx Cloud [8]*

At the same time, it offers written communication capabilities for either public or personal conversation. The virtual room of the CISCO WebEx is defined in any case via the web in the "cloud".

The advantages one may endure with the WebEx solutions platform are:

- Audio/Video/Sharing
- Up to 1000 participants
- Windows, Mac, and Linux compatibility
- SIP/H323/S4B (Skype for Business) browser
- Reporting analytics
- High-quality integrated services

- Good online training and user guides
- Ease of use
- The meeting host can record the session at any time
- Rich feature set like scheduling, pairing with clients, voice assistants and many more are offered via cloud.

The disadvantages of using WebEx are:

- Recording files are larger
- Mobile access to WebEx meetings is unavailable

4. INTERNET TRAFFIC DUE TO "STAYING HOME"

All the above services tools and scripts to work must use the Internet. Yet, AUTh has faced unprecedented situations and conditions, resulting in nothing working the same as before. Internet speeds have already been greatly reduced as user requirements and needs are constantly increasing. This is also evident from the data through the country's licensed national infrastructure and in particular Greek Internet Exchange (GR-IX), and it shows how much the Greek Internet traffic has increased due to "staying home" (Fig. 7).

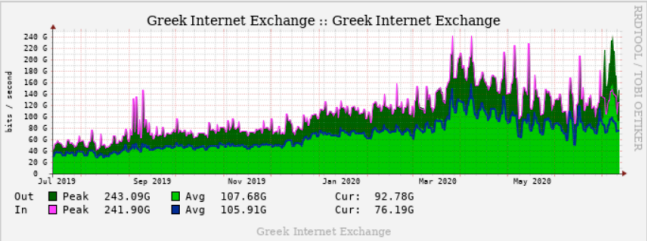

Figure 7. *Internet traffic for 2109-2020 in Greece (https://mon.grnet.gr)*

This considerable increase seems to be the most restricting factor, in quantitative terms, for the sufficient exploitation of digital schooling during the crucial examination period of June 2020, in compliance with the "staying home" initiatives for national education.

On a global level, Greece ranks 40th in terms of Internet connectivity, as seen in Fig. 8. According to the Economist Intelligence Unit, 2020 survey, Greece is among the weakest European performers in the index, ranking 22nd out of 24 European countries. The overall Index score of the Inclusive Internet Index 2020 is based on the scores of the below characteristics:

- Availability,
- Affordability,
- Relevance, and
- Readiness categories.

As stated by the Inclusive Internet Index 2020 among the areas in greatest need of improvement in Greece are relevance (particularly of local content), trust-safety, and e-inclusion policy [15].

The Fig. 8 chart overall specifies country-rank position in numerically ordered series in the pre-5G era. While otherwise this would not be a very user specific index, as it does not indicate the quality of Internet services within a tertiary institution's enclave, during the Covid-19 lockdown University students where dispersed at their parental homes over the country, to attend lectures remote; thus this otherwise not very proportionally formed series of data serves as an capable of giving the essence indicator until more user - centric measurements are released in Academia.

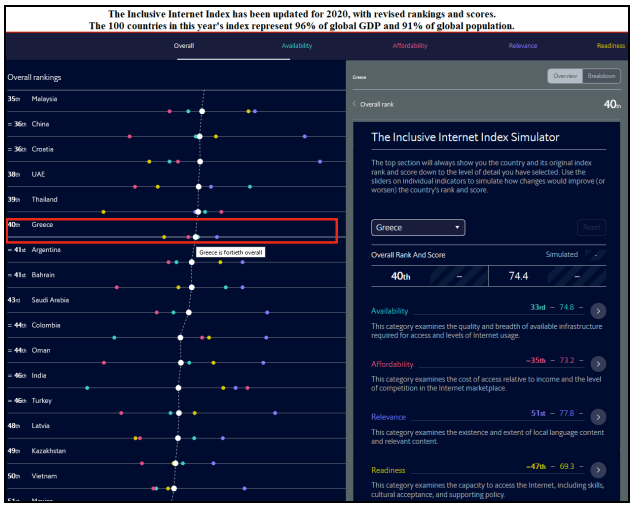

Figure 8. *The Inclusive Internet Index, 2020.*

Not withstanding the statistics of Fig. 8, which rely on the intention of national authorities to mesmerize the attention of the world by transfixed data, for the essence of Academic strategies the Internet and new technologies have become the most critical elements necessary for the organization of education. These elements are not only the backbone of education and learning, but they are also critical sectors for communication, work, entertainment, marketing, research development, etc.

Consequently, it remains unclear at the moment how the Internet traffic is used by students. Therefore, it is very important at a later stage to consider in what way and where interaction is oriented to Greek so to determine entirely the exclusively learning and educational Internet traffic.

5. PUZZLING OUT THE BIG PICTURE

Amidst the Covid-19 pandemic that was hard hitting infrastructure around the world, the immediacy of information dissemination was very critical. The effective adaptation of the Administration and the faculties to the emergency

operating conditions had been implemented in a very short time in AUTh, i.e. within a week. AUTh was in an advantageous position to achieve Distance Education as AATSO already had a lot of experience and know-how in this new way of working and teaching.

Although e-Learning culture is commonplace in other countries, in Greece the relevant experience was rather limited. Each University, due to its self-governing nature, was using its own Distance Learning methods. Distance Education is not merely a matter of posting synchronous lectures or video lessons over the Internet. E-Learning should incorporate good pedagogical practices and approaches such as interaction, communication, dialogue, autonomy, feedback, structure.

The integration of ICTs in the learning process and in teaching in general, often does not bring the expected results and may lead to confusing situations. However, the shift from traditional to digital classrooms is currently a one-way road ahead. Due to the compulsory adaptation of the educational process to the requirements of this new reality, there is an urgent need to place ICTs in all stages of the education system and at the same time to train teachers fast track on how new technologies may adequately meet the new requirements.

A very beneficial activity has to do with the production of educational audiovisual material, usually in English, originating from the Balkan countries (Fig. 9).

Figure 9. *Prof. V. Aleksić acting as invited lecturer under the Erasmus+ exchange scheme at the School of Informatics, Aristotle University of Thessaloniki.*

As these enclaves bear a cultural tradition that retains clues from common historic, linguistic and intellectual manifestations, it holds attitudes and behavior unique to scholarly achievements for the cultivation of a common culture.

Technological leaps have been indeed tracked during this research, as most parties involved exceeded themselves. During this crisis, it was essential to gain basic knowledge on these technologies in an environment which supported well-received pedagogical practices, instead of superficially improvising. This way, a University may turn the challenge into an opportunity, and perhaps, this legacy will be the biggest investment for the future of education.

Already, some notable steps ahead, in a bigger scale, that of national or governmental enclaves have been triggered.

As seen in Fig. 10, Digital Academies have been initiated, taking on the vast open-source learning material created by autonomous Institutes. By building upon these learning blocks expansive Academic structures, in pursuit of scholarly work and broader learning activities, the "go Digital" motto gets a wider perspective.

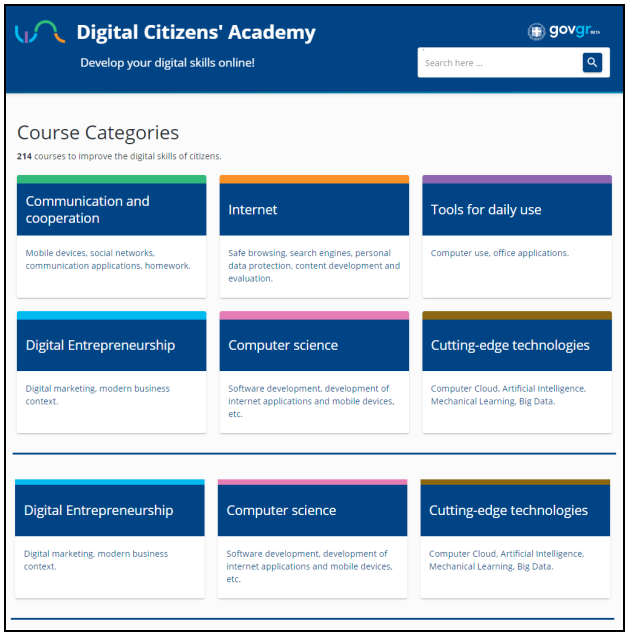

Figure 10. *From hundreds to tens of thousands: the Greek National Digital Academy portal (http://nationaldigitalacademy.gov.gr).*

At first, these initiatives aim to offer digital dexterities to massive scale. However, not in English, but in the official language of the enclave, promoting skillfulness in performing tasks for the local workforce, which controls and finances the federal government - and in return receives ample feedback.

As such governmental measures, National Digital Academies have by default a broader mission statement, serving as hyper-ways within the knowledge society. Thus far, the highest form of teaching was offered by a University or a consortium of tertiary education and similar research Institutes. Whether a more general structure, beyond this scheme may come up, it is not very unlike to take place [11].

The seeds of this new culture may be traced in exchange schemes, like the Erasmus+ mobility

project (Fig. 10), or in terms of music entertainment in the Eurovision song contest. These fundraising projects, amongst other large scale scientific or educational arrangements [12], destined to promulgate mobility between researchers of associated countries, have managed to appease the ability to establish educative links between different levels in societal, working and research relationships [13].

They seem to be the forerunners of a new apprehension in Distance Education, allotting as a necessity in widespread suppressions of schooling practices [14]. Well prepared statistical data from educational practices under this pandemic are driving ahead the global culture since they come out of the most innovative and radical part of our society, the tertiary education pool. Better apprehension and application of model analyses, considering the representativeness of the samples, would better prepare the learning sector, in collaborative terms, for the next turning point crisis.

6. CONCLUSION

The application of new technologies in education and especially in Distance Learning offers new possibilities, as these new innovative tools provide rich communication and interaction. The AUTh IT center offered the educational community different technological options so that on a case-by-case basis, favorable learning conditions were offered.

However, this case study has limitations, which require further research so to reach a safe conclusion about which technologies can be effective in times of crises. The pandemic brought to the foreground the least guided educational methods of teaching, which, although very popular, are not considered by themselves effective approaches. In other words, to be constructive they should get related to some learning theory and good pedagogical practices, yielding thus substantial learning outcomes.

Therefore, it would be interesting through further research to explore and take into account not only the collaborative platforms, but also the teaching methods assorted with these technologies. Thereby, instructors may understand how to facilitate learning and how to receive successful outcomes via accreditation and certified experiental learning practices.

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Original paper
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A Rubric-Based Evaluation of Video Conferencing Services for Educational Use

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Abstract: *The COVID-19 pandemic has brought about rapid changes in the educational process in all countries where extreme measures, such as lockdown, were applied. Almost all levels of education have turned to synchronous teaching, using various video conferencing services. This study will attempt to evaluate specific applications with the assistance of appropriate methodology based on rubrics and the SUS questionnaire for interactive systems. A comparative evaluation of 5 popular video conferencing tools (Big Blue Button, Google Meet, Skype for Business, WebEx, Zoom) was attempted based on a methodological approach with usability and functionality criteria. A rubric was generated to assist the authors in assessing the selected five video conferencing tools. The research took place in May 2020. The sample of the survey included 73 adults (teachers at all levels of education) that used those video conferencing services. The aim of this study is to highlight teachers' views and needs from tools supporting synchronous education in order to improve the online learning process at all levels of education.*

Keywords: *video conferencing tools; COVID-19; rubric; usability; SUS; synchronous education; distance learning*

1. INTRODUCTION

The pandemic of COVID-19 brought rapid changes in many aspects of everyday life. Especially in the field of education, there has been a shift towards completely online courses, thus radically changing the educational systems worldwide. The goal of using new technologies and methods at all levels of education is to enrich the online environments and lead to an increase in student engagement, retention, and student – teacher collaboration.

From the COVID-19 pandemic that forced schools to transition completely to online learning, it has become apparent that educational institutions must learn to adapt in order to provide students with the education they need to succeed. However, responses by higher education providers have been diverse worldwide, from having no response through to social isolation strategies on campus and rapid curriculum redevelopment for fully online offerings [1]. Several studies have begun to appear in international literature to highlight the transition to online education, e.g. [2] [3] [4].

It is said that in difficult situations there is always a benefit. The pandemic seems to confirm this saying in the field of education in the case of Greece. For their students to stop remaining inactive, teachers have surprisingly embraced distance education, both synchronous and asynchronous, mobilizing their students creatively - to the extent that distance education has allowed.

2. THE TRANSITION TO DISTANCE LEARNING

The field of education was perhaps one of the few areas that made a direct transition to its distance equivalent. The reason is that the tools and methods were already widely available. However, in the period before the COVID-19 pandemic, the purely online model was not preferred by many educational organizations, as face to face education (when feasible) has advantages that seem to prevail over the online version: interaction among students and a teacher, interaction between classmates, immediate feedback, increased reinforcement efficiency, etc. [5] [6] .

2.1. The Case of Greece

On March 10, 2020, the Greek government abruptly announced the closure of all educational units (private and public) at all levels, from nurseries to universities, for precautionary reasons for 14 days. On May 11, 2020, the schools reopened for the students of the 3rd level of Lyceum, while a week later (18/5/2020) all the children who attend secondary schools / high schools of the country (14+ years old) were able to return to the educational structures. On June 1, 2020, all educational structures reopened for all

students (of all levels). Of course, in each relaunched educational structure new safety rules are set (distances between trainees, separation of classes with a maximum of 15 students per class, different days and hours of attendance, cleaning protocols, etc.).

In the intervening period, software tools for distance education were gradually employed at every level, resulting in the consistent completion of the academic season. More specifically, higher education almost in its entirety (with the help of technological schools and IT departments) adapted directly within two weeks from the lockdown, continuing courses to large audiences with several tools for synchronous learning (where possible, e.g. at least in all theoretical courses). The video-conferencing services that were used by most of institutions are discussed and evaluated in the next sections of this paper. Besides, asynchronous teaching platforms (e.g. Moodle or similar software) were already widely used in almost all university courses in the country.

Concerning primary and secondary education, asynchronous teaching (which was not widely used until then at these levels) was immediately used, and later synchronous teaching methods and tools were gradually integrated, starting with secondary school students. Most primary school students used video conferencing services for synchronous teaching after the Orthodox Easter holidays, i.e. in May 2020, for a few hours a week (maximum 3 meetings of 1 hour per week). The frequency of online lessons, as well as the time of integration of each class in the process of synchronous learning was largely due to the readiness and familiarity of each teacher with modern technologies (beyond technical and educational reasons). The tool chosen for synchronous teaching in public primary and secondary education was Cisco WebEx.

By analogy, similar technologies were used during the same period in the country's private educational structures (private schools, secondary schools, foreign language centers, etc.). A great variety of software tools for synchronous and asynchronous learning were used in these structures, as well.

2.2. Massive and Rapid Adaptation

The way of the transition to the purely online model (even from the other end - the traditional model) [7] and adaptation of students and teachers at all levels are surprising. The transition to distance learning had two notable features: it was (a) *massive* (it took place at all levels of education in both the public and private sectors) and (b) *rapid* (the adaptation was immediate by the teachers, the students and their parents). What should be noted here is that before this unprecedented need, a negligible percentage of trainees (or parents in the case of underage students) did not have either the necessary technical knowledge or the will to support online education or (in many cases) necessary technical equipment.

2.3. Tools for Distance Learning

Distance learning can be (a) **asynchronous**, or (b) **synchronous**. Each of these forms uses different tools and methodologies.

Asynchronous learning describes forms of education, instruction, and learning that do not occur in the same place or at the same time. *Asynchronous online teaching* is where teaching materials are posted online, and learners work through them in their own time, communicating with each other and the teacher via discussion boards, forums, or email. Asynchronous learning is mostly supported by e-class platforms and learning management systems (LMS), such as Moodle (moodle.org). *Synchronous* learning is mostly supported by video conferencing tools, like the ones that are included in this study. Synchronous learning is discussed in the next section.

2.4. Challenges

No change is made without problems and challenges. In the case of Greece, there were several issues that need to be addressed in order to fully support online education. In addition to the lack of the necessary equipment from the various parties involved in the educational process, in some cases, two serious challenges arose from the transition: (a) the use of video camera for live streaming of the lesson from the school classroom, and (b) the examination process in higher education.

Regarding the live broadcast of the lesson that takes place in the classroom to the students who are absent (live streaming), there are many questions regarding the exposure (and / or recording) of students and teachers.

Regarding the university examination process, the main problem is the integrity of the process and there are challenges regarding the method used (oral exam, project elaboration, online quiz, or any combination), the identification of the students and supervision (also here issues concern privacy because of the need for camera and microphone use).

3. VIDEO CONFERENCING TOOLS FOR SYNCHRONOUS LEARNING

Synchronous teaching (and learning) requires the simultaneous participation of all students and instructors. The interaction between instructor and students takes place in real time, during which they can exchange opinions, as well as educational material. Simultaneous engagement can be achieved either by being in the same space (class, etc.) or by being interconnected via a network that allows audio and / or video conferencing.

An environment for synchronous education must be able to support the following:

- sending invitations to new students in order to attend classes through the virtual classroom
- monitoring of the working environment that the teacher has properly formed
- integration of texts, presentations and files
- attending discussions in the virtual classroom, and real-time conversation between students and the teacher.

There are several platforms available for synchronous communication of many users through video conferencing. Next, we will focus on the applications that were included in this research and were widely used for distance learning during the lockdown period in Greece.

3.1. Big Blue Button

Big Blue Button (bigbluebutton.org) is an open-source software that supports all forms of videoconferencing, screen sharing, desktop and file sharing, session recording etc., thus making it suitable for synchronous education and cooperative learning. It is an online application, with the current version being in HTML5 (while the previous one required flash support). This allows proper function on all computers, smart devices, tablets and mobile phones. It can also be installed as a plugin in learning management systems, such as Moodle, thus combining asynchronous and synchronous teaching.

3.2. Google Meet

Google Meet (meet.google.com) is a video-communication service developed by Google. It is one of two apps that constitute the new version of Google Hangouts, the other being Google Chat. It's essentially a useful and cost-effective platform for small businesses, as well as enterprise customers. It has a very light, fast interface that enables easy management of up to 250-person meetings.

The video-conferencing service serves about 100 million users every day, including G Suite enterprise and corporate clients, although Google has made Meet available to all Google account holders since April 2020, causing speculation about whether the consumer version of Google Meet would accelerate the deprecation of Google Hangouts.

3.3. Skype for Business

Skype for Business (skype.com) allows video conferencing between users in different geographical areas. The Skype for Business app will gradually be replaced by the Teams app, which is available in the same terms and similar environment, but with increased collaboration and multi-file sharing capabilities, as well as features of information management between teams within the same organization.

3.4. CISCO WebEx

CISCO WebEx (webex.com) is an online video conferencing service for up to 100 participants that offers users web conferencing capabilities with high quality video. The users of WebEx can fully collaborate remotely, increasing their productivity and reducing the cost of face-to-face meetings. It supports voice communication between users, as well as file sharing with partners without requiring complex settings and configuration.

3.5. Zoom

Zoom (zoom.us) is a commercial platform that allows multiple people to collaborate simultaneously, even creating webinars and conferences. The service has several features, e.g. user interface sharing, events creation via personal id and files and presentations sharing. The free version supports video conferencing of up to 100 users for up to 40 minutes. In the commercial "full" version, the creator of the events must own the purchased version of the tool, while the attendees can watch by installing the free version.

4. METHODOLOGY

4.1. The Neurocognitive approach

Teaching offered by University Institutions is not a simple or ordinary knowledge acquisition experience. Instructors develop reflective expertise in providing resources, descriptive metadata and explaining in depth collections of data that reside in huge local repositories, like libraries or research acquisitions.

Therefore, when the learning experience is transferred to the web sphere, the participants become aware of information that comes either from the learning resources or from observation of the complex rubric that biases the outcomes of the Interaction.

In other words, teaching with Zoom or similar paraphernalia is not a mere session for remotely working together, but for developing a culture of transgression in Academia.

As seen in Fig. 1, the goal of tele-education is to achieve high levels of Interaction. Indeed, highly proactive neurological therapeutic sessions, like Remote Fitting for Cochlear Implant users, or Play Audiometry sessions with young children, with or without hearing aids, and operative speech therapy over the Internet serve as road runners for the development of a culture for neurologically advanced training [8].

Figure 1. *Neurocognitively enhanced remote sessions of clinical operations with actual patients.*

This survey, even further postulates how e-Learning with such characteristics from small groups of interest may promulgate its characteristics to direct, on-line streaming services at national levels.

4.2. The Rubric

An approach for evaluating software is based on the use of Rubrics, that is, tables that contain characteristic criteria that are graded on a 3-level scale. The Rubric in this paper is based on 13 criteria in order to evaluate video conferencing technologies in a holistic high-level way and is based on the Rubrics designed in [9] and [10] for data visualization technologies and systems supporting data journalism. The criteria are divided into two categories with functional and usability features (as shown in detail in Table 1). The score ranges from 0 to 3 with 0 meaning poor, 1 modest, 2 good and 3 excellent.

The Rubric used in this research is a modified version of the one used in [10], specially adapted to the features of video conferencing tools. The differences between the rubric used in this paper and the rubric used in [10] are as follows (some features have remained the same):

- Features 1,2,3,5 and 13 have changes in the descriptions of the scores (some of them are minor, e.g. feature 5). The name of the feature is the same.
- Features 6,7,8,10,11 and 12 have been modified (in both feature names and score descriptions) to reflect video conferencing software capabilities.

Features 2,6,7,8,9,10,11 and 12 can be largely graded quite objectively, so the score is put by the writers, after reviewing the relative documentation of each tool. Most of these features concern the functionality of the tools. The score for features 1,3,4,5 and 13 results from the average scoring on a survey that was designed for the research. Note that these five features are *usability* features. The survey and the participants are presented in the next sections.

4.3. The Survey

For the purpose of this research, a questionnaire has been designed and distributed to the participants in the form of an online survey. The questionnaire is aimed at teachers who used a Video Conferencing tool (Big Blue Button, Google Meet, Skype for Business, WebEx or Zoom) for the purpose of synchronous teaching in their classes due to the dispersion of COVID-19. The questionnaire is anonymous, consisting of 20 questions that are divided into three parts: (a)

Table 1. *Modified evaluation criteria (Rubric)*

No	Category	Feature	Poor (0)	Medium (1)	Good (2)	Excellent (3)
1	**Usability**	**Ability to handle**	There is no control over communication.	Minor handling (control / modification of one or two elements).	Partial handling capability (modification of many items but with limitations).	Full control of all aspects / features of communication.
2	**Usability**	**Support materials**	There is no documentation.	Insufficient documentation with little information about key features.	Almost sufficient documentation. It leaves out some features.	Well documented. Available technical support (online chat, troubleshooting, videos, webinars, etc.).
3	**Usability**	**Ease of use**	Graphics are not labeled, and the available functions are not visible. Fonts are difficult to read, and navigation is poor. It is necessary for the user to have a cognitive background (i.e. the tool is not easily accessible to all users).	There are some available tags. The use of the tool's capabilities is not clear.	There are many available tags. The use of the tool's capabilities is clear, and navigation is simple.	The graphics are properly marked, the available functions are visible, and the fonts are legible. Using the application does not require extensive knowledge.
4	**Usability**	**Learning time**	It takes a long time (>5 hours).	It requires a moderate time (1 hour – 5 hours)	It takes less than 1 hour (from 10 minutes to 1 hour)	It requires a minimum of time (totally intuitive or less than 10 minutes)
5	**Usability**	**Making use of previous knowledge**	Previous experience with other software or previous versions required.	Previous experience with other software or previous versions is recommended. Quite intuitive.	It requires little experience with other video conferencing platforms or previous versions.	No previous experience is required. Totally intuitive.
6	**Functionality**	**File sharing**	It does not support file sharing.	It only accepts small files (e.g. <5 MB)	It can accept files of limited size.	It can upload/download files of any size for sharing.
7	**Functionality**	**Subscription requirements**	Subscription is required for all functions.	Subscription is required for most functions.	Subscription is required for some specialized functions, but access is possible for routine functions.	No subscription is required for full functions.
8	**Functionality**	**Support of large groups of students**	It can support 2-10 users.	It can support 11-50 users.	It can support 51-150 users.	It can support over 150 users.
9	**Functionality**	**Cost for "full" version**	High cost (over $ 100 / year)	Medium cost (between $ 100 - $ 20 / year)	Low cost (below $20 / year)	Totally free
10	**Usability**	**Screen sharing**	No screen sharing supported.	Only one option available (e.g. full screen).	Many functions available	Complete range of available screen sharing options.
11	**Functionality**	**Scheduling**	No scheduling options supported.	Supported only with the use of outside scheduling or calendar software	The ability to schedule meetings comes only in-app.	The ability to schedule meetings comes both in-app and with the use of outside scheduling or calendar software
12	**Functionality**	**Supported devices and software**	It supports only one type of device, browser and / or operating system.	It supports limited specific types of devices, browsers and / or operating systems.	It supports most types of devices, browsers and / or operating systems.	It supports all types of devices, browsers and / or operating systems.
13	**Usability**	**Aesthetics**	Minimalist style, few options, limited color palette, limited fonts…	Minimalist style, but some flexibility, more screen layout types or style options.	Various style options and screen layout types.	Many style options available, such as color, font, screen layout type, etc. Impressive interface elements.

demographics, (b) rubric questions, (c) SUS questions.

The first part of the questionnaire is presented in the next section to outline the participants' profile in respect to the use of video conferencing services as teachers.

The second part of the questionnaire contains five questions concerning usability features, namely the criteria 1,3,4,5 and 13 of Table I (as mentioned in the previous section). The participants were asked to rate these certain criteria by choosing the most suitable answer according to their experience with the video-conferencing tool they used. Replies were afterwards matched to a rating on a Likert scale from 0 to 3, according to the meaning presented in Table I.

The third (and last) part of the questionnaire contains the ten questions of the System Usability Scale (SUS) questionnaire. SUS is considered one of the most effective questionnaires in terms of *validity* and *reliability* of the results produced [11] [12]. In recent years, through extensive testing and validation, there has been a growing popularity of the SUS questionnaire for the following reasons:

- It' s free of charge
- Its validity has been established in a series of studies in both conventional software and websites, as well as other devices such as mobile phones, etc.
- It produces the same or more reliable results compared to other questionnaires even with a small number of participants [11].

4.4. The Participants

The sample included 73 adults. All of them used at least one of the video conferencing services presented above to teach their classes due to the dispersion of Covid-19. Only teachers of several educational levels participated in the research and evaluated the tools they have used (not students). The participants were of several age groups: 15 of them (20.6%) were 22-34 years old, 33 of them (45.2%) were 35-50 years old, while the rest 25 of them (34.2%) were over 50 years old.

Most of the participants (67.1%) were teachers in higher education and used the tools for the needs of their university courses. Moreover, 11% of the participants were primary school teachers and 4.1% of them were teachers in the secondary education. Finally, a significant portion of the sample (17.8%) were foreign languages (FL) teachers.

Taking into account the distribution of the education levels of the participants, the size of their classes (that used the video conferencing tools for distance learning) was as expected: 14 teachers (19.2%) had very small groups (3-9 students), 21 teachers (28.8%) had small groups (10-29 students), 28 teachers (38.4%) had relatively big groups (30-79 students), 8 teachers (11%) had big groups (80-139 students), and 2 of them (2.7%) had very big groups (>140 students). It should be noted here that classes with over 30 students are observed only in tertiary education and constitute 52% of the sample. Also, very small groups (<9 students) are observed only in FL classes and (in three cases) in primary school classes.

5. RESULTS AND DISCUSSION

Fig. 2 shows the percentage of use for each video conferencing service by the participants for synchronous teaching due to the dispersion of COVID-19.

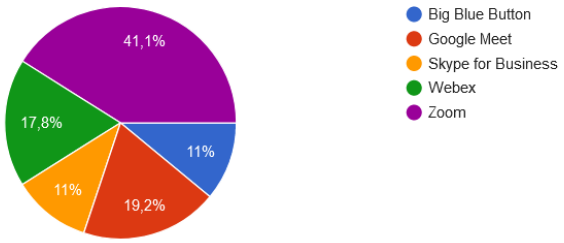

Figure 2. *Video conferencing tools used for synchronous teaching due to the dispersion of COVID-19.*

Certain abbreviations will be used for the results presentation and the rest of the discussion. For the tools, the following abbreviations will be used: *BBB, GM* and *SfB* to reference Big Blue Button, Google Meet and Skype[12 for Business respectively. WebEx and Zoom will be used as is.

There cannot be a direct linking between tools (Fig. 2) and grades of education, although there are some preferences. For example, GM, Zoom and BBB were widely used in universities and FL schools. Also, Webex was the main choice for teaching in primary and secondary public education. However, the general preference (41.1%) towards Zoom by the participants comes in agreement to our general sense of use "superiority" for the tool (from quality research, discussions etc.).

Only 7 out of the 73 participants had used this certain tool for distance learning in the past: 4 teachers had used Zoom before, 2 teachers had used SfB, while 1 teacher had used BBB (Fig. 3). Also, only 20 out of the 73 participants (27.4% of the sample) had experience with any video conferencing tool before the spread of Covid-19 (Fig. 4). Interestingly, although more than 70% of the sample had never used video conferencing tools before, they did respond quickly to distance education's requirements and even rated the tools quite high.

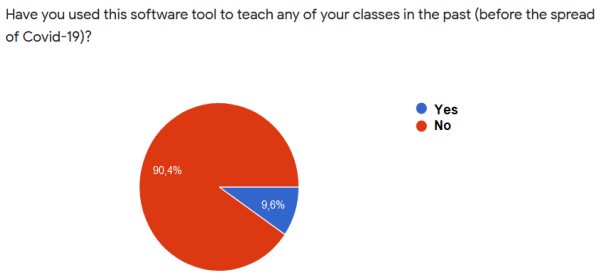

Figure 3. *Experience with the same video conferencing tool before the dispersion of COVID-19.*

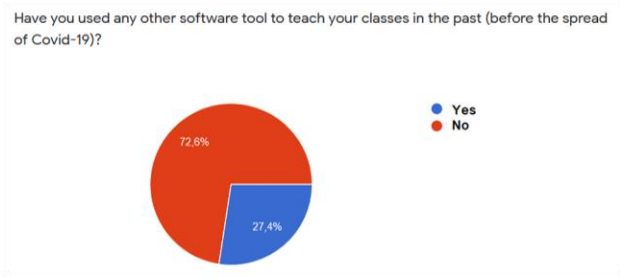

Figure 4. *Experience with any video conferencing tool before the dispersion of COVID-19.*

Summary Table 2 shows the average ratings of the participants' replies at the questions of the second part of the survey (they only concern usability evaluation criteria of the rubric). The rest of the comparative evaluation of the tools with the corresponding score that resulted after the authors' evaluation (according to info gathered from relevant research on the tools) is presented in Table 3.

Table 2. Average usability criteria

No	Feature	BBB	GM	SfB	WEBEX	ZOOM
1	*Ability to handle*	1,88	2,14	1,63	1,85	2,47
3	*Ease of use*	2,25	2,64	1,75	1,54	2,33
4	*Learning time*	1,88	2,50	1,88	1,31	2,07
5	*Making use of previous knowledge*	2,50	1,64	1,88	1,38	2,23
13	*Aesthetics*	1,00	1,86	1,25	1,38	2,00

Table 3. Rest of the evaluation criteria

No	Feature	BBB	GM	SfB	WEBEX	ZOOM
2	*Support materials*	2,50	2,50	3,00	3,00	2,50
6	*File sharing*	0,00	3,00	2,00	2,50	2,00
7	*Subscription requirements*	3,00	2,00	0,50	2,00	2,00
8	*Support of large groups of students*	1,50	3,00	3,00	2,50	3,00
9	*Cost for "full" version*	3,00	0,00	1,00	0,00	0,00
10	*Screen sharing*	3,00	2,00	2,50	3,00	3,00
11	*Scheduling*	1,00	2,50	1,50	2,50	3,00
12	*Supported devices and software*	2,00	2,00	3,00	2,50	3,00

Concerning our ratings in Table 3, there are some rankings that are mapped in between the explanations of the rubric (e.g. 1.50, 2.50, etc.). This was due to two reasons: (a) in some cases our experience was not totally accurate with the higher ranking, but it was higher than the lower ranking, or (b) sources were not clear or were controversial.

Fig. 5 shows the sum of all rubric's criteria for the 5 video conferencing tools, while the graph in Fig. 6 breaks down this sum in its two components: usability and functionality.

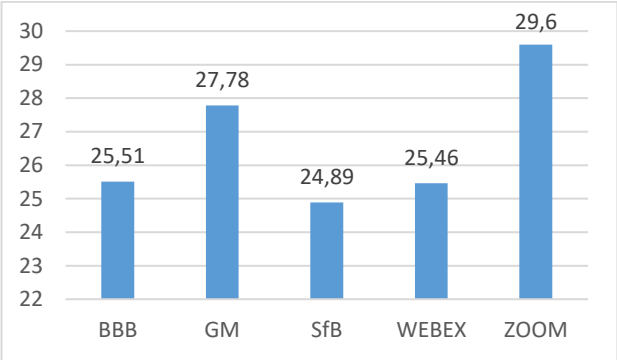

Figure 5. *Sum of all rubric's criteria for each video conferencing tool.*

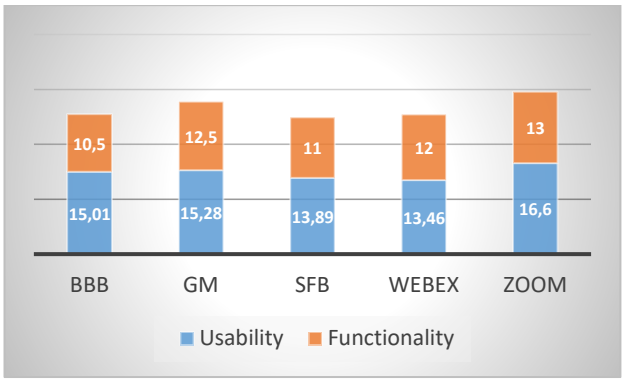

Figure 6. *Breakdown of the rubric's rankings in usability and functionality categories.*

It is obvious from the two graphs that Zoom has scored better than the other tools both in the total rubric as a whole and in its two component categories. Google Meet has the second highest ranking in total, which is also reflected in our functionality and usability rankings. The following graph shows the sum of the usability criteria only rated by the survey's participants (that is criteria no 1,3,4,5 and 13). As it can be seen in Figure 7, the participants' opinions on the second part of the questionnaire agree with the general usability rankings in Figure 6 (this is natural as the participants' ratings affect this ranking to a very large extent).

Table 4 shows the average ratings of the participants' replies at the questions of the third part of the survey. The reader can refer to relevant literature (e.g. [12]) for the complete list of the questions and the structure of the SUS questionnaire. In the results summary of SUS questionnaire for the five services under review is presented the average of normalized values (Ni =

X - 1 for questions 1,3,5,7,9 and N_i = 5-X for questions 2,4,6,8,10). As shown in Table 4, the average scores for all ten SUS questions for Zoom are ≥ 3 (≥75%)!

The result (final score) of each participant is calculated as follows:

$$FS(\%) = 2.5 * \sum_{i=1}^{10} N_i$$

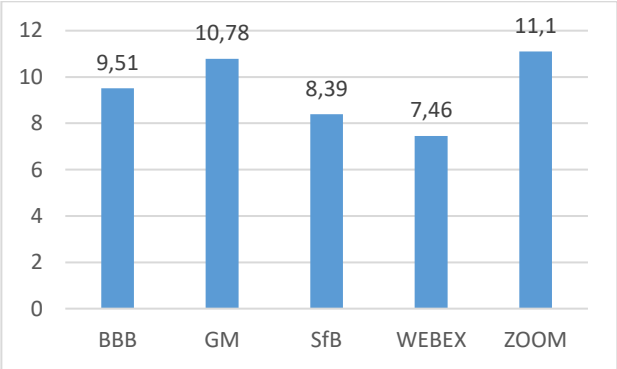

Figure 7. *Sum of usability criteria as evaluated by the participants.*

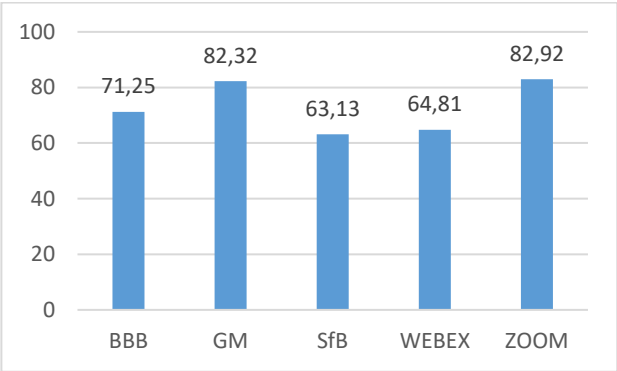

Figure 8. *Average scores in the SUS questionnaire for each video conferencing tool.*

Table 4. Summary of the SUS questionnaire

Question No	BBB	GM	SfB	WEBEX	ZOOM
1	2,25	2,93	1,63	2,00	3,17
2	3,38	3,64	2,75	2,92	3,47
3	2,75	3,71	2,88	2,54	3,10
4	1,88	3,29	3,00	2,85	3,37
5	2,50	2,57	2,63	2,46	3,20
6	3,00	3,50	2,13	3,00	3,53
7	3,13	3,50	3,00	2,46	3,17
8	3,50	3,64	2,38	2,77	3,53
9	3,00	2,93	2,25	2,00	3,00
10	3,13	3,21	2,63	2,92	3,63

The graph in Fig. 8 shows the average of the final score (percentage) from of the normalized user responses for each tool. Since the SUS questionnaire provides usability measurements, a comparison to the rubric's results (especially in usability criteria) is necessary. By comparing the rankings in Figures 6, 7 and 8, we can conclude that usability views on the tools are largely in agreement in both parts of the questionnaire. Only the ranking between Skype for Business and WebEx changes slightly. However, it is very interesting that the ranking order of the tools using the SUS questionnaire (Fig. 8) and the Rubric (Fig. 5) is the same!

Several statistical tests (in SPSS v.26) were conducted to reveal possible statistically significant findings. More particularly, ANalysis Of Variance – ANOVA [13] and (independent) t-tests were conducted between several variables. First, the role of the age group was examined in terms of the sample's ratings. Although it seems that for each age group the average response to the SUS questionnaire is relatively different (as seen in Fig. 9 older age groups gave a higher degree of usability to the tools they used), ANOVA analysis shows that there is no statistically significant finding at 0.05 level. The same is true for the Rubric usability criteria, which means that age does not affect how participants responded to the survey.

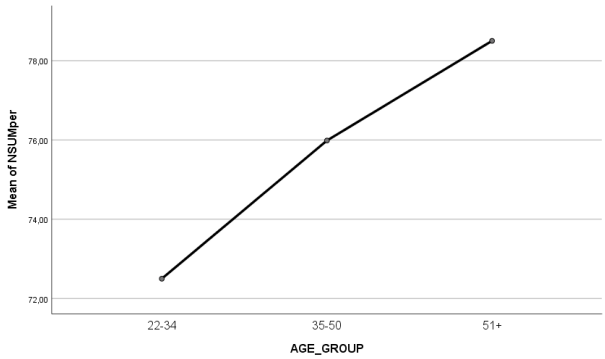

Figure 9. *Plot of mean SUS ratings in different age groups.*

An ANOVA test revealed a semantically significant finding concerning the education level to which each participant teaches (Table 5). Depending on the level of education, there were differences in how teachers perceived usability of videoconferencing tools. Combining descriptive and Post Hoc analysis statistics, we observe that **primary school teachers have rated the usability of the video conferencing tools that they have used statistically significantly <u>lower</u> (with 0.05 level of significance) than both teachers of higher education (p-value = 0 <0.05 and p-value = 0.001 <0.05 in the Rubric criteria and in the SUS questionnaire respectively) and the foreign languages (FL) teachers (p-value = 0 <0.022 and p-value = 0.049 <0.05 in the Rubric criteria and in the SUS questionnaire respectively).**

Similarly, another ANOVA test (Table 6) for comparing means of usability between teachers with different group size showed that: **teachers with large student groups (80-139 students) have rated the usability of the video**

conferencing tools that they have used statistically significantly <u>higher</u> in Rubric criteria (with 0.05 level of significance) as compared to teachers with very small classes (3-9 students) (p-value = 0.035 <0.05) and teachers with small classes (10-29 students) (p-value = 0.038 <0.05).

Table 5. ANOVA Post Hoc Tests (Comparing means of usability between education level groups)

Dependent Variable		(I) GRADE	(J) GRADE	Mean Difference (I-J)	Std. Error	Sig.
NSUMper	Bonferroni	Primary	Secondary	-12,81250	9,96650	1,000
			Higher	-22,65944*	5,61366	,001
			FL	-18,00481*	6,61523	,049
RUB_USER_SUM	Bonferroni	Primary	Secondary	-,91667	1,55308	1,000
			Higher	-4,12755*	,87478	,000
			FL	-3,09615*	1,03085	,022

Table 6. ANOVA Post Hoc Tests (Comparing means of Rubric usability criteria between group sizes)

Dependent Variable		(I) _GROUPS	(J) _GROUPS	Mean Difference (I-J)	Std. Error	Sig.
RUB_USER_SUM	Bonferroni	Big (80-139 persons)	Very small (3-9 students)	3,21429*	1,06620	,036
			Small (10-29 students)	3,00000*	,99950	,038
			Relatively Big (30-79 students)	1,10714	,96442	1,000
			Very big (Over 140 persons)	-,50000	1,90186	1,000

Concerning the experience of the participants with video conferencing services before the spread of COVID-19, independent t-tests showed that:

(i) there is no statistically significant difference (with 0.05 significance level) in the mean value of usability scores between participants who had used the same video conferencing tool in the past and those who used it for the first time because of quarantine.

(ii) there is no statistically significant difference (with 0.05 significance level) in the mean value of usability scores between participants who had used any video conferencing tool in the past and those who used a tool for the first time because of quarantine.

It should be noted, however, that the second observation is *marginally true* for the responses in the SUS questionnaire, since p-value is 0.056 (Table 7). Participants with experience in video-conferencing tools gave higher SUS ratings in the tools they used (mean=80.75%) than those with no experience in video-conferencing tools at all (mean=74.39%).

Table 7. Independent Samples t-Tests (Comparing means of SUS usability between experienced and inexperienced users)

Independent Samples Test		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
NSUMper	Equal variances assumed	8,957	,004	1,521	71	,133
	Equal variances not assumed			1,949	60,913	,056

6. CONCLUSION

Although the purpose of this study was not to have a "winner", it is obvious from the results that two of the popular video-conferencing services in our research (Zoom and Google Meet) were rated higher than the others. In fact, according to [14], a score of SUS greater than 81.2 implies ranking in the top 10% of the systems in the category under consideration. Interestingly, the participants rated these two services with such a high score (specifically Zoom with 82.92 and Google Meet with 82.32)! Big Blue Button followed both in Rubric's and SUS responses, which is interesting in terms of usability, as it is an open-source software.

In the context of the sample's ratings, it was found that there is a strong correlation (r = 0.682) between the answers given to Rubric's usability criteria and the answers given to the SUS questionnaire. The correlation is statistically significant at a significance level of 0.01, since p-value = 0. This observation methodologically enhances the reliability of the sample responses to the designed Rubric usability criteria.

Although Zoom was very popular and there was a common impression (mostly in informal discussions and posts) that it outperformed all other relevant services, this survey shows that Google Meet's move to provide its services to everyone for free (due to the spread of COVID-19) was a very effective strategic move to challenge on an equal footing its main competitor, Zoom. In fact, Google was also keen to push the security of Google Meet, following widespread criticism of Zoom's platform [15].

Some very important findings have been made in the present study. In principle, the age of users is not a factor in assessing the usability of video conferencing tools for teaching. In contrast, it seems that primary school teachers found the tools less easy to use than higher education teachers and foreign language teachers. This may be partially due to the inexperience of primary school teachers with innovative technological tools. Of course, the hypothesis of correlating experience with any video conferencing services before COVID-19 to their usability ratings is rejected. It is worth noting, however, that all primary school teachers in the sample used WebEx. Finally, video conferencing services proved to be a very good alternative for the most difficult teaching situations, i.e. large classes (> 80 students), where participants seemed to appreciate the high level of the tools' usability.

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Broadcasting Education - National & Transnational: A Heuristic Evaluation

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Abstract: *Television-like transmissions and multimedia productions were not thus far the main instigation force for replacing an instructor-centered agenda to a student-centered activity. The change abruptly brought into the educative field due to the Covid-19 pandemic has reoriented the Distance Learning nomenclature to product-driven processes, aiming to educate a global student community. As advances in infrastructure technology under the prism of remotely working have promoted within a few months tutoring and instruction to the most isolated places of educative jurisdictions, the schooling population, along with their families have adopted very fast instructive strategies that turn households to advanced hubs for receiving training. The target audience is punctually shifting to digital age recipients and users of online services and support solutions. The impact of new technologies on newly shaped societal frameworks, heavily dependent on Media and Tools along with vast Computer and Communication resources, is thoroughly examined for its Online Learning potential.*

Keywords: *multimedia learning; covid-19; usability; interaction; national and transnational distance learning*

1. INTRODUCTION

In the economic continuum it has been habitually quoted that "home is where the job is". Paraphrasing the meaning, using different arguments, the recent pandemic has repositioned the structure of a University campus.

It was commonplace for Academic institutes offering advanced learning to boast for their high-quality buildings, support (to learning) infrastructure and teaching amenities. It is not very clear how valuable these assets may be in meeting commitments or legacies for teaching during lockdown [1]. Have, indeed, Academic Institutes transformed themselves to Open Universities or Distance Learning providers?

The answer is not merely a point of strategic reorientation, especially in the field of education, as it would be, for instance, for the hard-stricken field of tourism or catering. In these grounds of economic activity, commercial organization and operational research prevail, letting down any other cultural or humanitarian consideration [2].

However, as the harsh financial reality would more accurately refer to a catastrophe with minimal, thus far, response from relief agencies worldwide, the next model of education in perspective is of crucial importance. Schools are usually built where economic activity brings people together, but, in terms of tertiary education, thousands of students and staff flock around established institutes [3], reversing this order, obviously investing in the valuable asset of establishing professional qualifications. Return on Investment (ROI) seems to be a crucial parameter for such an attitude [4].

Conversely, notwithstanding these analyses that are currently short of long term envision, future possibilities in this research will be limited to the Academic consensus and not to the overall macroeconomic factors of goods produced and services provided in specific regions and their ramifications to the society (that supports learning and instruction).

In online environments content is the king [5]. As it was realized during the Covid-19 lockdown, expenditures for e-Learning content alongside the investment on tools for the development and provision of full-time remote instruction exceeded by far any spending on the usual coexisted actions: accommodation, meals, libraries, facilities for promoting collegial interests and activities. Needless to say, most of the planning effort in Departments and Faculties was focusing on the instructional design of Computer Based Training (CBT) and the health maintenance organization leaving all other registered issues of their agenda to the background.

Designing innovatory learning environments is of crucial interest to the Academic community. If online teaching retains limited involvement, not

many dynamic exchanges and a not very interactive configuration [6], then, it is not guaranteed that Academia as is will remain the effective center of the social and economic activity.

2. FROM DISTANCE LEARNING TO BROADCASTING

ICTs in Education have been promoting Web 2.0 and Web 3.0 tools along with all kind of installations that mobile equipment may bring to instruction (thus, Web 4.0). These new habitats are not just digital places offering alternative forms of education: they morph student – centered environments, which have advanced communication potential, provide collaboration channels and exchange of ideas between students and everyone involved in technology-supported instructional processes.

Generally speaking, these collaborative environments promote the notion of teleworking. As members of a network seek to increase exchange and interaction between people, designers of CBT courses seek to involve new technologies that enhance the standards of teacher–student communication. Accordingly, Distance Learning develops to an attractive multimedia experience and a lucrative commodity.

Contemporary practices since 2000 have been mainly featuring multimedia systems with "widespread distribution of instruction through various media" [7] like printed material, audio and video broadcasts, television and interaction with Learning Management Systems (LMSs).

More recent advances in mobile, pervasive and ubiquitous computing clearly promote a massive CBT agenda. Whereas, thus, far interaction in University courses was experienced at a rather limited level (mainly as personal interaction among tutors-students and learning was only possible from the student just by interacting with learning content), recently interaction has been fully bi-directional by all involved stakeholders (learners, educators, material).

Clearly, a major shift in the learning paradigm has been reported: widespread procedures referring to a large community of recipients are encountered. New ICT tools have gained global acceptance and recognition promoting an online educative system highly dependent on vast conglomerates, the very same mode that Educational TV was reliant to other than normal educative processes for its distribution. On the other hand, these large global corporations have empowered strong interactivity during the lockdown, enabling education to survive the crisis.

Preexistent social networking was also used for educational purposes (extensive chatting among students, teachers, exchanging articles or featuring videos, sharing posts, creating groups that enhance engagement to learning material) motivating students to stay active, to achieve better grades, to push for a better understanding about a course, overall engaging them in higher levels of increased satisfaction as far as the University learning experience is concerned [8].

As seen in Fig. 1, what instrumentation may be used by students to regain control of remote learning, along with entertainment and connections to one's private life or professional needs is heavily dependent on the corporate tools offered by the dominant players of the field - in this example Apple iPhone™, Google™, Facebook™ (aka FB), et al.

Native App	Daily Usage
Messenger	30%
Reddit	25%
Spotify	10%
Safari	10%
YouTube	5%
Facebook	5%
Gmail	5%
Google Maps	5%
Google Drive	3%
Google Calendar	2%

Web App	Daily Usage
Safari	25%
Moodle	20%
YouTube	20%
Spotify	10%
Slack	10%
Reddit	5%
GoodReads	3%
Webmail	3%
E-banking	2%
Pinterest	2%

Figure 1. *Typical usage of a student's mobile device during the Distance Learning transition for synchronous and asynchronous instruction due to the Covid-19 lockdown.*

As interactivity and education can be identified with multivariable statements, a single definition would lead to erroneous predicates. Both terms have many shades and magnitudes, leading to some sort of affirmed arguments: for instance, Zoom-ing has the same nomenclature effect for Distance Learning with what FB implies for social media.

Therefore, Interactive Educational TV (aka IETV) as a learning experience would predominantly involve the experience that a viewer senses while watching an educational program. When interactivity and education are on the same sentence or connected in a single way, obscurity evolves about education from distance. When an applicable model of interactivity gives answers or simplifies problems probated on distance education, then it can be ascertained as leading the way to applicable digital services for learning with video lessons [9].

3. AN EMERGING CULTURE OF DISTANCE LEARNING WITH BROADCASTING

The continuing lockdown in education seems to be lasting for good or, at least, intended to remain unchanged for the Academic foreseeable future: most Greek Universities, amongst them the Aristotle University of Thessaloniki, have planned to have September exams in remote mode.

The lockdown of all in situ educative provisions had commenced on March 10, 2020 as a horizontal action plan by the Greek government at all levels, from nurseries to universities. Since May 11, 2020, schools commenced to gradually re-open, entrance examinations for tertiary education institutes took place between June 17 and July 10, 2020, and a very limited portion of formal Academic activities, like written examinations took place in Universities or Secondary Schools. It is not clear yet, in what mode and to what extend normal schooling will be operational in September 2020.

Furthermore, it remains unclear to perceive what obstructions or undesirable trends will be presented for new students in Academia, in October 2020. Will they seek to relocate themselves in the cities where their University classes are localized, or will they stay tuned at their parental premises awaiting for the production and marketing of new styles of learning modes?

3.1. The Case of Greece: National Portals

The National Digital Academy of Greece (http://nationaldigitalacademy.gov.gr), as of now, July 2020, hosts 214 different lessons in 6 different categories. These groupings are:

I. Communication and Cooperation
II. Internet
III. Tools of Daily Usage or Everyday Tools
IV. Digital Entrepreneurship
V. Computer Science
VI. Cutting-edge Technologies

More specifically, each of these categories focuses on:

- Communication and Cooperation: It contains 4 different sub-categories, which are, *Mobile Devices, Social Networks, Communicating apps, Work from Home*. This category hosts 25 lessons from different content providers. 23 of them are providers of private funding and 2 of them are from public.
- Internet: It contains 4 different sub-categories which are, *Safe Browsing, Search Engines, Privacy Settings, Development and Evaluation of Content*. This category hosts 25 lessons from different content providers. 13 of them are providers of private funding and 12 of them are from public.
- Tools of Daily Usage or Everyday Tools: It contains 2 different sub-categories, which are, *Desk Applications and Usage of PC.* This category hosts 37 lessons from different content providers. 30 of them are providers of private funding and 7 of them are from public.
- Digital Entrepreneurship: It contains 4 different sub-categories, which are, Digital Marketing and Modern Business Framework. This category hosts 18 lessons from different content providers. 9 of them are providers of private funding and 9 of them are from public.
- Computer Science: It contains 12 different sub-categories which are, *Development of Internet Applications, Development of Mobile Applications, Development of Software, Data Bases, Communications Networks, Human-Machine Communication, Programming Languages, Cyber Security, Operating Systems, Device Programming, ICT and Education.* This category hosts 81 lessons from different content providers. 54 of them are providers of private funding and 27 of them are from public.
- Cutting-edge Technologies: It contains 4 different sub-categories, which are, *Big Data, Machine Learning, Artificial Intelligence, Cloud Computing.* This category hosts 44 lessons from different content providers. 43 of them are providers of private funding and 1 of them are from public.

There are 32 different content providers to the National Digital Academy of Greece.

From these, 14 of them are Universities or institutions of public interest or non-profit organizations:

1. Aristotle University of Thessaloniki
2. E-Learning Distance Programs for Professional Training
3. National Technical University of Athens
4. Greek Open University
5. Economical University of Athens
6. University of Western Attica
7. University of Western Macedonia
8. University of Ioannina
9. University of Patras
10. Academic Network GUnet
11. National Center for Safe Network
12. Organization of Open Technologies
13. Unit of Organization and Management of Developing Programs
14. Government site about Education

18 of the providers are foundations or institutions that are having considerate connection with private funds [3]:

1. Vodafone foundation
2. Piraeus Bank foundation
3. Alpha Bank foundation
4. Eurobank foundation
5. eTwinning
6. Mathesis
7. OTE academy
8. SaferInternet.gr
9. Inte*learn
10. SQLearn
11. Amazon
12. Cisco Networking Academy
13. Coursera
14. Edx
15. Google
16. LinkedIn Learning

17. Microsoft
18. Oracle University
19. production and marketing of new styles of learning modes?

3.2. Transnational agendas

Already esteemed Institutes have excelled in offering Distance Learning courses at all levels, modes and methods of operation.

Since 2010 most well regarded American Institutes have been designing apps offering instruction for Mobile Devices and Interfaces, thus setting within easy rich very prestigious lecturers.

Through schemes like UCTV (University of California Television), MIT Open Courseware, or TED video lectures the most far ahead in development and delivery educational content may be accessed. For starters, free of charge or with limited endowments and contributions.

Even further, antipodal courseware, thus far failing to be noticed may be brought to the surface of collective global learning. Podcasts, videos and learning material from the Australian National University or even the Khan Academy of Pakistan lead aggressive strategies far beyond the capacity of these countries to have effect on tertiary education.

It seems that a culture of massive learning has been initiated with MOOCs. Big players of this game seem to be American, English, Western European, Indian, Spanish, Brazilian institutes that cater for the linguistic pool of mother tongue resources.

However, for STEM (Science, Technology, Engineering and Mathematics) courseware, English seems to be the "native" language for instruction.

Even students of local Universities, being offered instruction in their formally accepted language would turn to English for learning Technology related subjects, promising this way to turn a honest penny from work in progress. Thus, it was not that astonishing that Universities in Greece have begun to offer courses in collaboration with renowned global education players, influential in their affective modeling for learning [10].

4. DIFFERENT EVALUATION PROCEDURES AND THE NEED FOR HEURISTIC EVALUATION OF INTERFACES

Not withstanding how most Academic Institutes coped in their ardent transition to Open Universities for the spring semester 2020, the crash-tests for viable, en-masse Distance Learning retain the formative and formal evaluation processes adopted.

Already the literature offers previous examples of how well such a transition may serve educational processes. For instance, how viable is it to offer Medical accreditations via remote learning methodologies [11]?

4.1. The Aristotle University of Thessaloniki: a linear perspective

Within the Aristotle University of Thessaloniki, Greece, in its diverse fields of instruction, like Informatics, Legal studies, Medicine, etc. different pathways have been developed to conclude formal evaluations for the Covid-19 hit semester.

Extension was provided to the usual period of 13 teaching weeks per semester, to fill in any gaps, and the final examination period commenced in June 15, 2020. In most Departments the evaluation phase lasted some 4 weeks and by July 23, 2020, most formative evaluation assessments, including supplementary activities, had been completed.

For the first time in AUTh, probably the biggest Institute in South-Eastern Europe, 97% of the examinations took place by Distance Learning techniques. However, technological glitz seems to come short in providing creditable supervisor call instructions.

Instructors used a variety of techniques to assess the students' performances. The most difficult phase included creditable supervision and inspection of student classes that varied in pre-graduate courses from some tenths of students, in elective lessons, to more than 500 in certain core courses of populous departments.

To avoid hard proctoring techniques that may violate General Data Protection Regulation (GDPR) rulings concerning Personal Data violations, the use of perpetual camera-initiated supervision was not the most favorable technique.

The main problematic situation, albeit the use of AI or Machine Learning, appeared to be the issue of third-party involvement in all examination procedures.

Some of these interventionist practices have a cover of legitimacy for the state, like paid tutoring offered by third party equipage, while others seem to be adopting cloak-and-dagger intel operations. In hi-tech mode, that is.

To avoid excessive exposure to machine-assisted boost of performance or, even worse, duplicity and fraudulent representation in the other aspects of the assessment-chain procedures, instructors used their imagination so not to let a culture of cribbing prevail.

For instance, the TurnitIn™ Machine Learning tool was used to indicate what portion of the answer sheet had been copied from other public resources, or perhaps, co-students participating in the same assessment. Indeed, plagiarism seems to be plaguing tertiary education.

However, the issue is more complex and no efficacious methodology has been endorsed for copying from someone else or promoting others' ideas as if they were the examinee’s own work.

As a result, most professors concluded that the intelligence of such tool is highly predictable, letting room for repudiatory breach of the examination agreement. In other words, ant-theft and anti-plagiarism systems may be used as counseling tools to direct the examiner to hidden weevil attitudes, bugs and similar patterns of cheating, but not *per se* as absolute criteria for revealing unfairly acts to gain an advantage. Unless, of course, a case of outrageous or provocative falsification is met.

In practice, during this first period of the pandemic lockdown, examiners preferred more classic methods of authentication. As seen in Fig.2, left, for formative evaluations topics where examinees would develop in small groups talented approaches were opted in [12]. For final examinations, students were asked to answer the examination sheet in writing with a pen, to photograph it or scan it, bundle it in a pdf file and upload it the Learning Management System. All these in a rather limited time interval, so to dissociate cases of deceptive functioning during remote mode.

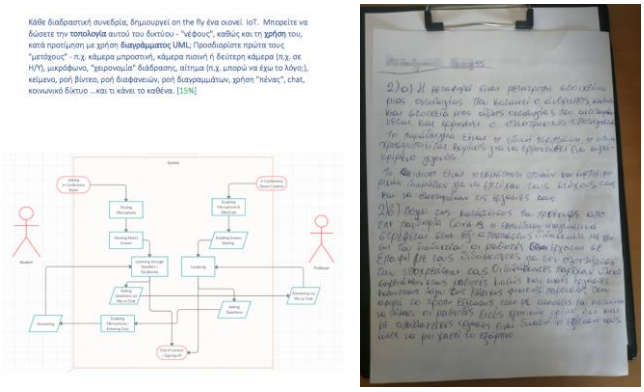


Figure 2. *Examination answering sheets for formative and final assessments that have been uploaded to the AUTh's official e-Learning module in 2020.*

It is suggested that the answer sheets should be kept in digitized format for quite a while.

4.2. An erroneous perspective

Contrary to the prevalent public opinion belief in Greece, a variety of Universities abroad, some of them being prestigious, are not deploying structurally different methodologies for accrediting or standardizing their students' assessments. Especially when under specific circumstances, the Institution may be asked to prove if the proper education and accreditation is delivered to the student body.

For example, a lot of medical schools have been asked in the past to prove the quality and the amount of education provided to doctors in malpractice trials. The better way to ensure, that indeed the adequate instructive practices and methods have been provided to student is to demonstrate the forms of past exams, and the actual answers provided by the examinees.

It is a type of assurance that is common to all levels of education, to each and every civilian practicing scientific applications to different layers of the society, for centuries. It happens, though, even for major institutions around the world not to use a very different evaluation approach when it comes to pathways that have a large proportion of theories and not so many practical lessons. Especially in medical cases, for example. Indeed, despite the fact that the last two years of the study curriculum are coping mainly with practical applications, in as small as possible groups of trainees, neither teamwork nor some kind of hands on accreditation may guarantee the risk of incomplete, swallow assessments. Hence the risk for improper or negligent professional activity.

Even worse, if the knowledge gaps are localized on the first years of study, when the theoretical foundations of each and every science are underpinned, the exercise of a profession becomes a battered industry.

According to a rule of thumb concerning the worldwide teaching agenda, the degree of concluded findings regarding the ability to exercise a profession by an individual is proportional to the proper completion of a proposed program of studies with its accredited practices included. It is a way to state that an educational program has been adequately monitored by a mixed board of authorities (state, educational, professional, etc.) and thus qualified for learning.

Thus far, however, although acknowledged as rather incomplete, there has not been found another alternative way to provide a solid proof that the student has already established the sufficient amount of knowledge than that of paper exams.

Provided, of course, that no intervention has taken place in the astuteness of the examination processes.

Further accreditation practices are building up, over a period of time, the practitioner's profile to cope with the more complicated hazards of his profession.

4.3. A common free-type evaluation

On the other hand, when there are not solid, mandatory theoretical backgrounds leading to practical lessons, educational procedures may rail themselves to more fruitful pathways, enhancing both student-instructor interactivity and class creative activity.

It is exactly this point that has been hurt for classic Universities, like AUTh, in their educational transformation during the Covid-19 lockdown.

It should be pointed out, though, that this happens because the nature of studies in Academia is linked with innovation and research, and as such reforms on the fly rework drastically the type and methods

of the education offered. Intuitive instruction adheres beyond formalism, has no real boundaries but the ultimate goal to educate the student in the best possible way.

Therefore, instructors are teachers, researchers and methodology providers the same time.

A brief example will be presented by considering the Ravensbourne University of London, UK. This particular public University was established to its current modern form in 1962; during the Academic year 2018-2019 a student force of approximately 2500 learners, both undergraduates and postgraduates, was commissioned to it.

Furthermore, it employs some 150 educative staff and mixed-duties workers, with a considerable variability in their job description.

According to its mission statement, declared in its website, Ravensbourne University is an innovative, industry-focused University which emphasizes on creativity and collaboration, aiding students in reaching the ultimate goal, i.e. let its learners obtain special skills and professional knowhow for a career in digital media and design [13].

When a tertiary institute or a faculty has such operational characteristics, then it develops more degrees of freedom so not to rely on the strict paper examination methodology for its formative and final assessments.

For example, a simple evaluation procedure may develop in three phases (for a typical semester period):

-Phase 1: The Foundations

Commencing the course, students assume the theoretical foundations of the subject taught. In class activity relies on presentations, in detail explanation of the topics involved and interaction with the students. They are encouraged at every step to give their feedback, to provoke discussions and to indulge themselves to the library for extensive study on the thematic resources.

This period has an endurance of 4-5 weeks.

A mid-term formative evaluation resumes this part giving the chance to both instructors and teachers to conclude on the progress of the theoretical learning. The answer sheets of the exams are digitized and kept in the courseware's archive.

- Phase 2: Formative Evaluations

This stage involves skill development, based on technological equipment provided by the University's resources. Students, either alone, or usually in small groups, advance practical teamwork by adhering a project with very clear, solid deliverables (Fig. 3).

Figure 3. *Deliverables from Phase 2 (multimedia files alongside documentation) - this snapshot comes from a video file describing what a specific group of 4 students managed to achieve in AUTh.*

In this phase, students learn by hands-on applications. The instructor provides the outlines, suggests bibliography and gives answers to feedback questions coming from the students [14].

Each team is encouraged to develop its dexterities, with guidance concerning the outcome and predominantly learners are motivated to use all the technological equipment made available to them and enhance skills that are coming through equipment know-how.

Formative evaluations and project development, along, perhaps, another midterm examination, either in oral presentation form or somehow written, last for another 4-5 weeks period.

- Phase 3: Final Evaluations

The finishing 2-3 weeks are dedicated to deliver the final project of the semester using standard, more or less procedures for the presentation, explanation of the project and, perhaps, the "public" release of its deliverables.

Industry standard tools - like the Turnitin™ platform - may be used, ensuring that the final project is evaluated in a proper and generally accepted way.

Indeed, in some AUTh departments for instance, a public exhibition of the deliverables may be organized, without however conveying to the audience the marks of each project or other details that GDPR restrictions prohibit from releasing, so to catch up with the views of the general public.

In case of written examinations, impartiality along proof-reading, accompanied by keeping the archived documents for quite a while is technically established.

In most cases for small in size classes usually there is little need for paper exams because the quality and authenticity of the last stage deliverables is cross-validated in a commonly agreed way.

Nevertheless, supervised written examinations are a fail-safe method for preventing malpractices, globally accepted and recognized, especially in times of trouble.

5. DIFFERENT EVALUATION PROCEDURES AND THE NEED FOR HEURISTIC EVALUATION OF INTERFACES

As it becomes evident world wide that education is shifting to broadcasting methodologies to carry out it's functioning in cases of prolonged lockdowns, cooperation between tutors and learners remains a keystone priority for successful evaluations [14].

The following heuristics [15], i.e. broad rules of thumb are of importance for delivering feedback and interaction [16]:

I. Visibility of the system status

The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.

II. Match between system and the real world

The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.

III. User control and freedom

Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.

IV. Consistency and standards

Users should not have to wonder whether different words, situations, or actions mean the same thing.

V. Error prevention

Even better than good error messages, is a careful design that prevents a problem from occurring in the first place.

VI. Recognition rather than recall

Minimize the user's memory load by making objects, actions, and options *visible.*

VII. Flexibility and efficiency of use

Accelerators — unseen by the novice user — may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users.

VIII. Aesthetic and minimalistic design

Dialogues should not contain information which is irrelevant or rarely needed

IX. Help users recognize, diagnose, and recover from errors

Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.

X. Help and documentation

Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation.

How these principles were applied in practice [17] [18], will be demonstrated within a formative evaluation example, from the *Computer Music* course in AUTh. It is an elective, attended by some 50 students each year. The following two-way flow of visual information took place:

A. The students were presented with an IETV video, in which Professor N. Paris and Erasmus+ student B. Y. from Ankara, Turkey, performed a well known tune in Mode 5 (Hypo Dorian - and at some points Phrygian).

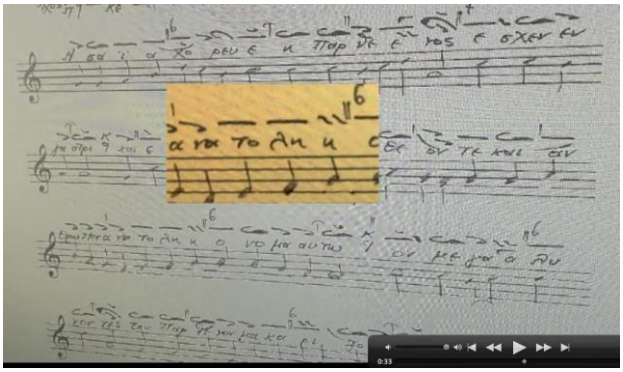
B. The distinguished performer from Turkey did not know either the Greek language or Byzantine Music notation, but followed with his tambour the score in the analogous *maqam* scale, performing with Donizetti-like alterations the Common Music Notation (CMN) semiology of the prototypal melody.

C. The music piece is very familiar in the Balkans, Asia Minor and Middle East as for at least 8-9 centuries it is sung accordingly (and danced "symbolically") in weddings, inaugurations and other liturgical celebrations. Therefore, students were presented with an accompanying video, along e-bibliography and other public resources on the Internet to catch-up with the theoretical background. (Picture cropped from social media uploaded video)

D. Students were asked, if they are competent at playing stringed instruments, to reproduce the melody as close as possible, and upload audiovisual feedback. Some did so by using Eastern instruments, tuned in non-CMN chromatic scales.

E. Other students used well-known Western music instruments, like the bass, to approximate as possible this diachronic tune with well-tempered scales.

F. The ones who could not use stringed instruments deployed appropriate Computer Music software, score editors and Digital Audio Workstations to reproduce the tune synthetically.



G. Formative Evaluation:

Students could ask questions, inquire for more theoretical or practical insight, via e-mail, phone or videoconferencing sessions. The instructing team would request involved students to make amendments or eliminate mistakes. Iterative uploads could repeatedly take place.

H. Final Evaluation:

Along written exams and other assignments, audiovisual submissions comprise important elements upon which the final mark depends on.

6. CONCLUSION

Audiovisual feedback and interaction pose unprecedented standards for reciprocal, twoway high-level communication between instructors and students, promising a viable possibility for continuing tertiary education, without flaws or uncharacteristic blemishes in cases of prolonged lockdown.

Student engagement retains features of high visibility, thus attracting the attention of class members for reciprocal action at every stage of the teaching process.

Clarity, intelligibility and beyond all transparency is achieved.

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Machine Learning Applications in Education

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Abstract: *Nowadays, artificial intelligence has become an identity that defines modern technologies and their applications across various fields of industry, especially in the field of Information Technology. Most of the educational institutions have integrated informational technologies in the everyday learning process and employing machine learning can greatly enhance their efficiency. The aim of this paper is to present the application of machine learning in the education area as well as its impact in altering the learning experience.*

Keywords: *artificial intelligence, machine learning; education; adaptive learning; Moodle.*

1. INTRODUCTION

Artificial intelligence is a branch of Computer Science engaged in building intelligent machines or computers capable of performing tasks commonly associated with human beings. In 1569, Arthur Samuel coined the term "machine learning" to describe computational methods that use available data to identify hidden patterns and make intelligent decisions [1]. Nowadays machine learning is being used in a number of areas. Industries like healthcare, banking, energy and retail are rapidly transforming and improving using machine learning technologies. Among them, education industry also has incredible potential for the application of machine learning [2].

There are different ways of using machine learning technology in education. Every student has different learning preferences and machine learning can support personalized learning in a number of ways [3] [4]. Machine learning algorithms, using the data about students' educational background and preferences, can also predict the right career path for each student [5] [6].

There are many countries that have deployed some type of automatic grading system, based on artificial intelligence, from middle school to college level. Automated grading if proven effective does not only reduce the time for scoring, but comparing it with human scores also makes the score realistic [7] [8].

Using intelligent tools for analyzing large amounts of data can provide educational institutions with the insights needed to predict enrollment, improve retention, reduce administration hours, arrange schedules for teachers on a daily basis etc.

This paper is organized as follows. Section 2 presents Machine learning and some of its main techniques. Examples of machine learning applications are also provided. Section 3 discusses the use of machine learning in education and presents some of the most popular platforms which support formal education as well as lifelong learning.

2. MACHINE LEARNING ALGORITHMS

Machine learning uses algorithms to parse data, learn from that data, and then apply what they have learned to make better decisions and predictions [9]. The machine learning algorithm is run on "training data" to build a model which should be a mathematical representation of a real-world process. The process of finding patterns in the training data is called "model training" or "learning process".

Machine learning algorithms are divided into two major groups: supervised algorithms and unsupervised algorithms. For example, if we want to create a model to predict whether a student gets admitted into a university, based on their results on two exams, we would use historical data from previous applicants as a training set. For each training example, we have the applicant's scores on two exams and the admissions decision. The classification model should estimate an applicant's probability of admission based on the scores from those two exams, without being specifically programmed to do so. This type of learning is called supervised learning, because the correct answer is given, in contrast to unsupervised learning where the machines are not fed with the labeled outcomes.

Recent development in sensor networks and communication technologies has enabled the collection of big data and deep learning has played an important role in big data analytic solutions [10]. Deep learning is a class of machine learning algorithms that imitate the workings of the human brain called artificial neural network. Deep learning techniques process data in real-time with high accuracy and efficiency by using a huge set of data and neural network architectures that contain many layers. The term Big Data refers to collection of heterogeneous data formats (text, image, video, graphics and so on) which is generating fast and requires to be processed in real time.

2.1. Examples of machine learning applications

The total amount of data created, captured, copied, and consumed in the world is forecast to increase rapidly, reaching 59 zettabytes in 2020. The rapid development of digitalization contributes to the ever-growing global data sphere and the need for machine learning is increasing day by day [11]. The reason for this is its ability to learn from data and provide data driven insights, decisions, and predictions [12]. The most convenient way to describe the potential of machine learning is to present how it is being used in various industries and professions. Currently, some of the most trending machine learning applications are: image recognition, speech recognition, automatic language translation, traffic prediction, driverless cars, product recommendations, stock market trending, online fraud detection, email spam and malware filtering and medical diagnosis.

Image recognition is used to identify and detect the feature or an object in the digital image. For example, Facebook uses facial recognition technology to automatically tag people in photos. Google assistant, Siri, Cortana, and Alexa are the virtual personal assistants that are using speech recognition technology to follow the voice instructions. Google Translate as automatic language translation tool uses deep learning to find more accurate words and automatically adjusts to a more natural sentences syntactically that are smoother and more readable [13]. While Google Maps traffic prediction improves its performance by taking information from the user, self-driving cars are trained to detect people and object while driving using unsupervised machine learning. Websites like Netflix, Amazon and Google use recommendation systems to improve customers' online experience by offering products based on their searching activity, past purchases, items liked or added to cart, brand preferences etc. Machine learning algorithms can predict how the stock market will perform with a high degree of accuracy even if there is a great influence of external entities (social, political, economic and psychological) on stock trends. Nowadays cybersecurity is very important and machine learning can help tracking money frauds online. PayPal is already using machine learning algorithms to distinguish between legitimate or illegitimate transactions between customers and sellers as a measure of protection against money laundering. One more way machine learning has improved cybersecurity is through spam and malware detection. Since machine learning has the capacity to adapt to varying conditions, spam filters constantly generate new rules based on what they have learned as they continue in their spam filtering operation. The machine learning model used by Google has now advanced to the point that it can detect and filter out spam and phishing emails with about 99.9 percent accuracy [14].

Machine learning can facilitate and enhance the work of medical experts by helping them diagnose patients faster and more accurately. It is being used for the analysis of patient's data for disease detection, therapy planning, prediction of the disease progression, medical-related researches etc.

3. MACHINE LEARNING APPLICATION IN EDUCATION AREA AND EXISTING PLATFORMS

Currently, machine learning technology is everywhere, including the education sector, where it has shown great perspective. Adaptive learning is one of the best usages that machine learning provides. Machine learning algorithms can learn how the students consume information based on the amount of time spent on completing each task, response latency and assessment results. This data can be used to tailor courses around the needs of individual students. Many recent Intelligent Tutoring Systems are using machine learning to decide what learning content to provide to a learner. For example, the iTalk2Learn system, designed to help young students learn about fractions, integrates structured, practice-based tasks with exploratory, conceptually-oriented tasks, and affect-aware intelligent support. The system focuses on natural interaction via intuitive user interfaces, which include speech recognition, and speech production [15]. Some of the popular adaptive learning systems are: DreamBox, ALEKS, Reasoning Mind, Querium, Kidaptive and Knewton. NewClassrooms, Carnegie Learning and Thinkster Math are math learning platforms that personalize the students' learning experience by tracking their learning habits and progress, identifying knowledge gaps and offering adequate learning material. Feedback is usually embedded in the instructional process as teachers can monitor overtime performance so that students can get real-time results and suggestions. Khan Academy offers interactive questions, quizzes instructional videos and articles on a range of academic subjects. They

use machine learning to award proficiency and motivate students to move forward in a purposeful way.

Machine learning techniques can be used to evaluate responses in open-response and assessment learning system. Such assessments typically contain questions that require written responses. For each specific question, responses from different test-takers are used to build models that can predict the quality of new, unseen responses [16]. Platforms like WriteToLearn and Turnitin are implementing machine learning to grade essays and detect plagiarism. They also help students develop writing skills and reading comprehension.

Combinations of machine learning algorithms can also be used for recommendation of courses in e-learning systems. Usually, course recommendation systems based on machine learning extract knowledge from learning management systems (LMS) such as Moodle and can be embedded in Massively Open Online Courses (MOOC) to enhance the learner experience [17]. Moodle stores detail logs of all students' activity on the platform. Those logs can also be used for predicting student academic motivation, identify at risk students and increasing students' retention [18]. The framework for a course recommendation system is shown in the Fig. 1.

Moodle has been used worldwide for practical teaching in higher education [19], with the aim to stimulate student independent work through self-evaluation exercises. Applying machine learning to data from activity logs can predict students' performance on the final exam of such courses [20].

Machine learning as a predictive data analytics tool has a potential to discover, analyze and predict meaningful knowledge from educational data which will help to education management system for flexible planning, execution and prediction for the future [21]. Using prediction models based on truancy, the disciplinary problems, on-course performance (time online, the number of assessments completed, time spent on the assessments) and overall grades the software could identify the most engaged students as well as the struggling ones. Software like eAdvisor and Degree Compass are already used in the United States for those purposes [22].

4. CONCLUSION

The aim of this paper is to point out the importance of machine learning and its application in different areas. The paper also describes the ways machine learning has been applied to the education sector. Existing education-related platforms that use a machine learning component are also presented.

Learning models based on machine learning can help identify individual student needs and sharpen the content delivered to every learner. This will improve student motivation and hence the overall results. Educators will also get a better understanding of each student's learning process, by taking real-time feedback. Machine learning technology can support teachers and institution stuff by completing repetitive tasks and routines. Thus, the teachers will have more time to focus on educating their students or engaging in research pursuits. Machine learning algorithms will also enable more efficient enrollment and admissions processes.

Although machine learning offers possibilities for improving the education around the world, we are still in the early stages of its use. A major challenge in the implementation of machine learning system is the big data that would be needed in order to train it. The challenge is finding a way to implement it and to do so in a cost-effective way.

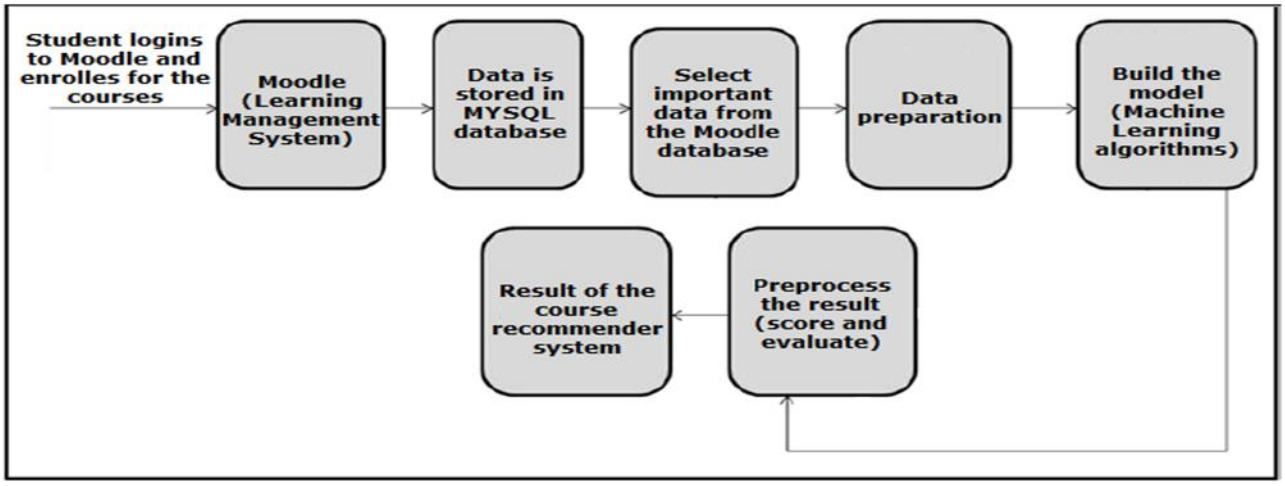

Figure 1. *An example of course recommendation system in e-learning*

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Expert Systems as a Means in Detecting Tax Evasion

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Abstract: *The paper presents an overview of currently existing methods for the detection of tax evasion in databases using expert systems and compares the method of improving the detection of tax evasion with the proposed expert system. Detection of tax evasion and its efficiency in recognizing them are essential for timely and efficient detection of them and improving the knowledge base of the expert system. The paper presents an abstract solution using an expert system on the domain of tax evasion as well as a performance model. Expert system builder is a GUI interface for the work of employees in the specified expert system. This way of realizing the detection of tax evasion enables facilitation in the work of the competent tax services. The results of such a proposed system of expert systems are presented in the paper and give an enviable level of detection of tax evasion patterns.*

Keywords: *expert system; expert system builder.*

1. INTRODUCTION

Tax evasion has been present since the very beginning of the economic development of human civilization, where only the instruments, methods and techniques have changed, in accordance with the technological possibilities of society. Also, the appearance of tax havens in the world allows individuals and legal entities to place their funds earned in their home countries to deposit in destinations known as tax havens and thus commit tax fraud or evasion. In this way, the perpetrators of these acts keep their capital and do not pay taxes in the countries from which they come.

Today, artificial intelligence and expert systems [1] are indispensable in the work process and everyday life, from simple technical software or machine aids to complex systems. With the development of science and technology, their importance grows and has a great influence in business, education, economics, informatics, etc.…

In the continuation of the paper, some ways of tax evasion-fraud will be presented. Simple or more sophisticated-sophisticated such as tax evasion by trading on virtual stock exchanges where cryptocurrency is traded.

These trends, the models of tax evasion available to "criminals", are constantly changing and improving in order to hide the traces of illegally acquired funds. Over time, tax evasion also improves in line with the development of technology and globalization. Due to these trends, all world institutions and financial regulators must be ready and willing to reveal patterns in order to reduce this phenomenon to a tolerable level and preserve their own economy and development.

2. APPLIED EXPERT SYSTEM IN DETECTION OF TAX EVASION

The use of expert systems and artificial intelligence in the process of discovering patterns of tax fraud has been documented in a number of papers published in journals and professional-scientific conferences around the world. In order to form the basis for comparative analysis of the possibility of their application in specific conditions of analysis of the fiscal system in BiH, as well as evaluation of the obtained results, it is necessary to analyze the selected set of available references taken from tax systems in BiH and in the world. In the process of analysis of a representative sample of references, emphasis was placed on documented examples of expert systems and mechanisms in the process of analyzing data on performed financial transactions within a set of organizational systems.

2.1. The use of artificial intelligence to detect fraud in Brazilian customs

This approach to identifying possible fraud is based on the interaction between customs service and Decision Support System DSS developed under the name Carancho [2], and it finds suspicious operations by detecting outliers (out-of-interval values). Such a system assumes that most international trade is legal, ie they are in

accordance with the law and the products are classified accordingly. Therefore, an Information System for Products and Foreign Exporters (PFEIS) [2] has been developed that uses orthographic verification features that suggest possible duplicates and assist in their classification.

Such fraud detection systems are important to reduce the manual work of customs officers in product inspection and to achieve the maximum amount of fraud detection. This system must be presented with several problems in its work, such as a large number of attributes with which the system operates, then the imbalance of the database and inaccurate spelling of the product in relation to which the data in the database are compared.

2.2. Income tax audits using the Bayesian network method in Brazil

As is generally known in all countries of the world there is a sales tax and income tax as tax deductions to individuals and legal entities in their businesses. This method primarily refers to the audit of personal income tax in Brazil. The basis of her work is on a probabilistic analysis of income for individuals in real time. In this scientific study, a conceptual predictive model was modeled, which gives quite good results in predicting whether a particular taxpayer's income is harmonized with the regulations of the regulator (tax administration of Brazil). Data analysis of all taxpayers is based on machine learning and CRISP-DM (Cross industry standard processing for data mining) standard. By training the Naive Bayesian network as well as by training the pronounced decision tree of the Bayesian network, a model of detecting the detection of compliance or non-compliance of taxpayers' tax revenues in Brazil is achieved. [3]

2.3. Detection of value added tax evasion of business entities in Kazakhstan

The basis of this paper is on data discovery of knowledge, ie on data mining for the target group of business entities in the state of Kazakhstan. This is a machine-oriented approach to learning the data that businesses have in their work. The analysis is taken for the basic characteristics (attributes) that are significant and a comparative analysis is made in relation to the method conducted by the tax administration of the state of Kazakhstan. [4]

Data exploration or data mining is based on Kohonen's self-organizing maps and clustering of samples. Such maps are suitable for easy review of the multidimensional attributes of the samples being analyzed. Data collection is in accordance with the rules of the Tax Administration of Kazakhstan with a special target group of taxpayers whose turnover does not amount to less than one million tenge of Kazakhstan. Visualization of this data is by means of self-organizing maps. Only the calculation and detection of possible deviations or tax evasion is based on the static approach of the Gaussian distribution. It was taken into account that the proposed approach was tested on a specially selected set of business entities.

3. ABSTRACT SOLUTION MODEL IN DETECTION OF TAX EVASION PATTERNS

Depending on the given case on the domain in the tax system of one institution or state, the applied expert system can give a pretty good assessment of the case of tax fraud.

Figure 1 presents an abstract model of solutions in the detection of potential tax evasion or fraud in the tax systems of Bosnia and Herzegovina.

As previously stated, the basic facts and facts available to the knowledge base of the expert system are stored in the repository of knowledge by extracting cases from the Criminal Code which prescribes penal provisions for certain cases known over the domain of evasion. Figure 1 shows an abstract solution in the form of an expert system or knowledge base in which there are combinations of knowledge provided by an expert in the field of tax fraud and the Criminal Code. By combining the two knowledge in building an expert system, the knowledge engineer gives the final look of the knowledge base. Also the knowledge engineer designs and designs what the reasoning machine will be like and what its appearance or design will be like.

Figure 1 shows the reasoning mechanism that gives the result of the search requested by the user depending on the case that interests him over the domain of tax evasion or fraud.

Figure 1 shows the cyclical or interactive exchange of data and knowledge exchanged by users of the expert system and the system itself intended to solve the specific problem of tax fraud. Through the application programming interface (API), the user queries using tools such as Java system shell, Prolog, Lisp or Expert system shell for individual cases that interest him over the "evasion" domain. he expert system or the reasoning mechanism mechanically searches the knowledge base using all the resources of one expert system specifically designed for special cases. The inference mechanism works in a way that it cyclically and cross-searches the knowledge base and draws conclusions that it gives to the user in real time.

Figure 1 shows the basic four segments consisting of the User Interface (user interaction tools and natural language), then the inference mechanism (Heuristics, reasoning schemes, inference), then the rule library (knowledge-managed rules) and the database. knowledge (facts and data that represent expert knowledge). This pattern of search and knowledge extraction mechanism is very efficient

and gives good results in cases of tax fraud in support of the work of users (tax officials or others).

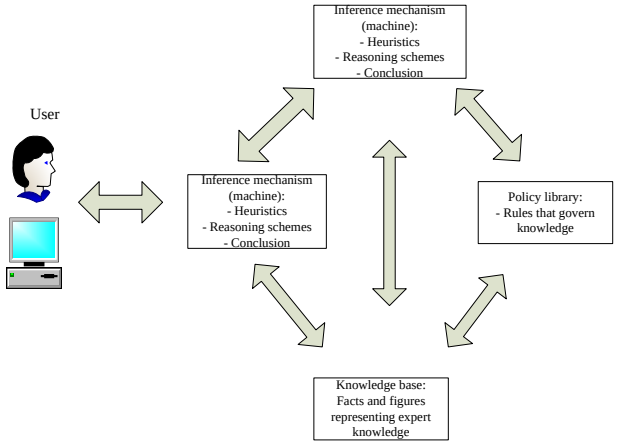

Figure 1. *abstract model of solutions in the detection of potential tax evasion or fraud in the tax systems of Bosnia and Herzegovina*

4. IMPLEMENTATION MODEL FOR DETECTION OF TAX EVASION BY EXPERT DATA SEARCH

Figure 2 presents an implementation model of a solution for the prevention, detection and prevention of tax evasion. This model consists of three blocks, which are (reporting-data collection block), then (transformation or data translation block) in which the data are prepared for the block of expertise or expert data collection. shows the expertise of the data collected by the expert module for knowledge extraction. Each taxpayer from his workstation via a link on the Internet reports or reports to the regulator on the transaction of the party or makes a report to the competent tax administration.

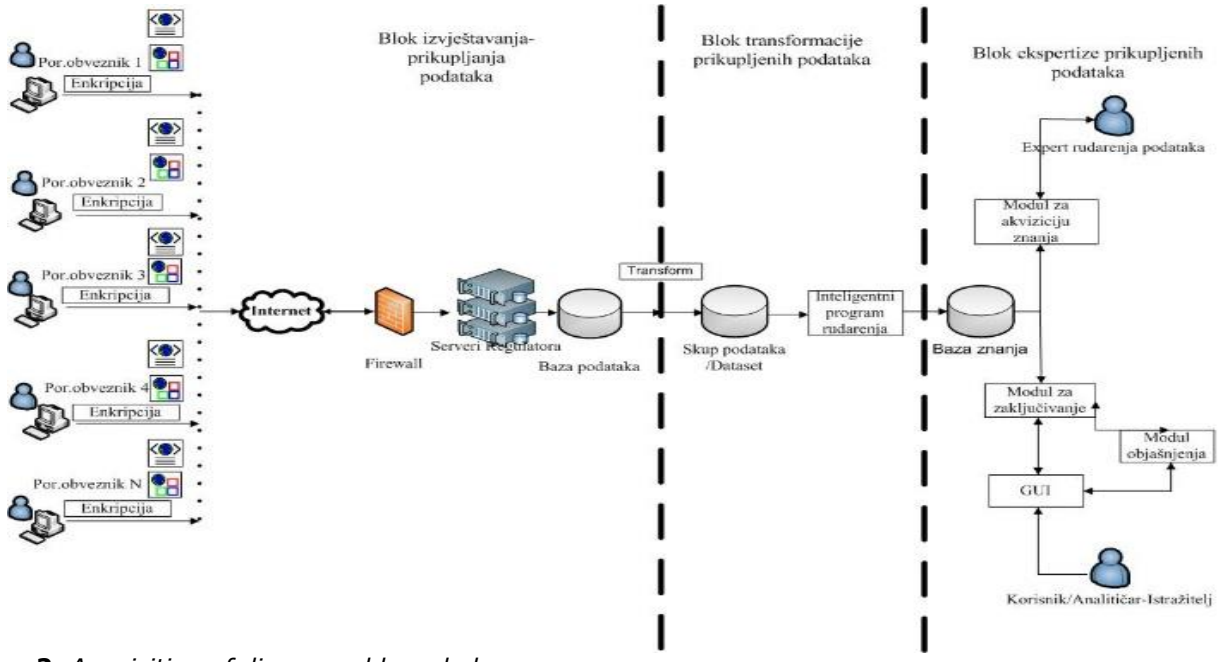

Figure 2. *Acquisition of discovered knowledge*

Taxpayers can report completed transactions of parties in single or batch mode, ie they can file one or more tax returns at once. Figure 4.8 shows the method of filing created by an authorized person for tax returns that are sent via a web service to the server of the tax regulator that is on the Internet. These file-transactions are encrypted and protected from attacks on the Internet. Reported transactions are transmitted via the Internet, protected by encryption, to the controller's server. The section shows the firewall that separates the Internet from the local intranet within the tax institution. All transactions are received on the servers of the regulator and they are stored in the database warehouse for storage.

By transforming structured data through in which a set of data suitable for expertise and analysis is created. The next step in is the application of an expert detection program over the data set and the extraction of the pattern from the data set. Permanent expert search of data forms a knowledge base. A collection of all the patterns found creates a knowledge base.

The next step in of the implementation solution is the acquisition of the discovered knowledge (acquisition module in Figure 2) which serves for the analysis and expertise of the knowledge collected from the database by the data analysis expert. Based on this module, the data analysis expert simplifies the knowledge found and helps all interested users of the system. This part of is designated for experts in the field of data analysis. Furthermore, the module in is a conclusion module that serves primarily users, and these are officials who investigate the occurrence of "tax evasion". This module interacts with system users through two modules, namely the explanation module and the GUI (graphic user interface). Through the GUI, the system user uses the knowledge found to analyze and investigate tax evasion.

5. EXPERT SYSTEM BUILDER

A practical example is given in Figure 3, which is the reasoning mechanism on the basis of which the conclusion is made and assistance in the analysis of transactions from the tax aspect of the tax officer. This reasoning mechanism is based on the decision tree as shown in Figure 3 The starting node is a transfer of funds, which is logical, because it is most likely according to the theory of information gain (Shannon's theory) [5] if it starts from this starting point.

Figure 3 is the starting point for whether the origin of funds is known and this is the basic premise of any analytical approach to tax evasion research. Without this evidence, there is no need to analyze every transaction within the fiscal system because the security factor (factor certainy is approximately 1) if the funds do not originate to be tax fraud or evasion.

This reasoning mechanism provides exact data to each tax officer and is a clear approach that can be used to analyze each set of data collected by each tax administration and which they have at their disposal in their databases. Furthermore, an important decision tree of the decision tree is the amount of the transaction that works in accordance with the analysis with (Police Agencies at all levels of government in BiH). If the amount of the transaction is less than 30,000.00 KM (cash transaction, non-cash, cash related) it has a high probability that it is related to tax fraud or tax evasion. (Safety factor is greater than 50%). A further important node of the analysis of this financial transaction is the review (view) of whether the legal or natural person regularly settles tax liabilities and especially for the performed transaction that is being analyzed and which is important for the tax investigation. This approach again gives a safety factor of approximately 1 according to Shannon's theory.

A further important node is the examination of whether direct and indirect tax debts have been settled by a natural or legal person, and especially for the analyzed transaction which is important for the investigation. This approach again gives a safety factor of approximately 1 according to Shannon's theory.

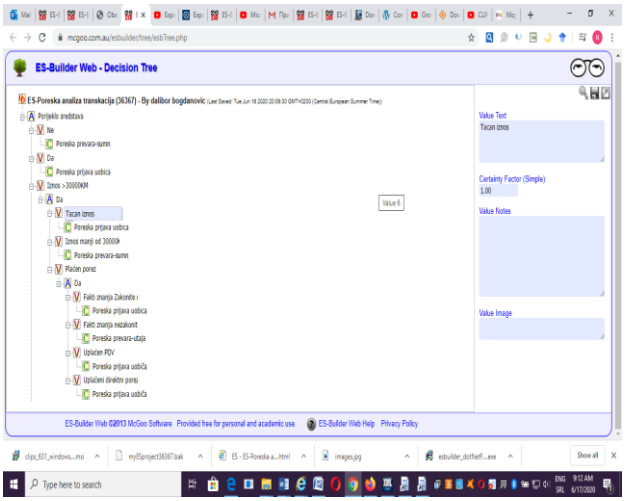

Figure 3. *Expert system builder for this model*

6. EXPERIMENTAL RESULTS

This chapter presents the experimental result of the success and efficiency of the expert system in working on a data set of an institution that fights against tax fraud or tax evasion. This approach can be applied to the global payment base in Bosnia and Herzegovina with appropriate empirical assumptions. As previously stated in the paper, it is shown that it is based on rule based rules (Legislation regarding taxpayers' tax returns) . In order to determine the results of the information search over the data set, the standard classification procedure for calculating the reported tax data was applied.

According to the required classification into "tax evasion" and "ordinary tax returns", the classification of the database can be simply described by a binary classification. The ID3 binary tree algorithm was used for this particular case. This algorithm is simple and practical to apply over almost all data sets. By applying this classification algorithm to the data set available to the financial institution over the data set, a clear model of tax evasion pattern recognition can be obtained. The first step of the ID3 algorithm of classification "origin of funds". The second step is "the type of transaction reported", the third step is the amount of the transaction, the fourth step is "whether the tax has been paid" and the fifth step is the final and these are the facts available to the expert. In binary data set classification, precision and recall are the two main parameters.

A simple metric was taken for this practical case. Two basic parameters precision and recall are

defined and they are represented by equations (1) and (2). [6]

$$precision = \frac{t_p}{t_p + f_p} \quad (1)$$

$$recall = \frac{t_p}{t_p + f_n} \quad (2)$$

The database of one tax institution contains a total of 3.597.933 reported tax returns. Of that amount, 1,891 were reported as "tax evasions", and 3.596.042 were reported as "ordinary tax returns".

For the purposes of this research, one set of data was taken and extracted from the database of the tax institution. This dataset contains transactions characterized as "tax evasion" and "ordinary tax transactions". This situation is not realistic because it is based on the legal recognition of "rule based" and it hides a large number of "tax evasions". This is the main goal of the study, recognizing or discovering hidden "tax evasion".

The current situation does not reflect the true situation in the set of tax transactions. It is clear that the accuracy of the data set of the tax institution is approximately 100% but the response over the data set of tax transactions is very small and is approximately 5%. It is clearly concluded that the accuracy of the proposed expert system is only slightly less than the accuracy of the current tax system, but the response is ten times better, ie for the order of magnitude of tax transactions.

Table 1 shows the parameters of precision, recall for 2019.

Table 1. *Results*

Transaction collection period (years)	Precision (%)	Recall (%)
2019	95.8	51.1

7. CONCLUSION

The paper specifically develops a model that, based on legally defined models (database of facts) of tax evasion, finds new models of tax evasion for a given set of data or data sets available to tax administrations or other institutions in the country. The analysis of the found new forms determines the relevance of the found forms for the next use (reusability) and they are automatically added to the knowledge base available to the system. This model is dynamic and can be used for a large number of data that are in the database and that arrive online by taxpayers who report on tax returns. All found patterns are compared with known models of tax fraud to gain additional relevance. This expert system provides a fast and efficient way to detect new models of tax fraud or evasion of tax systems in Bosnia and Herzegovina.

This system is the future in the research of new forms of tax fraud and relies on artificial intelligence, which in the foreseeable future will be much more widespread in this type of problem as well as in other fields of science and economy. The application of artificial intelligence in the detection of tax fraud patterns also reduces the error of users who deal with the occurrence of tax evasion, which is the goal of any decision support system.

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Game-Based Learning of Software Testing

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Abstract: *The importance of software testing is often overlooked leading to consequences that can affect a company's reputation. Software testing is representing a critical aspect of the software development process but considered often as tedious process when using traditional education methods. It is a challenge how to teach software testing in an effective way that can successfully motivate students. In this paper, we have carried out analysis of traditional software testing education method and software testing education with support of games. We pointed out advantages and disadvantages of using games in education of software testing.*

Keywords: *software; testing; games; traditional education;*

1. INTRODUCTION

Software testing is a critical phase in software product development [1]. It is also one of the skills that a good programmer possesses, but software testing is often considered repetitious action. It is an open challenge how to teach software testing in an effective way that can successfully motivate students. The traditional way of learning requires students to resort to standard methods of learning from provided literature and materials [2]. Every human action causes the production of the hormone dopamine, which serves as a significant part of the brain's reward system. Learning from the provided literature is a tedious process for students.

In contrast, playing games causes the student to produce very high levels of dopamine. As a result, students remain focused and spend significantly more time playing games than learning. A new generation of students has grown up in the digital world, using computers and smart devices every day, playing games and browsing the Internet. Students spend a lot of time playing games and use their problem-solving skills at a high level of motivation. In fact, the problem that the game gives them keeps their attention and concentration. Philippe Bootz's diagram clarifies the unique quality of digital texts which applies also to texts in games [3].

Given the difference between traditional and learning supported with games, more and more games that support learning have emerged in recent years. Those games have succeeded in improving student motivation and increased students desire to learn and make learning more enjoyable. Combining games and learning software testing provides easier education of software testing techniques and methods [4]. With minimal effort, students gather knowledge in the field of software testing that they can use in other subjects on faculty, in the implementation of their own projects or at work.

2. LEARNING SOFTWARE TESTING THROUGH GAMES

Educational games for software testing can be online web browser games, desktop offline games, multiplayer or single player. The target of testing games is to support material for subjects containing content related to software testing. In this way, students can improve their software testing skills even outside the classroom. Therefore, software testing games can be considered a additional material for learning of software testing. Software testing is a large area and encompasses a large number of methods that can be used in software testing [5].

Game used for software testing education should cover at least few of software testing methods shown in Table 1 [6, 7]. If software is not systematically and thoroughly tested, then software quality suffers. If students want to become experts in the field of software testing, they must know all the methods of software testing. The more software testing methods the game covers, students' knowledge will be more comprehensive.

Table 1. *Description of software testing methods*

Software testing method	Description
Unit testing	Unit testing is the first level of testing and is often performed by the developers themselves. It is the process of ensuring that a piece of software at the code level are functional and operate as they were designed to.
Integration testing	After each unit is thoroughly tested, it is integrated with other units to create modules or components that are designed to perform specific tasks or activities. Then the components are tested as group using integration testing to ensure that whole components of an application behave as expected.
System testing	System testing is a black box testing method used to evaluate the completed and integrated system to ensure it meets specified requirements. The functionality of the software is tested in detail. It is typically performed by a separate testing team than the development team before the product is forward into production.
Acceptance testing	Acceptance testing is the last phase of functional testing and is used to assess whether the final piece of software is ready for delivery. It involves ensuring that the product follows all of the original business criteria and that it meets the end user's needs. This requires the software be tested internally and externally.
Performance testing	Performance testing is used to determine how an application will behave under various conditions. The goal is to test its responsiveness and stability in real user situations. Performance testing is a non-functional testing technique and can be broken down into 4 types: Stress testing, Load testing, Spike testing, Endurance testing.
Security testing	Security testing is a non-functional software testing technique used to determine if the information and data in a system is protected. With the increasing of cyber-attacks and cloud-based testing platforms, there is a growing concern and requisite for the security of data being used and stored in software.
Usability testing	Usability testing is a testing technique that measures an application's ease-of-use from the end-user perspective and is often performed during the system or acceptance testing stages. The main goal is to determine whether or not the visible design and refined of an application meet the intended workflow for different processes, as for example logging into an application. Usability testing is a easy way for teams to overview separate functions, or the whole system, is intuitive to use.
Compatibility testing	Compatibility testing is used to measure how an application or piece of software will operate in different environments. It is used to check that your product is compatible with multiple operating systems, browsers, platforms, or resolution configurations. The goal is to ensure that software's functionality is consistently supported across any expected environment end users will be using.

3. BUILDING AN EDUCATIONAL GAME FOR THE SOFTWARE TESTING EDUCATION

Educational games are tools to support the teaching of educational contents, attractive and dynamic manner. However, before an educational game is used, it is necessary to evaluate if it can support the teaching of the proposed contents [8]. In order to develop quality software testing education game, development process should go through the phases given on the Fig. 1.

Each phase contains its processes. Only by performing all the processes from all phases provides as a result educational game for testing software with high quality. That further means that the student acquires the necessary knowledge in the field of software testing by playing the game [9]. Representation of processes is contained in next phases:

1. Literature review and systematic mapping (Fig. 2),
2. Implementation of the educational software testing game (Fig. 3),
3. Evaluation of the education testing software game (Fig. 4).

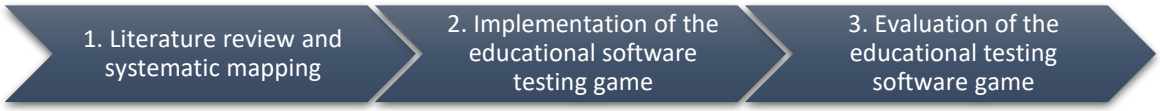

Figure 1. *Development process phases of educational game*

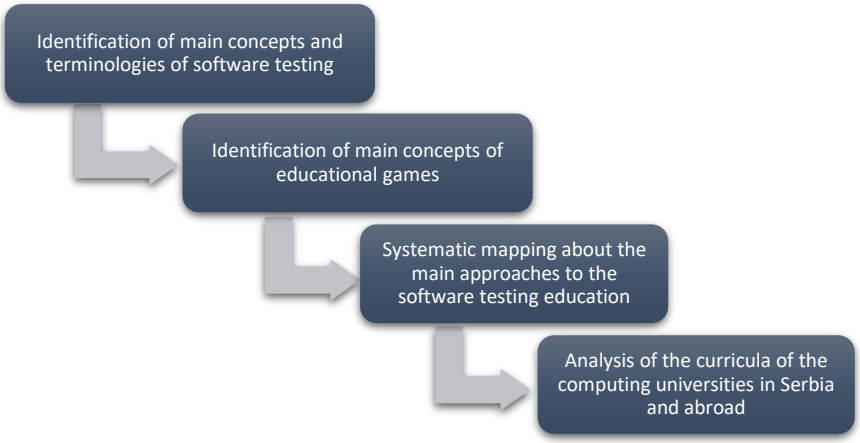

Figure 2. *Phase of literature review and systematic mapping*

Figure 3. *Implementation phase of the educational software testing game*

Figure 4. *Evaluation phase of the education software testing game*

After defining methodology used for development of the educational software testing game, it moves on to structuring the game [10]. Software testing methods covered by education game have been presented in Table 1. and there was said that game should cover at least several software testing methods. To accomplish that, multiple game levels are introduced. Each game level is representing one software testing method. Finishing one level of game means that student have learned one software testing method. At each level, there are different challenges regarding the addressed contents [11]. At the beginning of each phase there should be a description informing the students what they must do to succeed in the considered phase (Fig. 5). Another functionality should be related to the theoretical content of software testing. For each new content considered in the game, there should be a module in which the user can access and read about the new content related to software testing.

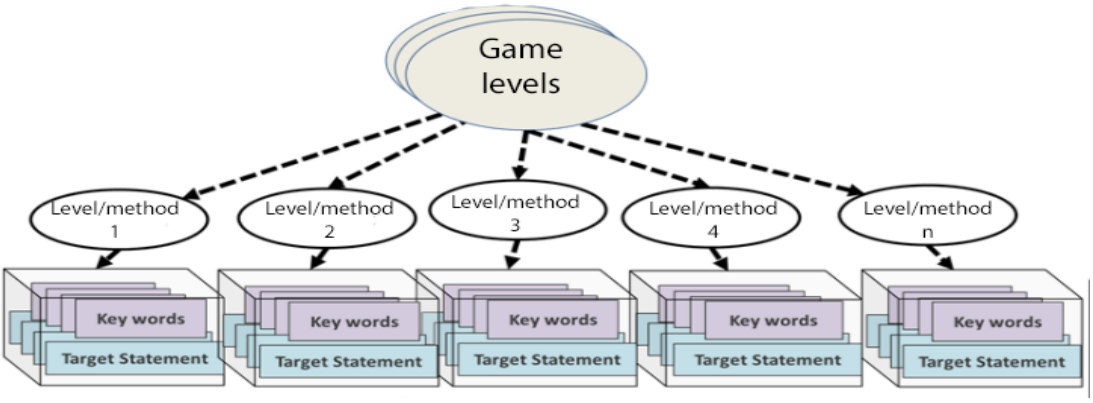

Figure 5. *Education model of each game level*

4. ANALYSIS OF EDUCATION SOFTWARE TESTING GAMES

Based on research in the field educational games in software testing [12, 13], we split effectiveness of those games in three parts:

1. Motivation,
2. User experience and
3. Learning.

Starting with the *motivation* of students, we highlight the key factors when it comes to motivation and these are: Satisfaction, Confidence, Relevance and Attention. To ensure satisfaction, students must understand that they will have the opportunity to use the things learned from the game in practice. Confidence is achieved by making the students feel they are really learning while playing the game. If the material is in line with the interests of students and related to other knowledge they have, the relevance is provided. The most important thing that distinguishes this way of learning is maintaining attention. In order to keep the student's attention, the game must have a variety of content, good design and problems that will interest students to solve them.

The next part of game effectiveness is *user experience*. The key factors in user experience are: Competence, Fun, Challenge and Immersion. If student have positive feelings about the efficiency during the game and was able to play the game trough his skills, then competence is ensured. To assess the fun of the game, we need to ensure that the student wants to play the game again, wants to recommend it to other colleagues, and wants the game to have more levels to accomplish. Game should be made to be challenging, in the way that evolves at an appropriate pace and does not become monotonous, offers new obstacles, situations or variations of activities. Students who play educational software testing game often fell more in the game environment than in the real world, forgetting what was around them, forgetting their day to day tasks, because they are staying focused on the game.

The last and most important factor of effectiveness of the educational software testing game is learning. The knowledge gained in the game should be usable in real life. When it comes to games, a person produces more dopamine hormones, and thus students spend more time learning, in other words, playing an educational game. The challenge ahead is to produce suitable games that exercise the testing methods described in Table 1. of this paper.

These examples would allowing a fine progress of the learner without leading to embarrassment (too challenging) or frustration (too easy). An overarching narrative may help to engage students. Once a software testing curriculum is implemented using these games, a further challenge lies in evaluating the effects on learners. Only if we meet all the parts of the effectiveness we have listed, learning in this way will be more effective compared to traditional learning. It will be easier for students to master the material of subjects that contain content related to software testing [14].

5. EXAMPLES OF THE EDUCATIONAL GAMES APPLICATION IN LEARNING SOFTWARE TESTING

In some countries, the application of educational games in learning software testing has been used for a last dacade. One of the first scientific papers that were created and show the development of games for learning software testing are presented in paper [15]. The games that were initially used mainly included functional testing technique, while structural testing and defect-based testing were less covered. Among the more well-known educational games used to learn functional techniques in software testing are: JoVeTest, U-TES, iTest LEarning and iLearnTest [6].

The other educational game is Bug Hide-and-Seek for reinforces testing principles by demanding students to develop correct solutions or solutions that consciously contain bugs [16]. While finding the correct or buggy solutions, students write corresponding tests. They should identify whether their solution contains bugs or not. The main goal of the game is to hide a smart bug that will mislead other students' tests and despite the hidden bug. The second goal is to recognize correct or incorrect software behavior.

6. CONCLUSION

Although software testing is a critical aspect of the software development process, there is a shortage of professionals in this field. Students usually do not understand the importance of software testing, so they often lack the motivation to learn this skill. To make learning software testing easier and give a clearer picture of the importance, many educational software testing games have been developed. As proven, students spend more time playing games than learning. Allowing students to play games and simultaneously learn software testing can be a winning combination. With educational software testing games, students' motivation increases, as well as the time spent on acquiring knowledge in the field of software testing. In the future work, we plan to survey students and provide an educational software testing game that they will play, give their opinion on this way of learning as well as grading of the achieved knowledge in the field of software testing.

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Maritime Single Window and Possibility of Improving Port for Business

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Abstract: *This paper briefly points out the importance and application of the port / maritime single window and the possibilities of their improvement in port operations. "Single Window" (SW - Single Window) concept is formalization of procedures undertaken by the competent services of the European Union through the Center for Trade and Electronic Business in order to achieve efficient exchange of relevant information between trade organizations and government entities. The concept of maritime / port single window is basically founded on formal facilitation of maritime trade and customs and is focused on increasing the efficiency of import / export mechanisms and procedures, where detailed information on cargo must be provided in all maritime cross-border activities. Application of single windows was originally focused on efficient and collaborative cross-border transactions between commercial and state / administrative entities. The paper presents main advantages of the application of single windows in the port industry that can be used as a platform for further improvement of the port and maritime economy.*

Keywords: *SW, MSW, NMSW, VTMIS, FAL Convention, single window*

1. INTRODUCTION

It is common to assume that maritime industry is globalized in functional, business and regulatory terms. At the same time these are basic elements of a barrier to development of the maritime industry, because all the participants are supposed to follow number of complex administrative procedures, including cooperation and work with customs, tax, immigration, security authorities, waste authorities, seafarers' health and the like. [1].

The United Nations Center for Trade Facilitation and E-Business (UN / CEFACT) defines SWS (Single Windows System - Single Window System) as "a service that allows customers involved in trade and transportation to submit standardized data and documents in order to fulfill all formalities of import, export and transit of goods and passengers, where information in electronic form is submitted only once in the so - called control point "[2].

The concept of SWS is also explained by the World Custom Organization (WCO) as a trade facilitation tool that allows traders or carriers to meet all the conditions of acceptance of goods in transport in a standardized format only once to the authorities that control it (WCO, 2018). However, the SWS cannot be established in a single step, but in individual steps as defined by UNESCAP / UNECE (United Nations Economic and Social Commission for Asia and the Pacific / UN Economic Commission for Europe - United Nations Economic and Social Commission for Asia and the Pacific) / UN Economic Commission for Europe) during 2012 in the Guidelines for Planning and Implementation through the following levels:

- Level 1: Paperless customs clearance;
- Level 2: Regulatory single window;
- Level 3: Unique window through B2B (Business to business) model;
- Level 4: Fully integrated single window;
- Level 5: Cross-border platform for the exchange of single windows (UNESCAP, 2018).

2. MSW

There are two SW systems, customs and maritime / port SW, and they started to be used during 2013. Within the European Union, some countries are already applying the so-called pilot / prototype (first version of the system) NMSW (National Maritime Single Window): Bulgaria, Greece, Italy, Malta, Romania and Norway, striving to implement the so-called national MSW.

MSW (Maritime Single Window) is a concept that aims to digitize and simplify administrative procedures before a ship enters / leaves a port (s), in accordance with the requirements of the European Union Reporting Formalities Directive (RFD) Formalities Directive, or short Directive 2010/65/EU, which deals with the standardization of electronic exchange of information and the rationalization of formalities for entering / leaving

a ship in / out of port (s). To achieve this, special data entry forms are used, adapted for loading into the MSW or the NMSW system [3].

Therefore, the concept of national maritime SWs is an initiative in the field of transport telematics that emerged as a result of several maritime development policies, especially the influence of the European Commission. It refers to the application of a national system that will be a single point of electronic delivery and exchange of information, different modes of transport, especially maritime transport and should be built on existing telematics applications and systems.

The NMSW model meets the needs of different participants from the local port community. Its architecture integrates and covers communication channels and reduces time and simplifies procedures in port operations (B2P - Business to Port) and operational processes in administration (B2A - Business to Administration) for ship formalities. It is clear that business relations of the port affect customers (B2C - Business to Customer), because they obviously have benefit from efficient and simple procedures with focus on standardization of information exchange. Coordination of NMSW and its function depends on the way it is analyzed. It is important whether it is analyzed as:

- a system focused on customs clearance, ie. import / export activities;
- a port and ship-oriented system with focus on maritime transport; or
- a system focused on increasing the safety and security of (maritime) transport and traffic [4].

Thus, the system with a single window is a tool that facilitates maritime and other forms of trade by enabling the entities involved in it to transmit all the necessary data, through a single platform, to the authorities that control and monitor them in order to meet all formalities and requirements [5].

The NMSW platform should be developed in accordance with national rules, European Union legislation and the IMO (International Maritime Organization), and in accordance with the Convention on the Facilitation of International Maritime Traffic (FAL). In its original form, the FAL Convention adopted by the IMO deals with the application of electronic maritime single windows and it includes the definition of procedures for all commercial ships navigating international waters.

In this way, Member States can manage different platforms, but all MSWs must meet the following requirements:

- providing electronic reporting formalities, by e-transmission through single windows by 1 June 2015;
- develop a one-spot reporting platform, that will be available to a number of Member States' authorities and controls;
- receive information in accordance with the reporting formalities provided by EU legislation, which must be available in the national SSN (SafeSeaNet - Safe Maritime Network), as well as to other EU bodies through the SSN system.

Following European and UK regulations on customs, taxes, immigration, security, health and safety, as well as waste management, there are additional, more detailed requirements in the UK than those prescribed by the FAL in the European Union. As NMSW is a new tool for providing detailed electronic reports and it does not expand the set and content of existing reporting requirements, including an environment for collecting, disseminating and exchanging of information, reporting from ships with a structured and commonly defined data structure, rules and access rights management, which are in accordance with the relevant international, national and local legal requirements, the following text briefly explains information flow in generation of the report, as one of the most important segments, on the example of the British prototype NMSW.

3. INFORMATION FLOWS IN CREATING MSW REPORTS

As already pointed out, the purpose of NMSW is, above all, delivery of electronic instead of paper documents, and users receive automatic confirmation if sent documents are received correctly, plus the document is received by the multiple entities at the same time. Below is a schematic presentation of the information flow within the NMSW system that is applied when generating reports in the UK. Since it is a prototype, detailed instructions for using NMSW for e.g. in the UK is likely to undergo changes very soon in the future. Currently, this system requires user registration when accessing by entering company data and user e-mail address, after which it enables and supports the entry of all relevant and requested documents in the form of attachments [6, p.7].

Access to the British NMSW model is protected, and data on the registered user is not passed on to unauthorized parties. The data is not used without the prior consent and consultation of users, e.g. when a system outage is expected or planned. A schematic presentation of sending reports in the direction of NMSW and VTMIS (Vessel Traffic Management Information System), or SSN, is shown in Figure 1.

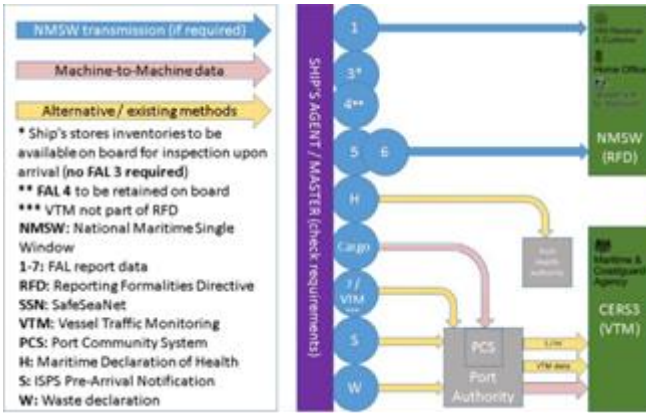

Figure 1. Information flow from the ship to NMSW and CERS (Consolidated European Reporting System) European reporting system) on the example of Great Britain (source: [4, p.11])

VTMIS forms the basis of an electronic platform for the exchange of information at the level of the European Union (as SSN) and includes aspects related to maritime affairs: security, safety, environmental protection, control, prevention of marine and coastal pollution, fisheries control, border control, etc.., in compliance with legal regulations. In addition, VTMIS is largely linked to the physical control of ship traffic. VTMIS aims to increase the safety and efficiency of maritime transport (goods and passengers) and maritime transport (ships) on the basis of regular information, exchange and sharing of information.

The time of receiving the report is contained in the e-mail sent to the user or users after the successful loading of the report into the system. Port authorities require that information is provided on the arrival of a ship to the port, in order to provide the necessary services in a timely manner, but this request is currently outside the scope of the NMSW.

In order to make it easier to follow the flow of information, some basic explanations related to NMSW, ie, NSW, VTMIS and SSN [6], are given.

Providing that international shipping faces problems in submitting mainly paper documents to national authorities, NMSW is trying to solve the problems of developing and implementing NMSW in creating and exchanging electronic reports and forms. The UK as well as the countries of the European Union have a legal obligation to provide NMSW services in accordance with the RFD.

By providing digital reports and electronic exchange, ships can be sure that their information has been received. The data can be accessed from several different parties, and the same can be used and received by multiple entities. The system is designed to be simple and economical to use, while problems such as the use of inaccurate contact information, faulty or unreliable equipment, unclear handwriting and lack of clarity about reporting are minimized.

The RFD defines the entry of relevant data at least 24 hours before the ship enters UK ports, and if the voyage is shorter than 24 hours, reports should be sent during the ship's departure from the previous port, while if the next port of call changes during the voyage, or is not known at the time of departure, the report should be sent as soon as the information on the next port is available. FAL reports cover reports related to the elements: FAL 1: General declaration reports; FAL 2: Cargo reports; FAL 3: Ship Trade Reports; FAL 4: Crew Performance Reports; FAL 5: Crew list reports; FAL 6: passenger list reports; FAL 7: Reports on the transport of dangerous goods; and reports related to ship-generated waste as well as reports related to seafarers' health are included (Figure 1).

With the introduction of national maritime SWs in all EU Member States, based on the flow of information contained in Forms FAL 1-7, PAN (Pre-Arrival Notification) and the Waste Declaration, it is clear that FAL 1 and FAL 5/6 must be entered in the NMSW, while other forms (announcements / declarations) are optional and communicate through the Ports' Community Services (PCS) and port authorities with VTMIS at the national or SSN level at the European Union level. Starting from June 1, 2015 when leaving the port of Great Britain, ships must send an exit check. This report is sent at the time of leaving the port, via the NMSW portal and must contain FAL 1 (Universal Declaration) and FAL 5/6 (Manifesto or crew / punt list) [6, p. 7]. If the NMSW is not available for any reason, reports should be sent as soon as the system becomes available. Scheduled outages are posted in advance on the user access page, and are usually scheduled at intervals when traffic is reduced.

In case of prolonged interruption, reports can be sent by fax or e-mail. Reports sent from UK ships to the NMSW are forwarded to: Border Police for Security and Immigration Procedures (FAL 1, 5/6) and - HMRC (Her Majesty's Revenue and Customs) to the Customs Service (FAL 1 , 5/6). Confirmation of receipt is sent to the official e-mail address of the user. Users can also provide an alternative e-mail address, to which they will also be sent a confirmation of receipt. All those documents that the commander or agent considers relevant can be loaded into the system as additional.

The forms are simple and contain a header with general information about the ship, they can be copied, ie. used in the same form in each subsequent reporting, thus reducing the volume of administrative work and the number of paper documents on board and on land. NMSW and MCA / CERS (Maritime and Coastguard Agency / Consolidated European Reporting System) are currently separate and serve different but not currently unrelated purposes. NMSW is used for reporting from ships, usually through agents, to the police and customs.

CERS is tied to individual ports and directs VTM (Vessel Traffic Monitoring) reports, such as PAN (Pre-arrival Notification) to the MCA, primarily for security purposes. CERS also has access to PCS. CERS is upgrading and the new version will be able to accept FAL 7, the Waste Declaration and the ISPS PAN (International Ship and Port Facility Security Code) by the ports. MCA works with ports in terms of defining methods for automatic exchange of information [7].

In the future, work will be done on the development of interaction and unification of NMSW and CERS, and any decision on this issue will be forwarded to the users of both systems. For now, in this British prototype there is only an experimental link between NMSW and CERS.

4. ADVANTAGES OF MSW IN IMPROVING PORT BUSINESS

Regardless of numerous implementation problems, a number of key benefits are highlighted below, which MSW provides to the shipping and port industry and onshore administrations involved in maritime transport:

- MSW is a flexible and user-friendly tool for automatically linking relevant information on ships, passengers, crew and / or cargo, related to reporting from the ship to the coast and port and vice versa;
- By exchanging information on the ship, passengers / crew / cargo, among all participants involved in the reporting process, the application of MSW respects the right of access to information;
- The implementation of MSW significantly reduces the time to send reports, which frees the crew from part of the administrative work and provides a better focus on the tasks of direct ship management, increasing the safety of navigation;
- Total reporting costs are reduced and the need to hire intermediaries is eliminated;
- IT complexity is reduced by using simple solutions in the field of maritime transport / traffic, full reporting is provided, ie, monitoring of ships at the local, regional, (supra) national level (s);
- Compliance with international standards is ensured, such as: ISO 28005, WCO, EDIFACT (Electronic Data Interchange for Administration, Commerce and Transport), including specific EU requirements [8, p.14] etc.
- Maritime and logistical procedures have been simplified;
- Shipping services have been improved in business terms, with a significant reduction in delays, as the most important element in reducing maritime operating costs;
- The need for direct contact is reduced by reducing costs and increasing data transparency;
- Transaction security is increased, and data transfer is adapted to all (included) business systems;
- Paper transactions are eliminated, and the universal single point for entering relevant data avoids duplication of data entry and exchange;
- The system is protected from intrusions, information leaks and viruses;
- The system is scalable with simplified procedures for activating new customer services.

5. PROBLEMS IN THE IMPLEMENTATION OF MSW

The development and implementation of SW can be analyzed from an international, national, regional or local aspect. All EU members, as well as associate members, are connected (or will soon be) to a central national body that will be the official liaison with the SSN, to which EMSA (European Maritime Safety Agency) is responsible [4].

The most important problems related to the implementation of MSW relate to the issue of ownership, because it is not yet clear whether it represents: public, private or public-private ownership. From the point of view of costs, the question arises whether the services provided by the system are free for users or are paid, that is, who pays for them and how much.

In many cases, the Port SW is identified with the PCS (Port communication System), which is based on integrated procedures, rules, standards and ICT solutions that support automatic data exchange, ie, documents relating to the ship, crew, passengers. and cargo, when entering, staying in port and / or leaving the ship.

However, although the PCS supports the requests of national agencies and entities interested in cargo, it covers customs and cargo handling requirements, as well as the exchange of information related to services provided in the port to the ship and cargo, emphasizing private and commercial information related to ordering and charging for port services, rather than just tracking the ship.

On the other hand, EPC (Electronic Port Clearance) is a concept that is more related to ships and their electronic management of formalities related to documentation and procedures at entry / departure, ie, during the ship's stay in port [4].

Finally, there is a need to combine these two (PCS and EPC) very complex and so far incompatible systems that can be combined with a single MSW.

6. CONCLUDING REMARKS

Initiatives to establish a European environment with a single window in port and maritime transport solve the problems of the current inefficiency of the environment in reporting in port transport for maritime transport operators, which arose from some limitations of the RFD directive of the European Union. However, the currently valid directives do not provide precisely defined guidelines or define obligations that can guarantee development of a common and integrated model and data exchange flows in maritime transport. Therefore, the main challenge is to harmonize procedures that may be imposed by national regulations, given that inconsistent reporting at EU level is a lengthy process that simultaneously burdens both shipping, ports, seafarers and maritime and transport companies operating in the international market. However, the most important thing is that the whole port community recognizes the benefits of adopting the MSW model, because only in this way can the entire supply chain through ports and the maritime economy be an efficient and simple model of communication and information exchange tailored to users.

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Data Analysis and Artificial Neural Network Modelling of COVID-19 Patients

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Abstract: *The pandemic of novel coronavirus (SARS-CoV-2) causing the COVID-19 infectious disease has changed our life significantly. From the moment of its detection, numerous teams of scientists and medical staff have worked tirelessly to find the cure and vaccine, and to take care of the patients. In this paper, a small contribution in this combat has been made by creating an artificial neural network model for predicting the patients' outcome of the disease. The mean accuracy of the realized model was 87.50%, which can be further improved with a larger dataset being provided.*

Keywords: *artificial neural network; COVID-19*

1. INTRODUCTION

COVID-19 is an infectious disease caused by SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) virus, a member of the coronavirus family. It was first reported in Wuhan, China, in December 2019, and the World Health Organization (WHO) declared a pandemic of COVID-19 disease on March 11, 2020 [1] – [3].

As of August 3, 2020, there are 17,918,582 total confirmed cases of COVID-19, with 686,703 deaths worldwide [4]. The number of COVID-19 cases by countries is graphically shown in Fig. 1 [4]. The distribution of COVID-19 total cases by WHO regions is given in Table 1 [5]. As for Serbia, the total number of registered COVID-19 patients by August 3, 2020, is 26,451, and the total number of registered deaths caused by COVID-19 disease is 598 [6].

The main symptoms of SARS-CoV-2 infection are fever, dry cough, and tiredness [7]. Other symptoms include loss of taste or smell, aches, nasal congestion, headache, sore throat, diarrhea, skin rash, etc. Around 80% of the patients develop only mild symptoms of the disease, while those with chronic diseases are of great risk of complications [7] – [9].

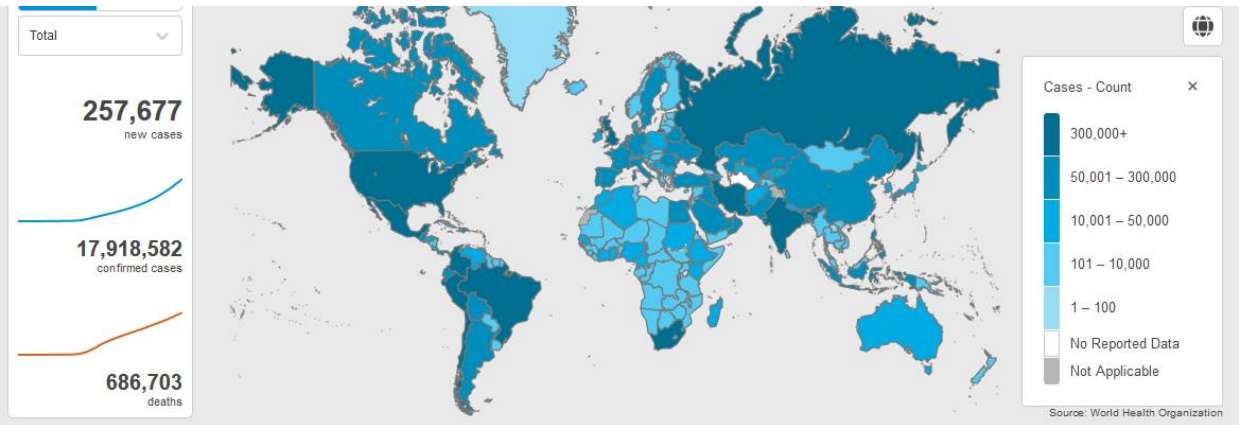

Figure 1. *The number of COVID-19 cases by countries [4]*

The main purpose of this research is to make contribution in the combat with COVID-19 by inspecting possible correlations between patient's age, symptomatology, and medical condition. This is done by creating the artificial neural network that takes these parameters as inputs and tries to determine the patient's outcome (dead or healed).

In [10], the authors created a model for predicting the status of COVID-19 patients in South Korea. The total number of patients records used was 1308. The overall accuracy of recovered cases was 95.7% in training, and 93.8% in testing subset. The overall accuracy of dead cases was 99.6% in training, and 99.5% in testing subset.

The authors of [11] created a support vector regression model for predicting COVID-19 cases in India. Their model had above 97% accuracy in predicting number of dead, recovered and total number of cases, and 87% accuracy in predicting daily new COVID-19 cases in India.

Similar research was conducted in [12], where artificial neural networks were used in forecasting COVID-19 cases in several countries.

Table 1. *Total number of COVID-19 cases by WHO regions [5]*

Region	Total number of cases
Africa	815,996
Americas	9,630,598
Eastern Mediterranean	1,564,836
Europe	3,391,779
South-East Asia	2,187,015
Western Pacific	327,617
Worldwide	17,918,582

2. DATASET DESCRIPTION AND ANALYSIS

The dataset used is consisted of 26,529 patients and it is available at [13]. Of these patients, 54.93% are male, and female the rest. The distribution of patients' countries is given in Fig. 3.

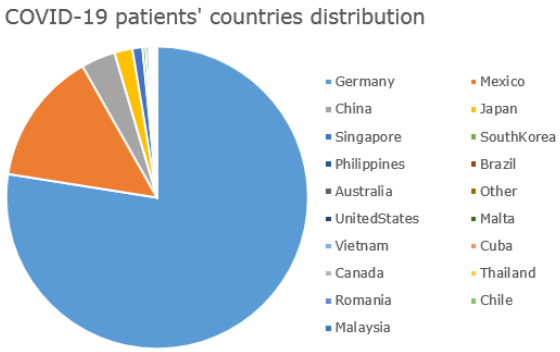

Figure 3. *The distribution of patients' countries*

The average age of patients was 44.22 years. The average age of male patients was 44.72 years, and of female patients was 43.63 years.

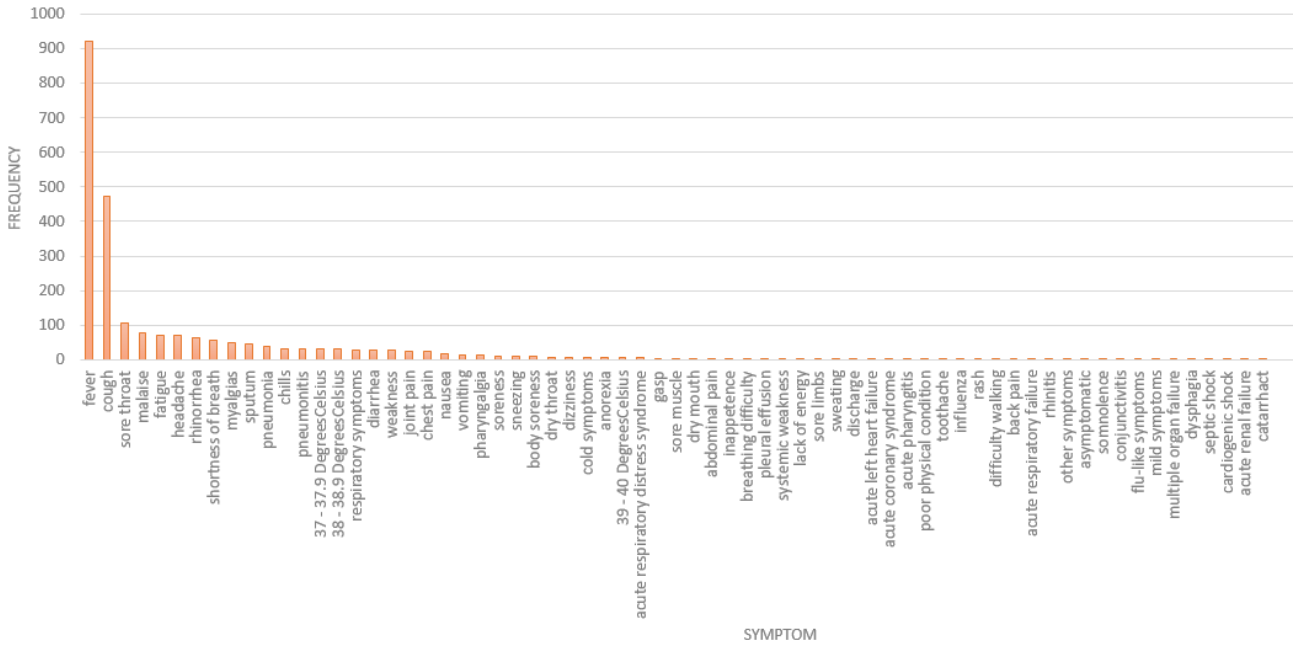

Figure 2. *The frequency of patients' symptoms in the dataset*

The number of recorded patients with symptoms was 1220. These symptoms, along with their frequency is shown in Fig. 2. From Fig. 2, it can be seen that fever and cough are the two most frequent symptoms among COVID-19 patients. Far from those, there are sore throat, malaise, fatigue, headache, rhinorrhea, shortness of breath, etc.

The total number of patients who died was 45 with an average age of 70.44 years. Out of all patients who died, 14 were women, and 31 were men. Of these 45 deceased patients, 30 had chronic diseases, with 17 of them having two or more chronic diseases. These chronic diseases with the number of occurrences among the deceased patients are given in Table 2.

Table 2. *Chronic diseases with a number of occurrences among deceased patients*

Chronic disease	Number of occurrences
Asthma	1
Cerebral infarction	1
Chronic bronchitis	2
Chronic kidney disease	2
Chronic obstructive pulmonary disease	1
Chronic renal insufficiency	1
Colon cancer	1

Coronary heart disease	4
Coronary stent	1
Diabetes	15
Encephalomalacia	1
Frequent ventricular premature beat	1
Hemorrhage of the digestive tract	1
Hip replacement	1
Hypertension	20
Parkinson's disease	2
Stenocardia	1
Tuberculosis	1
Valvular heart disease	1

As can be seen from Table 2, the two most frequent chronic diseases are hypertension and diabetes, with coronary heart disease far in third place.

The symptoms that these patients had before admitting to the hospital are given in Table 3.

Table 3. *Onset symptoms among deceased patients*

Symptom	Number of occurrences
Acute renal failure	1
Acute respiratory distress syndrome	5
Acute respiratory failure	2
Cardiogenic shock	1
Chest pain	4
Chills	1
Cough	18
Diarrhea	1
Dizziness	1
Fatigue	6
Fever	27
Gasp	4
Headache	2
Multiple organ failure	1
Myalgias	2
Pneumonia	6
Septic shock	1
Shortness of breath	4
Somnolence	1
Sputum	2
Vomiting	1
Weakness	1

As can be seen from Table 3, the top two symptoms among deceased patients are fever and cough.

The number of patients who were healed was 194. Their average age was 45.68 years, and 116 of them were men, while 78 were women. The number of discharged patients with chronic diseases was 21, with hypertension and diabetes being the most frequent. Also, the two topmost symptoms among them were fever and cough.

3. ARTIFICIAL NEURAL NETWORK MODEL AND ANALYSIS

The main goal of the research was to determine if the artificial neural network (ANN) could be used for the prediction of patients' outcome (dead or healed). Firstly, the original dataset was modified in a way that only patients that were categorized as dead or healed were included. From the original 26,529 patients, the comprised dataset consisted of 241 patients, of which 45 were deceased, and the rest were discharged from the hospital as healthy.

The ANN model was created in Python programming language, using Keras and Sci-Kit Learn libraries. The ANN consisted of three layers, one input layer of 82 neurons, one hidden layer of 41 neurons, and one output layer of one neuron. The input variables were age, sex, symptomatology with individual symptoms, presence of chronic diseases, and the number of chronic diseases. The output variable was the determination if the patient had died.

The Adam optimizer was used with a uniform kernel initializer. Also, the activation function used was the Rectified Linear Unit in the hidden layer and Sigmoid in the output layer. For the loss function, the Binary cross-entropy was chosen. For ANN training, 80% of the dataset was used, and the rest for ANN testing [14].

The initial run of the ANN model gave an accuracy of 91.15% on the training data subset. The accuracy of the testing subset was obtained with the confusion matrix, Fig. 4.

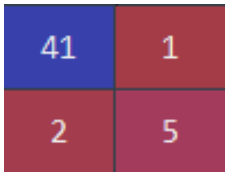

Figure 4. *The confusion matrix*

The confusion matrix is composed of True Positive (TP) cases (top left), False Negative (FN) cases (top right), True Negative (TN) cases (bottom right), and False Positive (FP) cases (bottom left). The accuracy from confusion matrix is calculated as [15]:

$$accuracy = \frac{TP+TN}{TP+TN+FP+FN} \quad (1)$$

As can be seen from Fig. 4 and Eq. (1), the accuracy of the ANN model on the testing subset was 93.88%. To establish model validity, 10-fold cross-validation was performed. Based on cross-validation results, the mean value of accuracies was 87.50% with an 8.5% variance, which means that the ANN model has significant variations in the accuracy. This can be explained by the lack of data since it was trained on only 241 patients' data.

Comparing the obtained results with relevant one from the literature [10], it is clear that the realized model has somewhat lower accuracies, but that can be due to the substantial differences in datasets used in both cases. The dataset used in [10] is over five times larger than the one used in this research.

4. CONCLUSION

COVID-19 is an infectious disease caused by the SARS-CoV-2 virus. It was first detected in China in December 2019, and in a relatively short amount of time, has widespread across the Earth. It caused many deaths, with quarantine being in effect in almost every country that has encountered it. It changed our way of life and habits and has the potential to break even the largest economies.

In this paper, the ANN model was created for predicting COVID-19 patients' outcome. It was shown that even with a relatively small amount of data, the realized model can be used for prediction of whether the patient will die or recover from it. Of course, with the availability of a larger dataset, the model could be further improved and its validity verified.

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Analysis of Term ”Web” Using Opinion Mining Techniques

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Abstract: *Due to the growing amount of data available on the web and the valuable information that can be obtained from their analysis, this paper aims to present one of the ways of data processing, using opinion mining techniques. In this paper, the term "web" is analyzed, and the data on which the analysis was performed are taken from various social networks on which this word is mentioned. From the achieved results, a certain successful application of the mining tool is intended in order to determine the positive or negative connotation of the text, while further work in the field of "neutral" attitudes is forthcoming.*

Keywords: *data mining; opinion; web mining; text analysis; web mining tools*

1. INTRODUCTION

Web content mining involves extracting useful information from the content of the Web page, i.e. researching text, images and graphics on the Web page to determine the relevance of the content for a given query. Due to the heterogeneity and shortcomings of structured Web data, disclosing such information is a great challenge. The process of discovering content on the Web can be divided into two points of view: an agent-based procedure and a database-based procedure. The first aims to improve the retrieval and filtering of information, and the second to model data on the Internet in a more convenient form, in order to apply standard query mechanisms for databases and data mining for analysis [1].

Opinion mining, also known as sentiment analysis, involves the research of a text, i.e. the processing of natural language to monitor the public's mood about certain products and events. In this way, companies can analyze the opinions of users about their products, services or ideas. Opinion analysis involves the use of data mining, machine learning and artificial intelligence to process changing opinions [2]. Social networks like Facebook and Instagram have increased the ability to analyze opinions.

There is a large amount of related research in this area. Authors in [3] used opinion mining techniques to analyze the term “Information technology”. The results indicate the possibility of successful application of the mentioned techniques while opening up a future research question in the domain of “neutral” attitudes.

The authors in [4] analyze students attitudes with text processing in Rapid Miner.

Sentiment analysis is used with a variety of data sources, from text to social media. In general, both structured and unstructured data are analyzed. The authors in [5] present an analysis of unstructured Twitter data.

Having in mind the previous research, the goal of the paper is defined: to determine the possibility of applying two different tools in order to analyze sentiment.

2. RESEARCH TOOLS AND METHODOLOGY

Voyant Tools [6] is an online tool for analyzing various text formats (text, HTML, XML, PDF, RTF, MS Word). The "Voyant Tools" tool was used to analyze the text for the experimental part of this paper. The tool offers the ability to copy the text we want to analyze or upload the entire file. For the purposes of this paper, the text “Introduction to Web Mining” (M. Yadav, P, Mittal, “Web Mining: An Introduction,” IJARCSSE, March 2013, [1]) taken from the Internet was analyzed. Some of the sentiment analysis tools are: Brand24, Clarabridge, Repustate, Lexalytics Social Mention, Social Searcher, Sentiment Analyzer.

RapidMiner [7] is a tool that provides an integrated environment for data preparation, machine learning, text analysis and predictive analytics. It is used for business and commercial applications, for research, education, training, rapid prototyping and application development and supports graphical data analysis.

The RapidMiner tool was developed on an open core model. The free version is limited to one logical processor and 10,000 rows of data and is available under the AGPL (Affero General Public License -

license for free software) license [8]. Commercial versions start at $ 2,500.

As in the free version of RapidMiner the tool has much greater possibilities of graphical data analysis compared to other programs, this tool was used for the experimental part of the work. For the purposes of this paper, using the RapidMiner tool, the CSV file downloaded from the social-searcher site was analyzed. Data analysis was performed on a set of data collected from the English-speaking area, for the term "web".

Data analysis begins by inserting the downloaded data into the "RapidMiner" tool, when it is possible to make changes and adjust the data entry, or format the data in the table. Downloaded data includes images, statuses and videos downloaded from Facebook, Instagram, Twitter, YouTube, Vimeo, Flicker, Dailymotion, Reddit, etc. Collected user comments are positive, negative or neutral.

3. RESULTS

RapidMiner operators were used for data analysis, the data analysis procedure is shown in Figure 1.

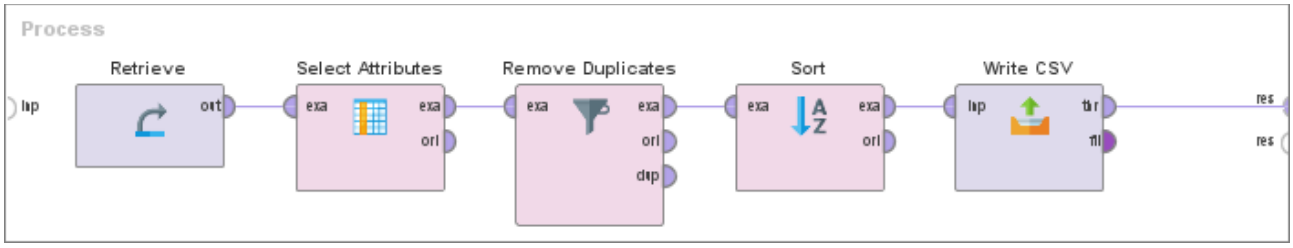

Figure 1. *Processes for data analysis*

The data is first entered into the Retrieve operator, whose task is to retrieve the entered data, which in this example is stored locally, in the data folder.

Once the data has been downloaded, the Select Attributes operator selects the attributes to be used in the analysis. The Select Attributes operator offers the ability to select the type of attribute selection. Only one attribute can be selected, which attributes will be displayed, and regular expressions can be used to customize the display of attributes. In this case, the attributes to be used in the analysis are selected.

After selecting the attribute, it is necessary to remove duplicate entries using the Remove Duplicates operator and sort the data using the Sort operator. In the given example, sorting is performed according to the network attribute, in descending order.

When sorting is complete, the results are saved to a CSV file using the Write CSV operator. The Write CSV operator offers the ability to adjust parameters such as the type of separator, whether to display attribute names in the first row, and whether to add it to an existing file.

Figure 2 shows the result of starting this process.

Figure 2. *The result of starting the data analysis process*

The RapidMiner tool offers the possibility of analyzing data based on the network from which they were downloaded, as well as a ranking list of all social networks sorted according to the amount of downloaded data.

In the given example, the data were collected from ten different social networks, and in Figure 3 it can be seen that most of the data was downloaded from Twitter, YouTube and Instagram, and the least from Reddit and Flicker.

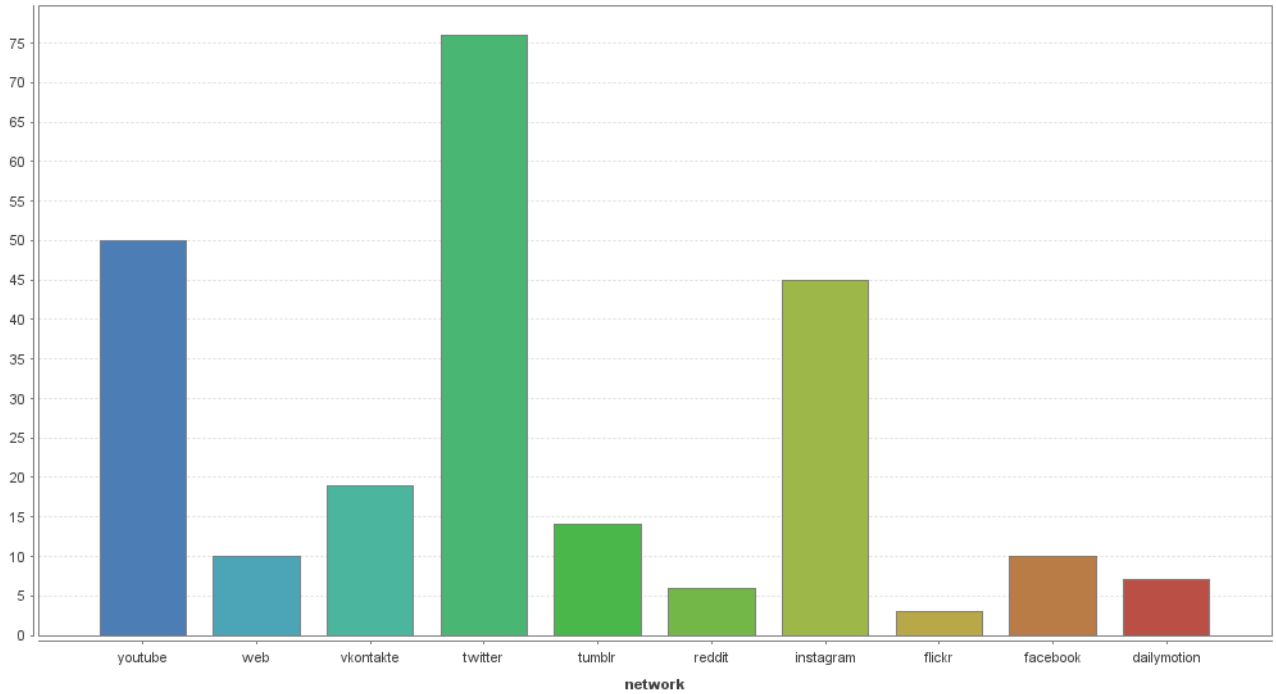

Figure 3. *Data analysis based on the network from which they were downloaded*

Data types are determined based on the Web sites from which they were downloaded. The collected data can be divided into four groups:

- links,
- videos,
- status,
- pictures

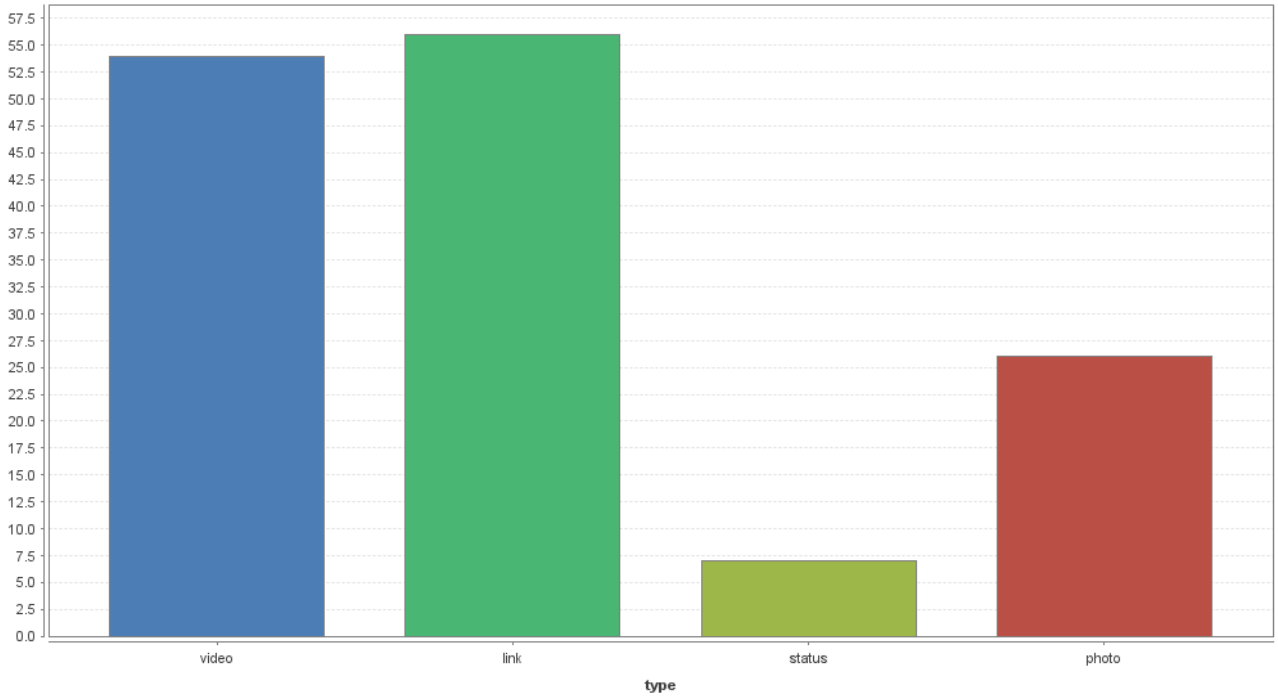

Figure 4. *Data analysis based on data type*

Figure 4 shows that the most common data types are link and video, while the least common type is status. The reason for this statistic is that most of the data comes from sites that serve for the distribution of multimedia data (video, images).

The sites that are used for discussion, publication of opinions and publication of tutorials are selected.

Sentimentality is the basic feeling, attitude, assessment or emotion associated with an opinion. It can be divided into three basic groups:

- positive,
- negative,
- neutral.

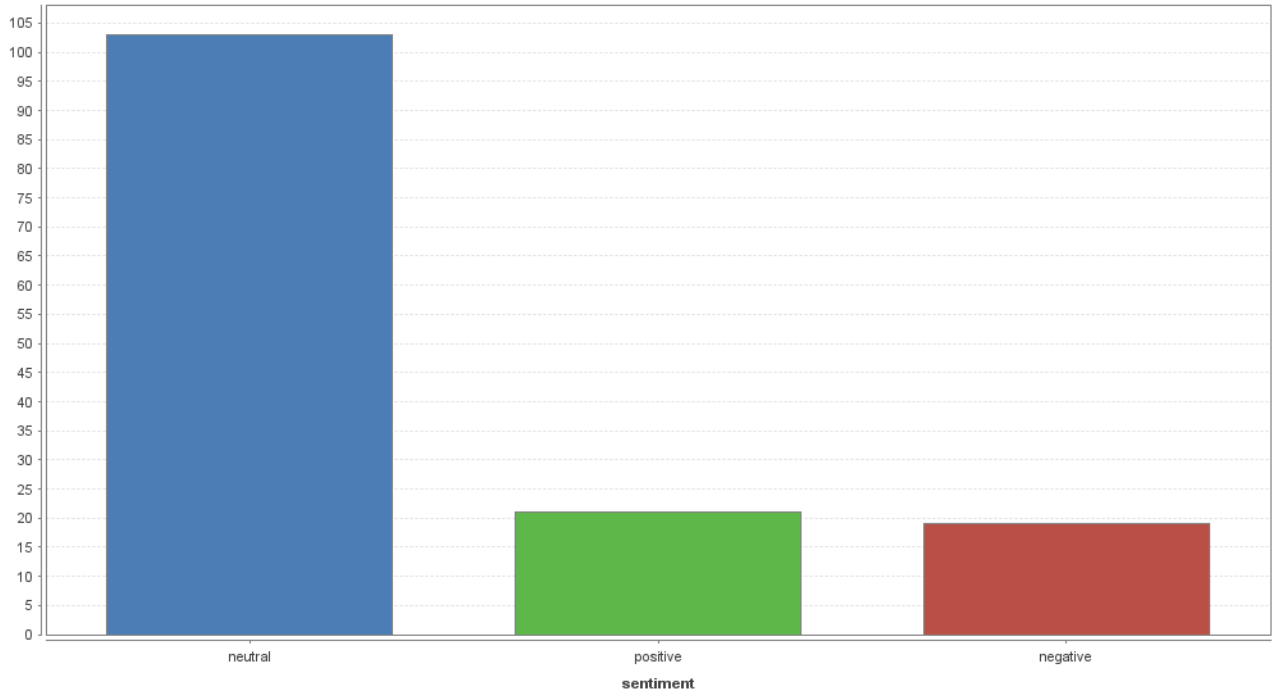

Figure 5. *Data analysis based on sentimentality*

In Figure 5 it can be seen that most neutral opinions (103), 21 positive and 19 negative. There is a possibility that neutral opinions can be classified as positive or negative opinions, because the programs that take comments are not advanced enough to recognize sarcasm or ambiguous expression of people.

Figure 6 shows the key words in the document, i.e. the words that are most often repeated with the links between them, so e.g. if any word is selected, the words associated with it will be bolded, as in Figure 6.

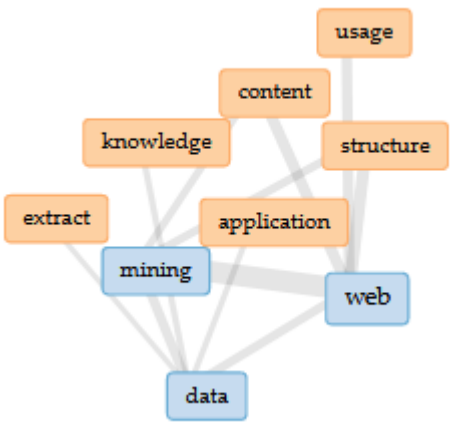

Figure 6. *Links between the most commonly used words in a document*

In order for the user to have an insight into the analyzed text, this tool also offers one of the windows in which the content to be analyzed is displayed. The user can thus review the text and can mark each word in the content and see how often it is mentioned in the entire text (Figure 7).

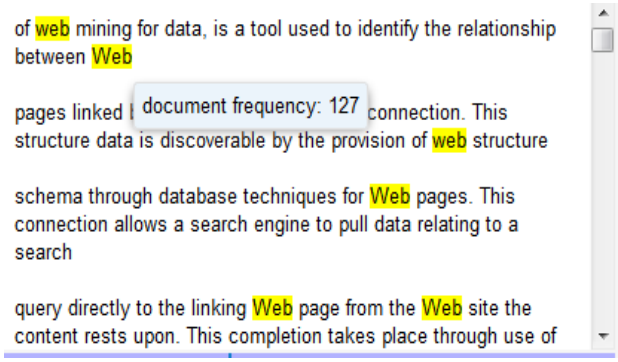

Figure 7. *The appearance of the word "web" and* the *total number of impressions*

Figure 8 shows the trend of the number of most frequently used words. The X axis presents the entire document that can be viewed by the number of pages, while the Y axis presents the number of repetitions. The disadvantage of this analysis may be the presentation of conjunctions that are inevitable in any text, so this type of analysis does not always bring useful results. The graph presents

an analysis of the most commonly used words, there are 5 of them and they are presented in various colours in order to more easily notice and see the results.

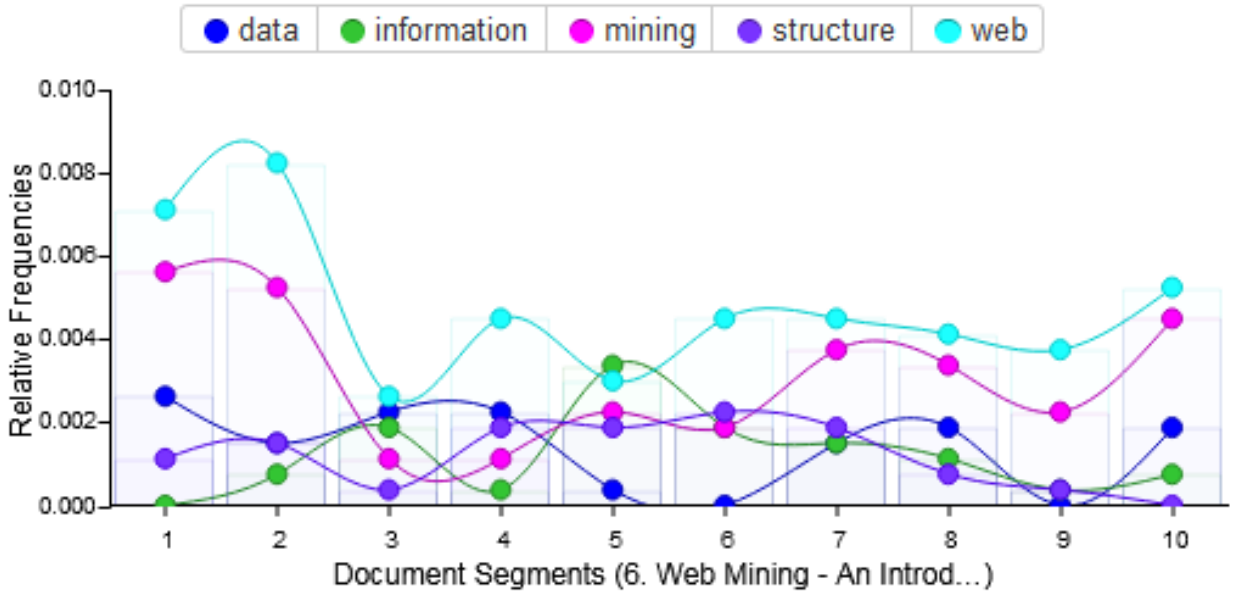

Figure 8. *The trend of the most frequently used words*

Figure 9 shows the summary results of the analysis of most frequently used words. The tools used at universities in order to detect plagiarism, i.e. the degree of identity with the content found on the Internet, or in the database, are based on a similar principle and technologies. For such systems, such technologies are used, i.e. the display of connections between words, so the identity of two or more textual contents is checked.

			Term	Count
⊞	☐	1	web	127
⊞	☐	2	mining	83
⊞	☐	3	data	38
⊞	☐	4	information	32
⊞	☐	5	structure	32
⊞	☐	6	content	20
⊞	☐	7	usage	17
⊞	☐	8	page	14
⊞	☐	9	pages	14

Figure 9. *Summary results of the analysis of most frequently used words*

4. CONCLUSION

Bearing in mind presented results it could be concluded in several directions:

- the possibilities of opinion mining in analysis of different terms and getting valuable knowledge about using selected terms and context of using;
- the use of term "web" in context of status and trends of use;
- types of possible use in different sites (e.g. links, videos, status, pictures)

Future work is related to appliance of order technique of sentiment analysis in order to get more precise information about analysed term.

ACKNOWLEDGEMENTS

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Professional paper
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Adaptivity of Web Applications – Case of Preschool Web Portal for Interinstitutional Data Integration and Analysis

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Abstract: *Adaptivity and adaptability of software has become one of most important issues, since changes are the essential aspect of modern agile approach to software development. It is very important to address types of changes and how they could be anticipated and supported in software as a product. Therefore, the adaptability and adaptivity of software rise as an important feature that needs to be planned, integrated and maintained during the software lifecycle. Aim of this paper is to present a case study which demonstrates the adaptivity and adaptability of a web portal, which has been developed for the particular needs of preschool management. This portal enables data collection and integration from various institutions, data processing and visualization of results, in aim to support strategic management decision making. This paper specially emphasizes adaptivity (automated self-adaptation of software) and adaptability particular aspects that were implemented in the solution - graphical, functional and platform-related.*

Keywords: *adaptivity, adaptability, web application, preschool, data integration, data analysis*.

1. INTRODUCTION

Changes are inevitable in modern software development. They are constant due to [1]: refinements in user requirements, infrastructure/ technology advancements, organizational and legislation transformations, which encourage appropriate software improvements. Frequent response to clients' needs and changes is key aspect in modern agile [2] software development.

Having human role and productivity in software development and maintenance, it is of a great importance to consider software to be adaptable and adaptive. The crucial distinction between these two terms is in the level of software self-adaptation [3], where being completely "adaptive" includes ability to perform automated self-adaptation (including behavior and structure), as a response to changes in working environment.

This paper presents results in creating an adaptive software solution – a web portal for preschools that enables collection of data from various sources, i.e. institutions, as well as the data processing and visualization. The purpose of the web portal is to be the support to strategic management, particularly in resources planning. Aim of this paper is to focus on specific aspects of the solution's adaptivity – challenges and implementation of this important feature.

The rest of the paper is organized as follows: section two provides theoretical background, section three presents related work, section four describes the developed web portal solution and section five specifies details regarding implemented adaptivity of the software. Finally, section six provides conclusions.

2. THEORETICAL BACKGROUND

According to [4][5], adaptive software is defined as a software that dynamically adjusts its' behavior during run-time, as an answer to changes in working environment. In [3], self-adaptive software is defined as a system with closed feedback, where the control information is gained from the system itself (the "self" component - states of the system, i.e. elements of the software architecture) and the working environment (the „context"– everything that is in the operative environment and that affects the properties and behavior of the system).

Figure 1. presents key elements and the process of self-adaptation, which includes sensors to detect changes in environment, monitoring process over

the events in the working environment, detecting the change, requesting and deciding to make change and acting upon decision by initiating effectors to perform the change.

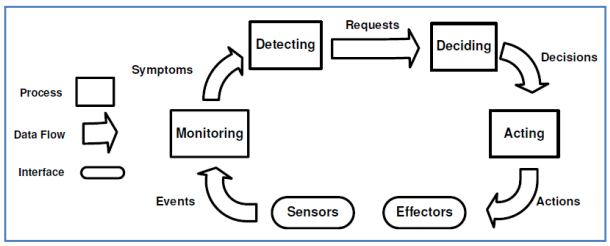


Figure 1. *Key elements and process of self-adaptation [3]*

Figure 2. presents key functional aspects of self-adaptive software, such as:

- *Primitive level (self-awareness and context awareness),*
- *Major level (self configuring, self-optimizing, self-healing, self-protecting),*
- *General level (self-adaptiveness).*

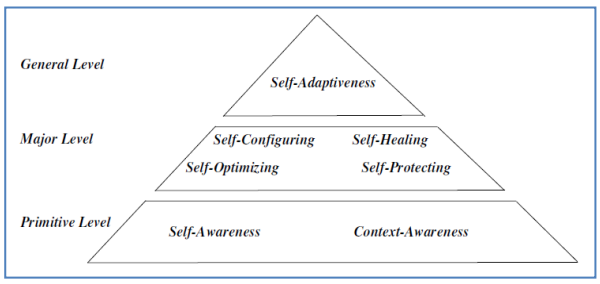


Figure 2. *Hierarchy of key features of self-adaptive software [3]*

Figure 3. presents two types of software regarding the level of automation in the adaptivity:

- Adaptive software (i.e. self-adaptive software) – internal approach where the adaptation mechanism is within the software solution itself,
- Adaptable software – adaptation mechanism is a module external to the core functional software itself.

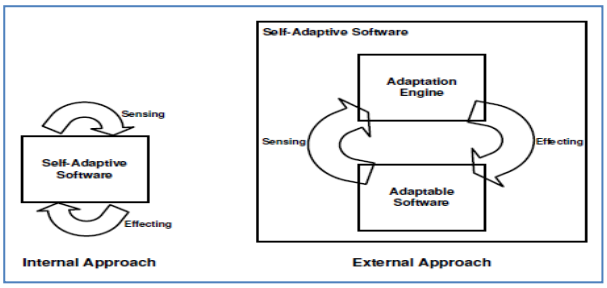


Figure 3. *Adaptive and adaptable software [3]*

3. RELATED WORK

Software changes generally could be positioned in:

1. Standards related to software maintenance (ISO/IEC 14764), with four categories: corrective, adaptive, perfective and preventive.
2. Software evolution, where Lehman [6] has defined eight laws that emphasize continual adaptivity of software, increasing complexity and broadening functionality, according to user needs and requirements.

Software changes management, within the software development lifecycle, was one of emerging areas in scientific research [1] and practice. Having software life-cycle in focus, starting with requirements changes anticipation [7], software changes are closely related to software evolution. Results in software evolution monitoring could be the basis to predict future requirements changes [8]. Case studies were analyzed to determine causes and effects of software requirements changes [9]. One of the main aims to encourage adaptivity of software is to enable software system longevity [10]. i.e. to have long living software system.

In the context of adaptive web-based information systems [11], one of the adaptivity aspects is related to the software user. The system user models enable adjustments to user profiles (created according to the user's knowledge, behavior and history). In that context, there are usually two types of software adaptation:

1. Adaptability– adjustments of the statical user profile. User is categorized to a group/profile, at the beginning of the software usage.

2. Adaptivity– multiple adjustments to "dynamic user profile", during software system work and usage. User characteristics could change, which requires constant monitoring of user behavior. Dynamic adaptation of the software is performed according to changes of the user behavior.

Research and development in software adaptability and adaptivity contributed with theoretical concepts, supported by practical results. The terms proposed in research work in this area are introduced as: pure adaptivity vs. intelligent adaptation [12], i.e. micro-adaptation (self-adaptive) vs. macro-adaptation (human-action dependent adaptation) [10]. Adaptation is analyzed from the user perspective (adaptive interfaces), operating environment and working context, as well as from the perspective of software architecture [10] [12].

Software adaptation is analyzed within different programming environments and approaches, such as interactive programming [12], rule-based systems [10] [13], model-based systems [14] [15], graph-based adaptivity [10], while implemented with software agents [13] [14].

Special concerns are focused on run-time adaptability [10] [15] and software evolution [15].

Adaptability and adaptivity of software have found particular applications in certain software working environments, where non-functional uncertainty (e.g. response time) could affect the software functionality [16], especially with possible dependency on fault-prone software components [17]. Particular applicative domains emphasize adaptivity as a critical feature, such as aviation (airplane software) [18] and legislation (law-related software) [19].

4. THE PRESCHOOL WEB PORTAL SOLUTION

Web portal for preschool strategic management was developed by joined team from Technical Faculty "Mihajlo Pupin" Zrenjanin, Serbia, Preschool institution Zrenjanin, Serbia and CIP center Belgrade, Serbia in year 2018. Initial focus was to support resources planning in preschool children population enlargement. Particularly addressed problem was determining and supporting children not included in preschools work. The goal of the project was to determine number of those unsupported children, by integration of relevant data from various institutions.

The business process model, for determining non-included children, was presented in [20]. That was the basis for software design of web portal [21]. Design was described with architectural, functional and data-related aspects. Implementation of this web portal included software quality- related ISO standards. Mapping of ISO standards-related software quality elements to elements of software solution was described in [20].

Developed solution represent a centralized web portal where institutions, related to the problem of non-included children, periodically enter relevant data. Web portal enables integration of these data and processing in aim to compute derived data, predictions and graph-based visualizations.

Web application was developed by using native PHP/MySQL without using frameworks and it is available: http://www.predskolskazr.edu.rs/projekat/index.php. The same application is also presented with a demo version, with illustrative amount of data http://www.predskolskazr.edu.rs/demo/index.php . The demo version has all the functionality as a regular version, but only has previously prepared illustrative amount of data, to be presented to potential users at presentations and usage trainings.

The first page of the web application is presented at Figure 4 and other relevant user-interface screens are given from the demo version at Figure 5,6,7 and 8.

Functional aspect of the developed web portal include software functions for three types of users:

- *Administrative user role (Figure 5)* - maintains data in coding tables (regions, institutions, data categories), registers institutions and employees from these institutions as software users, assigns institutions to particular data categories according to their responsibilities, defines computing formulas (combine data from coding tables, raw data entered by institutions employees and other computed/derived data).

Figure 4. First page of preschool strategic management web portal

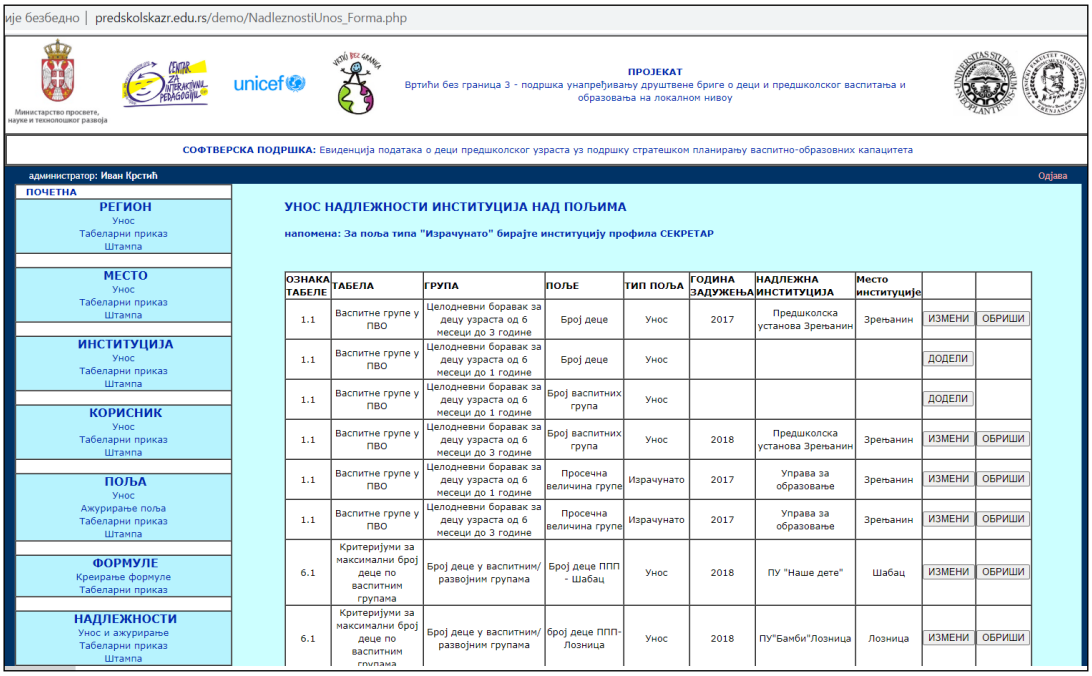


Figure 5. Assignment of data categories to the responsible institutions within administrative role in preschool strategic management web portal

- *Institutions" employee user role (Figure 6)* - engaged to enter raw data that are assigned to particular institution, as their responsibility.
- *Secretary (data analysts and manager) user role (Figure 7)* - initializes data collection by defining data entry period, monitors data entry progress, review the data collected and control missing data, archives data, performs data processing, prediction and visualization with graphs. Data processing is performed by combining raw data from institutions with local and national norms (i.e. referent values), by using previously defined formulas. Processed data are used for further analysis with data prediction (simplified assuming to have a linear function as a background, in this version of software). Visualization shows trends based on previously computed data prediction and it is presented in the form of line/bar type of graphs.

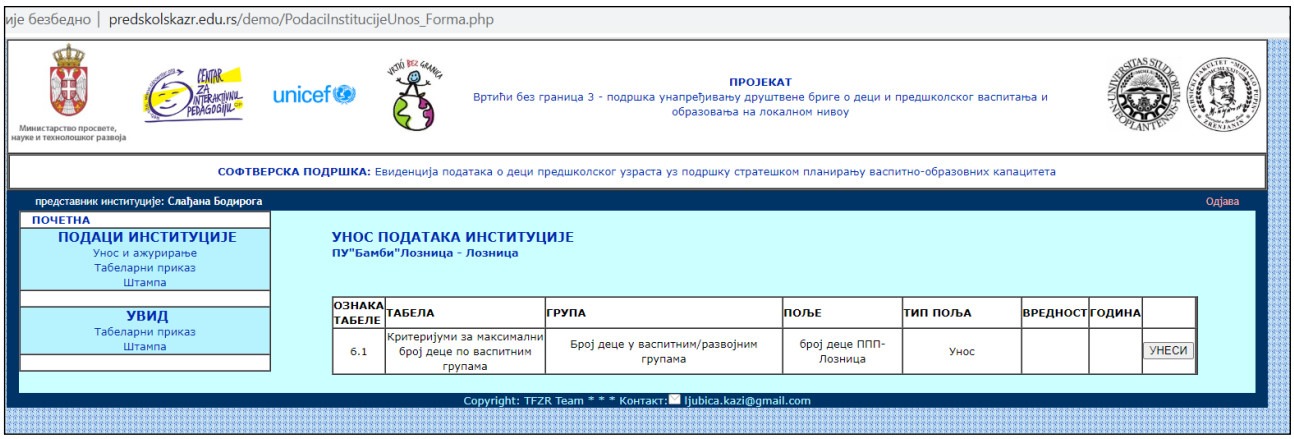
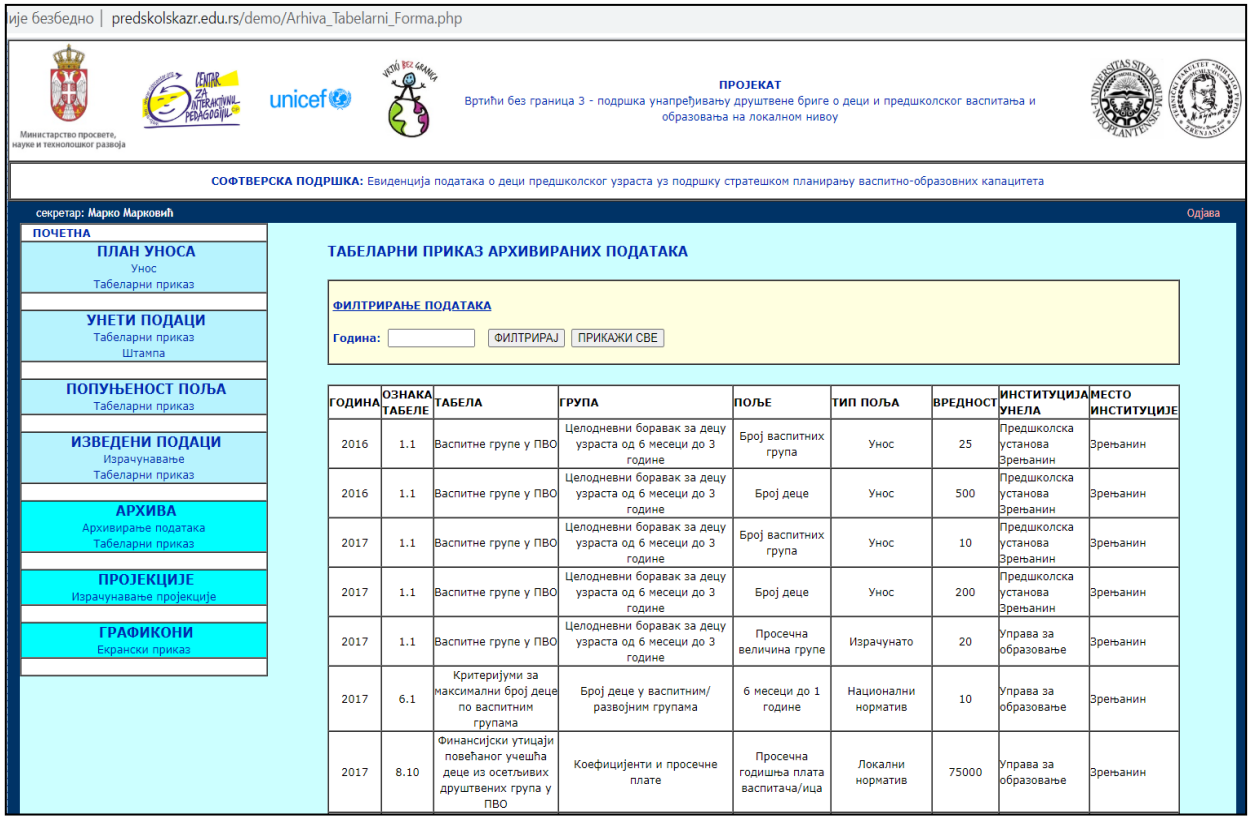


Figure 6. Page for assigned data entry within institution employee role of preschool strategic management web portal



ГОДИНА	ОЗНАКА ТАБЕЛЕ	ТАБЕЛА	ГРУПА	ПОЉЕ	ТИП ПОЉА	ВРЕДНОСТ	ИНСТИТУЦИЈА УНЕЛА	МЕСТО ИНСТИТУЦИЈЕ
2016	1.1	Васпитне групе у ПВО	Целодневни боравак за децу узраста од 6 месеци до 3 године	Број васпитних група	Унос	25	Предшколска установа Зрењанин	Зрењанин
2016	1.1	Васпитне групе у ПВО	Целодневни боравак за децу узраста од 6 месеци до 3 године	Број деце	Унос	500	Предшколска установа Зрењанин	Зрењанин
2017	1.1	Васпитне групе у ПВО	Целодневни боравак за децу узраста од 6 месеци до 3 године	Број васпитних група	Унос	10	Предшколска установа Зрењанин	Зрењанин
2017	1.1	Васпитне групе у ПВО	Целодневни боравак за децу узраста од 6 месеци до 3 године	Број деце	Унос	200	Предшколска установа Зрењанин	Зрењанин
2017	1.1	Васпитне групе у ПВО	Целодневни боравак за децу узраста од 6 месеци до 3 године	Просечна величина групе	Израчунато	20	Управа за образовање	Зрењанин
2017	6.1	Критеријуми за максимални број деце по васпитним групама	Број деце у васпитним/ развојним групама	6 месеци до 1 године	Национални норматив	10	Управа за образовање	Зрењанин
2017	8.10	Финансијски утицаји повећаног учешћа деце из осетљивих друштвених група у ПВО	Коефицијенти и просечне плате	Просечна годишња плата васпитача/ица	Локални норматив	75000	Управа за образовање	Зрењанин

Figure 7. Data archive page of secretary role in preschool strategic management web portal

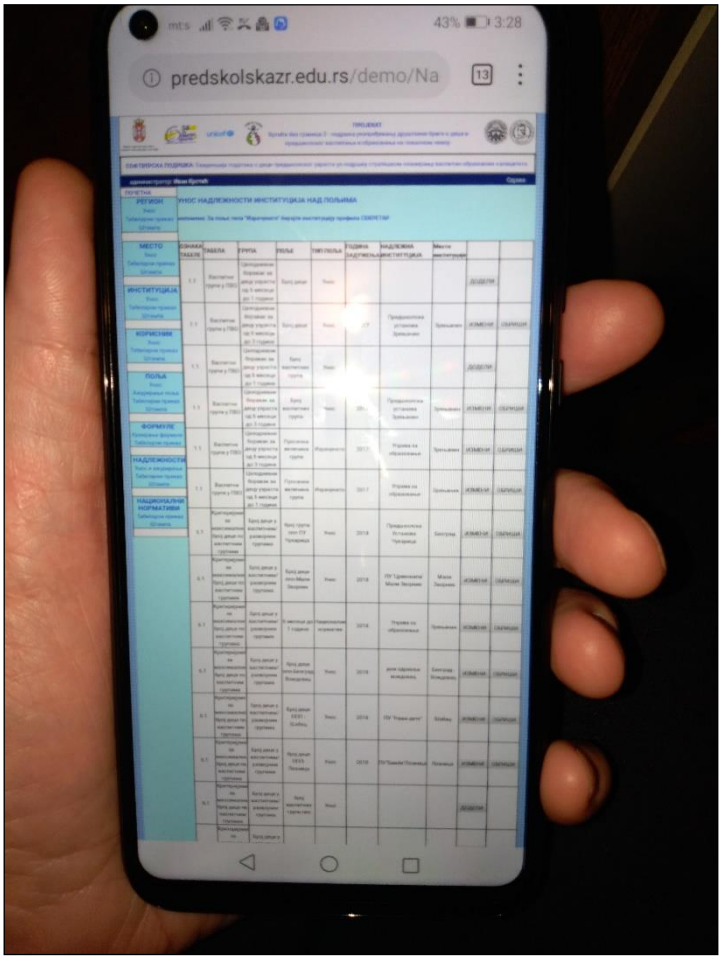


Figure 8. Responsive web design enables presenting the developed web portal at mobile phone

5. ADAPTIVITY OF PRESCHOOL WEB PORTAL

Adaptivity of the developed preschool web portal has many aspects implemented:

I – Adaptivity Dimensions

- *Graphical* – responsive web design that enables web application to automatically fit into any device (desktop monitor, laptop screen, tablet or mobile phone, presented at Figure 8).
- *Functional* – enables the administrator role to define data categories that are to be assigned to any responsible institution (Figure 5), regarding any problem or strategic orientation that needs data entry, integration from any number of institutions and processing. Flexibility in data processing, with options of custom creation of formulas that include raw data, constants (national and local norms) and previously processed data.
- *Platform-based* – software solution could automatically detect the hosting platform (PHP language support version) and adjust key code syntax variant to appropriate platform. The solution consists of:
  - *Sensor* – detecting PHP version supported at hosting (Listing 1),
  - *Effector* – different behavior, i.e. PHP syntax (Listing 2).

```
private function DetectPHPMySQLVersion()
{
        $VersionPHP = phpversion();
        if ($VersionPHP >='5.5.0')
        {
           $this->VersionMYSQLSyntax="mysqli";
        }
        else
        {
          $this->VersionMYSQLSyntax ="mysql";
        }
}
```

Listing 1. Detection of hosting platform PHP version (sensor)

```
if ($this-> VersionMYSQLSyntax =="mysqli")
        {
        $this->connectionDB= mysqli_connect($host,
        $username, $password, $this->databaseName);
        }
        else // mysql
        {
        // establishing connection to DBMS MYSQL
        $this->connectionDBMSMYSQL=
        mysql_connect($host, $username, $password);

        // establishing connection to database
        $this->connectionDB = mysql_select_db(
        $this->databaseName,
        $this->connectionDBMSMYSQL);
        }
```

Listing 2. Different behavior of code, regarding appropriate PHP syntax, according to detected PHP support version at hosting platform (effector)

II – Adaptivity types

- Adaptive software:
  a) Automatically detects hosting PHP support and adjusts php code syntax version;
  b) Automatically adjusts to the user device in responsive web design.
- Adaptable software – functional elements (data categories, institutional data assignments, data processing formulas) are set before the software usage, manually adjusted (by human user in administrative role) to particular problem or strategic goal that is addressed.

6. CONCLUSION

The developed solution of preschool web portal was initially developed for particular strategic goal – to enable data collection, integration and processing related to the problem of detecting the number of children not included in preschools. Having the solution designed more generally, it became a universal tool to support data collection from different institutions, data collection monitoring, data integration, processing, prediction, analysis and visualization. Web portal usage starts with setting a strategic goal and selection of the needed data to be collected regarding reaching the goal. Appropriate data categories are defined and entered in system, as well as assigned to the responsible institutions. Data processing is defined by adding appropriate computing formulas, which combine raw data with national and local norms (constant values).

Particular aim of this paper was to address the issue of making flexible, adjustable software, i.e. web portal. The presented solution shows software adaptivity of adaptive and adaptable type in the aspects: graphical, functional and platform-related. Having all these adjustments integrated in the solution, it brings features such as:

- Scalability to any number of data, users, institutions or processing formulas,
- Universal applicability to any particular problem domain and strategic decision making,
- Automated adaptivity to different hosting platforms and user devices.

This way, it represents one implemented example of adaptive software, which is not only a prototype, but in use. Having all these features, it brings many benefits for using institutions, as well as it makes software maintenance easier.

ACKNOWLEDGEMENTS

This paper presents part of results in the project "Preschool without Frontiers 3 – support to improvement of social care about preschool-aged children at local level". The project was implemented in 2017-2018 year period, by

partners: Ministry of education, science and Technology development of Republic of Serbia, UNICEF, CIP center for interactive pedagogy Belgrade. The web portal was one of the results that was created in year 2018 by team from University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia in cooperation with Preschool institution Zrenjanin and Center for Interactive pedagogy Belgrade, Serbia.

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Professional paper
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Smartphone Application for Evaluation of Jumping Rope Exercise in Physical Education

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Abstract: *This paper presents the usage of smartphones in the evaluation of student activities in physical education. Results from jumping rope exercises are collected by smartphone sensors and data is processed and can be used by the teacher for precise evaluation. For this purpose, we developed an experiment-based on the Phyphox platform using a built-in accelerometer to measure student performance in jumping rope exercises. This application enables remote evaluation which is convenient for recent virtualization of education due to ongoing pandemic.*

Keywords: *physical education; jumping rope; smartphone; sensor; accelerometer.*

1. INTRODUCTION

The concept of teaching physical education is based on the improvement of student's physical abilities, motor skills and knowledge in the field of physical and health culture. The realization of these goals of teaching physical education is achieved through various and systematic motor activities, which contribute to the integral development of students' personalities. Evaluation of student results on these activities requires some basic technical equipment, such as stopwatch, tape measure.

The closure of schools around the world due pandemic outbreak has forced teachers to conduct online lectures and evaluate student performance remotely. The subject of physical education faced one of the biggest challenges for online evaluation and it relied on students taking video recordings of their exercises which are then evaluated by teachers.

Smartphones include built-in sensors that can be used to directly measure student activity, and increase the accuracy of student evaluation. In this paper, we developed a smartphone application for jumping rope exercise which evaluates student performance base on reading from a built-in accelerometer which is present on every smartphone.

2. JUMPING ROPE EXERCISE

2.1. Evaluation

Evaluation is an integral part of the teaching and learning process, which ensures constant monitoring of the achievement of prescribed outcomes and student achievement standards. The main purpose of assessment is to improve the quality of the learning process [1-3]. Assessment is the process of monitoring and evaluating the flow and outcomes of learning, and assessments are the outcome or product of that process.

The principles of evaluation are:

- Objectivity in evaluation according to established criteria,
- The relevance of the evaluation,
- Use of various evaluation techniques and methods,
- Fairness in evaluation,
- Regularity and timeliness in evaluation,
- Evaluation without discrimination and separation on any basis,
- Respect for individual needs, differences, ages, previous student achievements and current conditions in which evaluation takes place.

Monitoring the development, progress and achievement of student achievement during the school year is done by formative and summative assessment. The formative assessment represents regular monitoring and assessment of progress in achieving the prescribed outcomes, standards of achievement and engagement within the compulsory subject. It must be guiding, developmental, preventive (prevents failure), descriptive. Summative assessment evaluates the achievement of students at the end of the teaching period against certain standards (grade at the end of the year, in the semester, grade in the quarter...). It must be concluding, evaluative, at the end of the learning process.

2.2. Jumping rope working technique

Jumping rope is a sports equipment used by the children from the earliest age. It can be either handmade or be found in almost any sports equipment store at affordable prices. The length of the jumping rope should match the height of the student. The optimal length is determined by the student standing in the middle section of the jumping rope in the connecting position, and pulling the ends which reach exactly to the armpits.

The proper technique of working with the device requires its proper holding. The jumping rope must not be held convulsively, but quite casually so that its ends lie between the thumb and forefinger. The convulsive posture reduces the amplitude of movement in the wrist and thus the mobility of the device. The basis of the technique of working with a jumping rope are:

- Turning the jumping rope in the wrist joint;
- Rotating the jumping rope with shoulder and elbow joint movements.

Turning the jumping rope with movements in the wrist joint is the basic technique for all movements of small amplitudes and high speeds. The rotation of the jumping rope with movements in the shoulder and elbow joint is performed with the aim of extending the jumping rope, which is necessary when moving large amplitudes, and with a low speed of execution.

The jumping rope exercise is performed in the following way: the rope is held by the ends with lowered hands. The jump is performed by bouncing both legs from the squat position and landing on both legs, ending the movement also in the squat. In the jump phase, the legs and the body is stretched. The rotation of the screw is performed by movements in the wrist, with slightly bent elbows. Jumps can be performed with or without intermediate jumps, with the jumping rope turning back and forth. It is necessary to coordinate the movement of students and the movement of the jumping rope. The goal is to develop skills, strengthen the muscles of the lower extremities, and strengthen the abdominal muscles. There are various variants and combinations of skipping the jumping rope - in place, moving, in pairs, with cross rotation, with double pulling.

2.1. Expected outcomes

Assuming that student-teacher communication takes place online, the student will be able to:

- Recognize the link between physical education and health;
- Names the motor skills to be developed;
- Performs exercises for the development and improvement of motor skills;
- Demonstrates proper technique;
- Explain why the characteristics of physical education are important, to actively participate in the teaching process and to independently implement a particular program;
- Considers the negative influences of the modern way of life;
- Enjoys performing movements and movements.

3. ACCELERATION ANALYSIS OF VERTICAL JUMP

Dynamic and kinematic analysis of a vertical jump, sargent jump, broad jump or jump with the rope shows that these jumps are essentially very similar [4, 5]. When parameters such as the center of mass displacement (CM) and linear acceleration of the body are observed, significant coincidences can be observed in vertical jump and jump with the rope. The difference is observed only in the absolute values of the displacement of the center of mass and linear acceleration, which are somewhat more pronounced in the vertical jump.

Figure 1 shows the different phases that a jumper goes through during a vertical jump. In phase A, the jumper stands still and in an upright position. The position of the center of mass in this phase of the jump is taken to be the reference level, ie equal to zero. The jumper is not affected by additional acceleration except for the acceleration of the Earth's gravity directed vertically downwards.

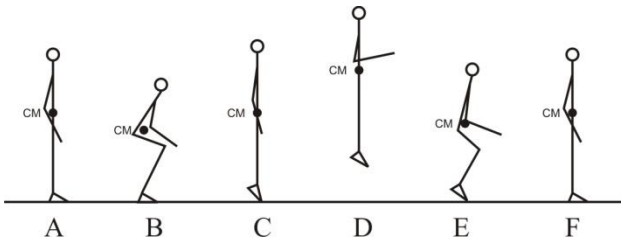

Figure 1. *The different phases that a jumper goes through during a vertical jump*

Phase A is followed by a jump preparation marked by phase B in which the jumper lowers his CM by bending his knees and preparing for the jump. During this phase, the sensor on the phone shows an increase in the value of the linear acceleration (Fig.2). At the end of this phase (preparation for the jump) the maximum value of the CM acceleration, which has a downward direction, is recorded. This results in a linear acceleration directed in the opposite direction since the sensor on the smartphone show the accelerations whose direction is opposite to the direction of the body's movement. Point C indicates the moment when the jumper is reflected and in which the jumper moves upwards, pushing his feet off the ground and straightening his knees. This results in a significant increase in the value of the linear acceleration with the downward direction recorded by the smartphone. At point D, the jumper reaches the maximum height, the linear acceleration on all three axes (X'Y'Z') is approximately equal to zero,

except for the vertical acceleration which is constant and directed vertically downwards throughout the jump (g_o = -9,81 m/s^2). At this point, an acceleration of approximately zero is recorded. It should be noted that in the Phyphox application there is a possibility to record the linear acceleration at all three coordinates of the phone (X'Y'Z') as well as their sums at absolute values, without taking into account the acceleration of the Earth's gravity (g_o = 0 m/s^2).

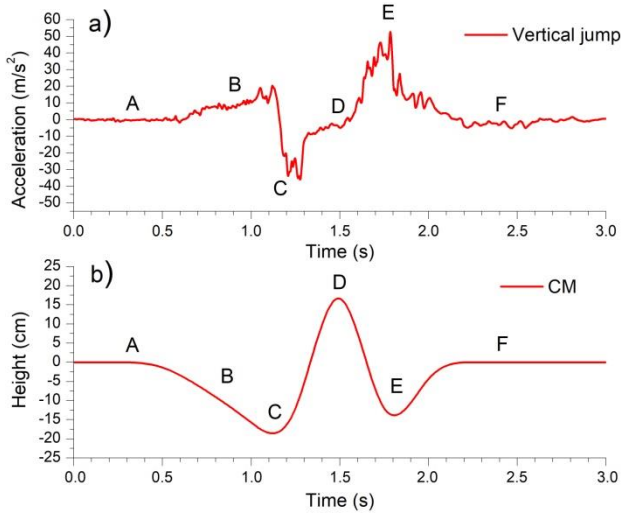

Figure 2. *a) Total linear acceleration registered by the sensor on the smarthpone along all three X'Y'Z 'coordinates during the duration of the vertical jump; b) displacement of the* jumper's CM *during the vertical jump.*

Upon reaching the maximum height, the CM of the jumper begins to descend which increases the value of the linear acceleration registered by the smartphone. At the moment of landing (point E), there is a significant increase in the value of the linear acceleration. Additional peaks that may occur in the phase of reflection (point C) and landing (point E) originate from the movement of the joints and are a consequence of the amortization of the bounce and landing and the movement of the joints during the rotation of the rope. By returning CM to the initial position (point F), the accelerometer records again values that are approximately equal to zero along the X'Y'Z' coordinates. This phase is identical in characteristics to phase A.

It should be noted that the orientation of the X'Y'Z' coordinate system that is fixed to the smartphone in relation to the XYZ coordinates that are fixed to the ground does not affect the obtained result. In the Phyphox application, there is an option to summarize the results of linear accelerations on all three axes, with or without the acceleration of the Earth's gravitational field. When jumping, the only condition that the jumper must meet is that his smartphone is in a fixed position during the entire measurement time. Ideally near his center of mass, that is, in the waist area.

4. SMARTPHONE AS SENSOR PLATFORM

Most smartphones have several built-in sensors that measure motion, orientation, and various environmental parameters. These sensors provide high precision raw data that can be used to monitor device movement or positioning in three-dimensional space or to monitor changes in the ambient environment in device proximity.

Phyphox is a free smartphone application that enables the usage of built-in sensors to perform various experiments, primarily in the field of physics. Phyphox application represents an acronym for physical phone experiments and was developed in 2016 at RWTH Aachen University [6]. This application is available on all smartphones running at Android or iOS operating systems. This application allows users to use existing experiments or create programs for new experiments, which can perform some level of data analysis on collected sensor data. Since virtually any student has a smartphone, this can drop the cost of many physics experiments almost to zero.

The application allows usage of different sensors that are present depending on the phone model: accelerometer, gyroscope, magnetometer, light meter, barometer, microphone, proximity sensor and GPS (Fig. 3).

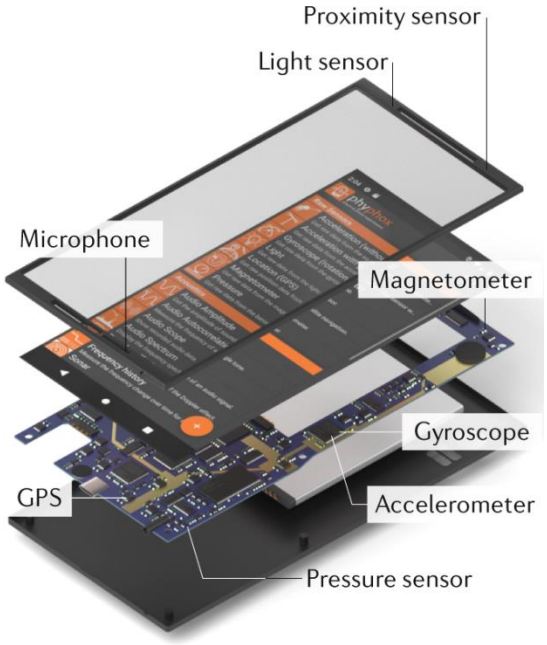

Figure 3. *Typical sensors present in smartphone*

There are lots of predefined Phyphox experiments such as Doppler Effect, sonar, acoustic spectrum, pendulum and spring oscillations, roll and centrifugal acceleration, etc. Processed data can be processed and shared as exported in CSV (Comma Separated Values) or Excel format. The application also allows remote control of the experiment using the built-in web browser interface which can be accessed from the laptop computer or other smartphone via WiFi hotspot.

Besides predefined experiments, users can create custom experiments using Phyphox web Editor [7]. Using the Input tab of this editor, the user can select which sensors will be used in the experiment, and define its properties, such as data rate, range, etc. Then the user creates a layout of experiment screens on the Views tab, in which output data will be presented. These include interactive graphs, buttons, text boxes, labels and numerical output fields. Analysis tab enables users to define algorithms in graphical form using predefined mathematical and program control operations, as well as advanced functions, such as correlation, Fast Fourier transform, smoothing, etc. The experiment is saved in XML form and can be downloaded to smartphones.

5. JUMP ROPE PHYPHOX EXPERIMENT

The accelerometer sensor measures a force applied on a sample mass in three principal axes X, Y, and Z (Fig. 4). The accelerometer will, therefore, experience 9.81 m/s² acceleration caused by Earth's gravitational field while the phone is resting. Earth acceleration will be distributed along different sensor axes depending on the phone orientation.

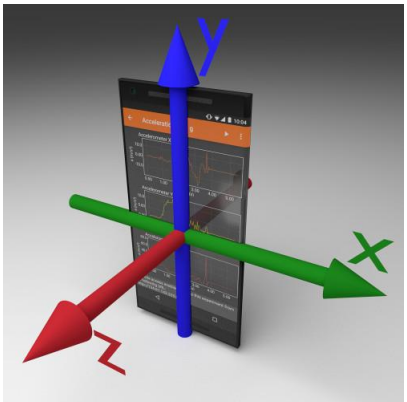

Figure 4. *Accelerometer coordinate system*

Therefore to eliminate the influence of phone orientation on acceleration measurements, absolute acceleration is measured along all three axes (Fig. 5).

$$a = \sqrt{a_x^2 + a_y^2 + a_z^2} \tag{1}$$

The sampling rate for the smartphone accelerometer is model dependant and the typical rate for midrange phone models is around 100 Hz (high-end models achieve sampling rates up to 500 Hz).

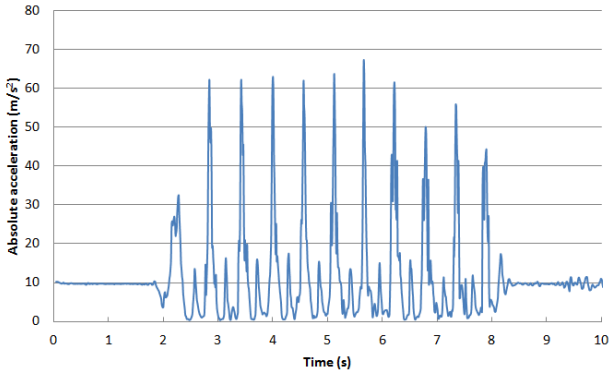

Figure 5. *Raw absolute acceleration from sensor during rope jumping exercise*

Since accelerometer data is susceptible to noise, even when the phone is resting, we calculated RMS (Root Mean Square) value for successive n=10 samples

$$a_{RMS} = \sqrt{\frac{1}{n}\sum_{i=0}^{n} a_i^2} \tag{2}$$

RMS value of absolute acceleration acquired from the accelerometer sensor is calculated in Phyphox Editor as shown in Figure 6.

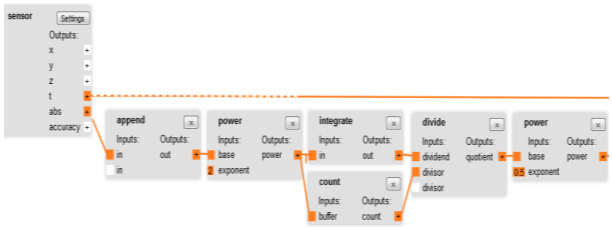

Figure 6. *RMS acceleration calculation*

Calculated RMS values are appended to an array which is shown on the Y-axis of the graph, while the X-axis is acquired from the timer (Fig. 7).

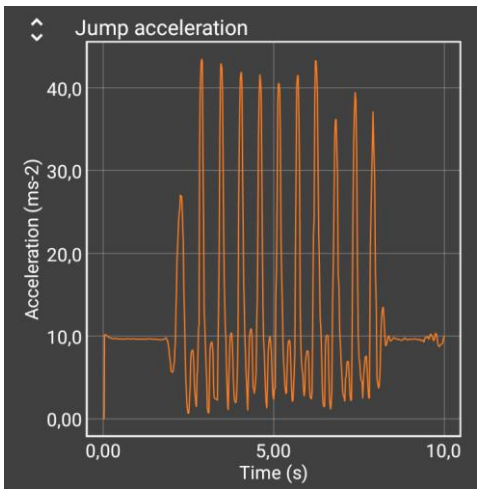

Figure 7. *Graph of RMS acceleration*

Acceleration RMS value is processed by max block which locates the position and values of multiple peaks in the input signal. The threshold field is used to enter threshold value for multiple peaks detection and this value depends on the jumping style, surface type, student's weight, etc. Obtained

maximum values are averaged and shown on screen in the form of a jump intensity field. Jumps are then counted using determined positions of detected peaks. Since some jumps can be counted multiple times due to multiple detected peaks, the range filter was used in order to eliminate peaks that are very close to each other (Fig. 8).

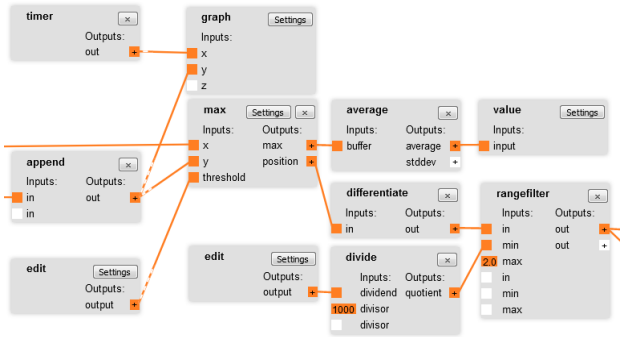

Figure 8. *Locating peaks in RMS acceleration*

Jump duration field is used to enter information about jump duration which is dependant on jumping style (typically 100 ms for turning jump technique and 200ms for rotating jump technique). This value is used to filter all detected peaks which are too close to their neighboring peaks which originate from the same jump. Filtered peaks are counted and displayed on the screen in the form of the jump count field. The average duration between detected peaks is used to calculate jump speed which is also shown on screen.

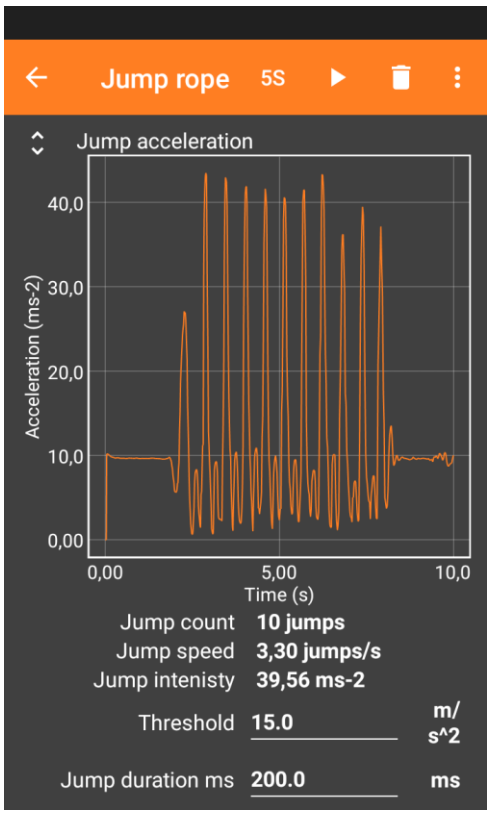

Figure 9. *Layout of Jump Rope experiment*

The screen layout of the realized Phyphox experiment is shown in Figure 9. The experiment can be started with a delay timer which gives students enough time to put his phone in the pocket and start performing the exercise. The student performed 10 jumps, as can be seen on the graph, and all jumps are successfully counted as well as jumps speed of 3.3 jumps per second and jump intensity of 39.56 m/s2. Also, students can share experiment results with teacher and export graph data in form of CSV for further processing on a personal computer.

6. CONCLUSION

In the time ahead, we should work on modernizing physical education classes. This will make it more interesting and creative and students can use their knowledge of IT technology for useful purposes. We know a lot about the advantages of physical activity and nothing can replace it. Rational use of new technologies can greatly facilitate the work of students, increase their engagement and motivation.

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Professional paper
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Development and Evaluation of CATAPEX Tutorial for the Database Practice Course

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Abstract: The paper presents the development of CATAPEX tutorial *(Camtasia Tutorial for Apex) that is composed of five education video lessons. The tutorial describes application creation for a particular database "Radost". Its main goal is to help students to gain necessary skills in application development in APEX tool (Oracle Application Express). Also, a short questionnaire is conducted where students evaluate CATAPEX and results are presented as well.*

Keywords: *database; tutorial; Oracle Application Express*

1. INTRODUCTION

Undergraduate students of the Faculty of Technical Sciences Čačak attend the Database practicum course in their third year of study. The curriculum of this course envisions the Oracle Application Express tool for application development of a demanding real database. During the course, it has been noticed that students show certain difficulties when creating some parts of the application, such as forms, reports based on SQL, menus, triggers, procedures, etc. Tutorials, as interactive software created learning tools, would help students to overcome these obstacles and acquire new skills using a step-by-step procedure [1].

Many researches are conducted on this topic since Oracle APEX is very important tool for teaching and learning and it is commonly used at many faculties. In research [2] authors propose a tutorial for system management and Oracle APEX. The development of the application is presented and the evaluation of the system is shown in this paper. Authors of paper [3] prepared a variety of challenging tasks that the students solved with the help of the Oracle APEX tool. This research showed that Oracle APEX can be used at all levels of higher education, even for the content that is not closely related to the field of computer science and informatics. The paper [4] is focused on an evaluation of APEX in respect of: administration, scalability and reliability for teaching; teaching and learning of introductory database application development; promotion and monitoring of engagement and feedback of learning; teaching and learning of more advanced database application development. The paper concludes with an overall positive view in relation to these four criteria and identifies areas of improvement for using APEX for teaching and learning. The importance of Oracle APEX tool is also reflected in the number of books written to help users of all levels of knowledge.

However, literature research shows a lack of some significant tutorials in the Serbian language concerning this issue. Although students are considered to be fluent in English, that is not the case in practice. An additional problem is that many of these tutorials are developed by people whose English is not their native language which makes them difficult to understand regardless of the student's fluency.

Based on these findings, we have decided to create several trial tutorials in the Serbian language that will help students in overcoming before-mentioned issues. CATAPEX tutorial is composed of five tutorials that include main concepts that students have a problem with.

The rest of the paper covers the main features of APEX tool (Section 2), database project that is used as the tutorial foundation (Section 3), the structure of CATAPEX itself (Section 4), and its evaluation (Section 5). The last section of this paper is dedicated to the conclusion and future work (Section 6).

2. FEATURES OF ORACLE APPLICATION EXPRESS

Oracle Application Express [5] (APEX) is a low-code development tool offered by Oracle Cloud [6]. It enables users to quickly build professional data-driven web applications. The goal is to help programing-savvy users to relatively quickly develop and implement applications for different devices, from desktop to mobile.

Oracle Application Express has free and paid versions depending on the level of professionalism it provides. The free version covers all necessary features for students of the Faculty of Technical Sciences.

APEX consists of four main parts (Fig. 1):

- *App Builder,* used to create pages that make APEX application. It is also used for the development and maintenance of web dynamic applications.
- *SQL Workshop,* which provides a full database object explorer. Also, it provides an interface to run SQL queries and see query results.
- *Team Development,* which gives access to the rich collaborative development features of APEX.
- *App Gallery*, which includes a suite of predefined productivity applications that can be installed and used.

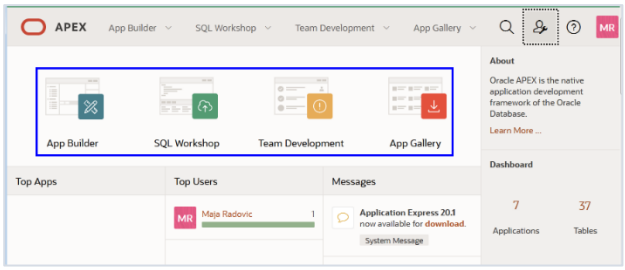

Figure 1. *Four main parts of Oracle Application Express*

The most significant advantages and capabilities of the APEX tool are: Creating reports, forms, charts and calendars for the database (within the application), launching and working within the Oracle database, flexibility in the appearance and functionality of the application, distribution of applications regardless of environment and platform, scalability and providing access for a large number of users without the need for a license.

Although an application can be created from scratch without an already created database, a fully formed database was used in this paper. In the following section, a brief description of database creation is explained.

3. DATABASE FOR PRESCHOOL INSTITUTION "RADOST"

Preschool institution "Radost" performs the activity of preschool education of children. "Radost" has headquarters in Čačak, Nadežde Petrović Street No. 8. It has 8 facilities i.e. kindergartens: "Nadežda Petrović", "Sunce", "Neven", "Majski cvet", "Bambi", "Radost 1", "Radost 2", "Boško Buha", in which children are accommodated in 63 groups of all-day stay. This institution needs to have up-to-date information on parents, children, institutions and groups, enrollment and placement of children in institutions, days of stay and absence in the institution, and the method of calculating costs for used services (SCALE entity).

In order to answer institutional needs, the database "Radost" was developed following conceptual modeling rules that involve recognizing the needs of the system and using diagrams to represent them. In other words, the conceptual model integrates all entities, relationships, constraints, and processes into a single global view of the data in the enterprise [7].

The Entity-Relationship Diagram (ERD) is a high-level conceptual data model [8]. It is used to graphically represent the conceptual model. Entity-Relationship Diagram (ERD) was created based on the above-mentioned needs of the observed system (Fig. 2). The ERD model describes data as entities, relationships, and attributes.

An Entity represents the basic object of ERD. It can be said that an entity is a "thing" in the real world with an independent existence [8]. That means everything that can be unambiguously determined, identified, and distinguished. Each occurrence of an entity is unique and different. *An attribute* is a characteristic of an entity.

A relationship describes an association among entities. The notation used for ERD was Crow's foot modified by Oracle Corporation [9].

ERD model for the preschool institution "Radost" is presented in Fig. 2. Each entity is described with several attributes that reflect the real-world system:

- **PARENT** entity with attributes: *ID, Name, Surname, Unique identification number, Address, Place, Phone, Phone2;*
- **CHILD** entity with attributes: *ID*, *Name*, *Surname*, *Unique identification number*, *Date of birth*;
- **INSTITUTION** entity with key attributes: *ID, Name, and Address;*
- **GROUP** entity with attributes: *ID* and *Name Of Group*;
- **ENROLLMENT** entity with attributes: *Date of enrollment* and optional attribute *Date of drop out*, due to the occurrence that children during adulthood move from kindergarten to preschool or change the institution in which they are;
- **SCALE** entity with attributes: *ID*, *Payment options* such as: regular payment, Single parent child, second and third child, child from vulnerable groups and *Payment Percentage*;
- **RECORD** entity with attributes: *Date*, *Days of stay and absence* and optional attribute *Remark*;

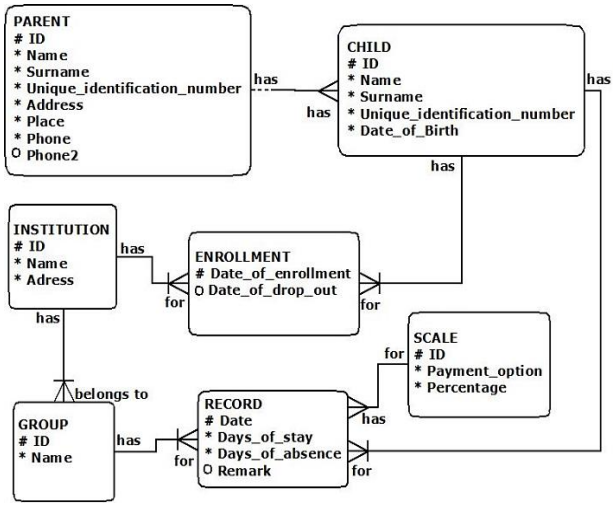

Figure 2. *ERD for preschool institution "Radost*

The database scheme is created by transforming ERD. This implies that entities, attributes, and links are translated into relational database objects (Fig. 3). Entities are translated into tables, attributes into columns, and connections are represented by corresponding foreign keys.

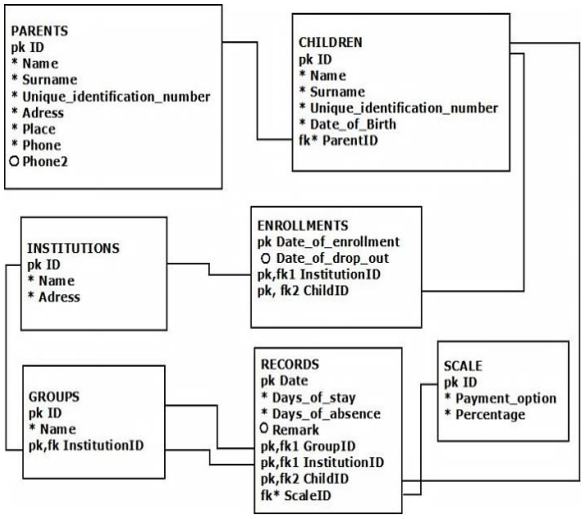

Figure 3. *Relational diagram for preschool institution "Radost"*

Based on the database, the application "Predškolska ustanova Radost" is created in APEX.

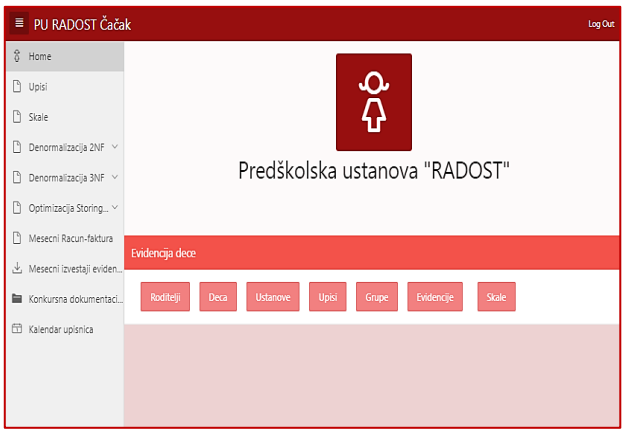

Figure 4. *Home page of the "Radost" application*

The application home page is presented in Fig. 4.

Applications made in APEX are highly user-oriented which implies that users who are not very familiar with computers can learn to use them with ease.

Easier ranking of children who applied for preschool, storing their records, easier management of groups and control over them, cost management as well as issuing reports is provided by APEX application for the institution "Radost".

The structure of CATAPEX tutorial is described in detail in the next section.

4. THE STRUCTURE OF THE CATAPEX TUTORIAL

CATAPEX tutorial is composed of five separate video tutorials. Tutorials are available online at: https://tinyurl.com/y8ybscpr. Camtasia software was used to create the CATAPEX tutorial [10]. It is a software suite, created and published by TechSmit for creating video tutorials and their presentations. The screen area to be recorded can be chosen freely, and audio or other multimedia recordings may be recorded at the same time or added separately from any other source and integrated into the Camtasia component of the product.

The necessary steps for the successful creation of the APEX database and application are explained in each tutorial. All explanations are presented through the example of creating a complete application for the preschool institution "Radost".

A short content description of each CATAPEX tutorial is given in Table 1.

Table 1. Content of each CATAPEX tutorial

Tutorial	Content
Introduction	The purpose of tutorials, to whom it is intended and explanation of its structure.
Table and foreign keys	How to create tables and keys through *SQL Commands* and *Object Browser* options.
Forms and Reports	How to use *App Builder* to create Pages i.e. *Forms* and *Reports*.
Navigation menu	How to create a Navigation menu to facilitate end-users navigation through the final application.
Home page	One of the ways how to edit Home page.

An insight into the topic that each tutorial covers is shown in the introduction.

Table and Foreign keys tutorial describes in detail the process of table creation in the example

of the PARENTS table. Two possible ways are shown, through SQL code or by object browser. Based on created tables the forms will be created as new pages that would be base for further work on the application.

Creating Forms and Reports tutorial describes in detail creation of new pages, i.e. forms and reports in the application. The forms are essential for data manipulation, such as: entry, update, delete, and search. Reports provide different ways of showing and shaping and resuming obtained information.

Creating Navigation Menu tutorial provides information about defining all necessary labels within the menu, so as to link labels to particular pages.

Creating a Home page tutorial gives information about Home page editing through adding buttons and linking them to forms. It also explains how to add application logo and visually adjust pages.

The screenshot of the Form and Report tutorial is presented in Fig. 5. It shows creation of form PARENTS with key attributes.

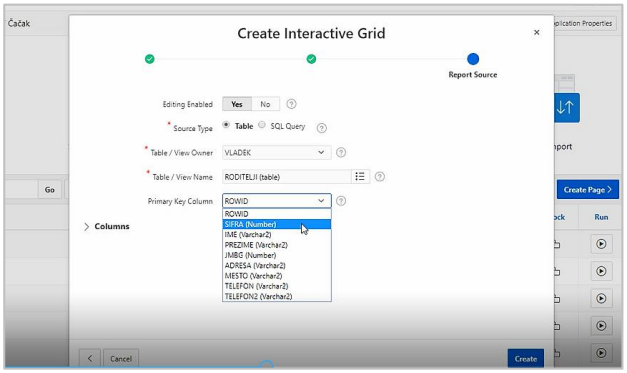

Figure 5. *Screenshot of Form and Report tutorial*

5. EVALUATION OF CATAPEX TUTORIAL

Since CATAPEX tutorial is in its trial version, the feedback from students about their satisfaction with tutorials and whether they are interested in upgrading it with an explanation of new options was needed.

Evaluation of CATAPEX tutorial was conducted at the end of the semester through a brief questionnaire (Table 2). Students were given five questions within this questionnaire.

The first question was related to the gender issue. Three questions are close-ended, and the last one was an open-ended question where students had the opportunity to express their views on the tutorial.

Table 2 also shows the results of the questionnaire.

Table 2: Questionnaire about student satisfaction with CATAPEX tutorials

Questions	Responses	Results
1.Gender	Male	21
	Female	9
2. Why did they access the tutorial?	It is an interesting topic.	6
	Because of the preparation for the project.	24
	No other alternative was offered.	1
	Other reason.	3
3. How many tutorials have you watched?	All	23
	All but one	1
	I missed a few	4
	I didn't look at any of them	2
4. Claims about different aspects of the tutorial:	The topic of the tutorial is interesting.	1(3) 2(5) 3(9) 4(13)
	The content of the tutorial is understandable.	1(0) 2(3) 3(7) 4(20)
	Tutorials encourage students to better design a project.	1(1) 2(3) 3(12) 4(14)
	Overall satisfied with the tutorial.	1(4) 2(4) 3(5) 4(17)
5. Students' suggestions	Open ended question	30

The questionnaire was answered by 30 students, 9 females, and 21 males. Based on obtained feedback it can be concluded that 70% of students access the tutorials because it helps them to finish their project in the *Database practice* course. Other responses can be seen in Fig. 6.

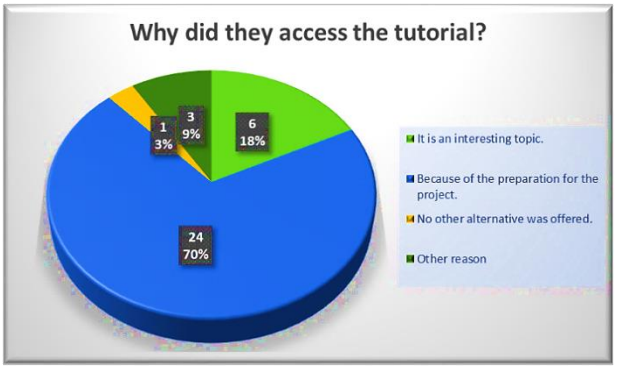

Figure 6. *Pie diagram of responses to question about reasons to access tutorials*

Responses to question about number of watched tutorials show that a relatively large percentage (77%) of students watched all the tutorials (Fig. 7). However, 7% didn't watch any of the tutorials.

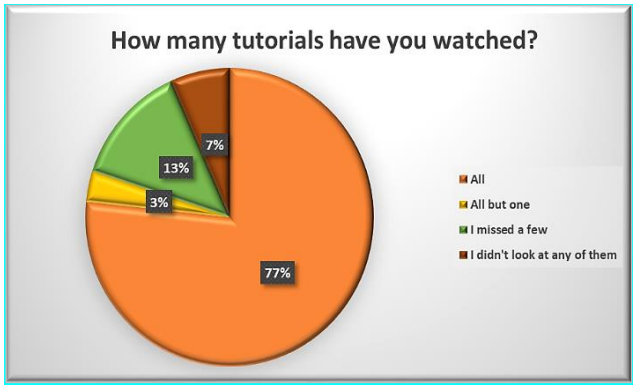

Figure 7. *Pie diagram of responses to question about number of watched tutorials*

The fourth question was about the degree of agreement about four statements. Fig. 8 shows that 13 students, i.e. 43 percentages agree with the first statement that the tutorials are interesting. What is more important, 66.7% agree with the second statement that the tutorials are understandable, which was one of the main authors' goals. Overall satisfaction with the tutorial is also high, with 56.6%.

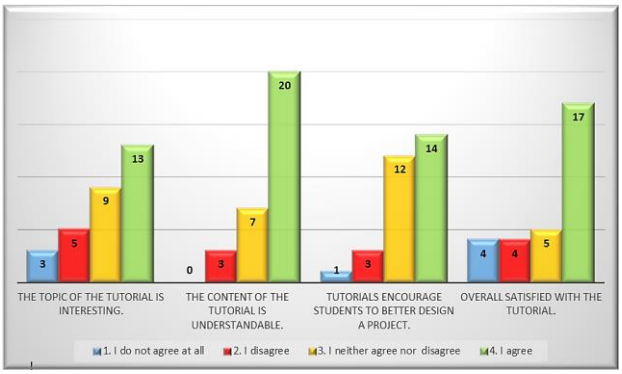

Figure 8. *Results of the degree of agreement with statements about the tutorials*

The last question, in which students could express their opinion and write a comment, demonstrates attitudes among students towards the tutorials. Eight students complimented CATAPEX without any remarks. However, eight students suggested that the authors should make more tutorials that will cover more APEX functionalities such as wizards, charts, calendars, master-detail tables, plug-in installations, etc. Other students did not comment on the tutorial through this question.

In the next section, the key conclusions of this paper are highlighted, the challenges that arose during the development and evaluation of the tutorials are listed, and plans for future improvements and further work on this topic are presented.

6. CONCLUSION

The main focus of this paper is development and evaluation of CATAPEX, the tutorial designed to provide the necessary explanations and assistance to students in creating an application in Oracle Application Express tool. CATAPEX tutorial is composed of five education lessons in the Serbian language: Introduction, Creating Tables and Foreign Keys, Creating Forms and Reports, Creating a Navigation Menu and Creating a Home Page.

In this paper authors presented:

- Several characteristics of Oracle Application Express tool, which is used for application development,
- Database for the preschool institution "Radost",
- Structure and content of CATAPEX tutorial,
- Results of CATAPEX tutorial evaluation.

Based on the conducted evaluation and following the suggestions that students gave, further development will refer to refining the existing tutorials and adding new ones, i.e. by improving and upgrading lessons in the form of innovative lessons that follow the latest version of the Apex tool, adding new lessons related to creating procedures, modifying designs, etc. Knowledge and skills in the development of database application through Oracle Application Express can be gained using this tutorial not only by students from the Faculty of Technical Sciences Čačak but from other faculties as well. Also, the tutorial can be posted as a part of the courses on an e-learning site or on social networks such as YouTube, so that they can be accessed by a greater number of interested persons. Further, creating and publishing tutorials in English or some other language can be highly beneficial in terms of achieving a wider application of CATAPEX.

Based on the internal evaluation by the authors, it can be noticed that CATAPEX tutorial is very time consuming during video editing and narration rehearsing, which greatly affected the speed of its production. The most complex part during video editing is cutting out unnecessary content and synchronizing the video with the narration. The easiest part when creating a tutorial is the creation of the final "product" (production), i.e. saving the tutorial in the desired format. Future work will also cover consideration of applying some other less demanding screen recording tools.

ACKNOQLEDGEMENTS

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Professional paper
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On-Line Programming Course Model for Students in IT

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Abstract: *There is a lack of connection between the industry and educational institutions. Students which graduated from colleges are looking for employment and facing difficulties adapting to the current job market, the requirements and expectations, with their minimal amount of real work knowledge. The main goal of this paper is to provide a model for creating a comprehensive developer course aligned with the current industry standards in IT.*

Keywords: *IT; undergraduate; backend; e-learning; teamwork.*

1. INTRODUCTION

Students represent the future of each country and adequate investment in education brings long-term results that distinguish between developed and underdeveloped countries. The education system has changed over the years trying to keep pace with the development of the industry and its needs. Systems that recognize in time the essential need for closer cooperation between education and industry have a real opportunity to become leaders in technological growth.

However, there is always a gap between the needs of industry and what educational institutions provide. The goal for students is to get a degree as soon as possible, and it is in the interest of employers to get employees who can immediately get involved in the work process.

One of the most common problems in education is bridging the gap between educational institutions and the industry [1, 2, 3, 4]. This gap was wider in the past, but with current advancements in education and partnering with various industry partners has narrowed the gap considerably. However, this has not closed the gap completely. With companies constantly moving forward in order to gain the edge over their competition, it poses a new challenge of constantly being up to date on the latest trends in IT. In most cases, students must spend at least 6 months in training, at companies, before they can start working on projects. One of the more common problems are the tools companies use in their development, often times these tools are unknown to students, and, unfortunately for them, have a steep learning curve.

This course model has the goal of improving existing skills previously gained in higher education based on the real-world needs of companies. Also, this model combines these skills in order to create a deeper understanding of how they are all linked together. Common programming and design concepts can be applied to all programming languages. The course is expected to prepare students for the challenges they face in the business environment, with an emphasis on the most common requirements in such an environment, without wasting time on classic programming lessons that are present in most schools or colleges today, as one assumes that this knowledge has been adopted, and this is an upgrade and preparation for actual work. The demands of employers are such that they expect employees to solve a given problem as soon as possible, regardless of the level of complexity, and most students cannot adequately respond to such demands of employers and the market. The course should provide the knowledge and experience for this type of requirement.

The concept of the course presented in the paper participated in the Public Competition of the Ministry of Education, Science and Technological Development for application and participation in projects financed within the program activity "Development of Higher Education". Based on the preliminary ranking list of the Ministry, the project "Development of mobile applications" won the maximum number of points and will be financed by the Ministry during the school year 2020-2021. The project will be implemented at the Academy of Vocational Studies in Western Serbia, Užice department, during the winter semester of the school year 2020-2021.

The subject of the public competition is the financing by the Ministry of Education, Science and Technological Development of projects to support higher education institutions in the development of new and innovation of existing subjects within accredited study programs, which should contribute to the Ministry's program goals:

1. Improve the competencies of teachers and associates for teaching;
2. Innovate existing study programs that follow the needs of the labor market;
3. Improve the quality of the educational process by creating better conditions for the implementation of teaching and learning of students;
4. Develop the entrepreneurial skills of students and improve the cooperation of the higher education institution with the economy and other interested actors in the local community;
5. Increase the use of information technology in teaching and learning process.

2. E-LEARNING CONCEPTS

The concept of e-learning is not new and over the years it has successfully adapted to new trends and developments in IT, which are a necessary component in the implementation of this concept. Keeping in mind that e-learning has expanded from classic computers to many other devices, such as tablets, smartphones etc. Most, if not all, e-learning systems of today are platform independent, usually web-based services, that will run on anything that adheres to web standards. Some of the key advantages of e-learning are: mobility, the ability to access learning content from anywhere, higher flexibility, increased study efficiency, etc. [5]. There are some drawbacks which include the inability to convert all classic courses to online courses, it requires extra motivation and good time management in order to avoid work piling up, there is also the question of cheating, however, that is a problem present in classrooms as well [6, 7].

E-learning systems typically consist of three key elements: LMS (Learning Management System), Content and Collaboration [14]. It is necessary for all components to function for the purpose of the system. There are various LMS variants, such as Moodle, ATutor, Chamilo, Blackboard and others, with different options and tailored to different needs. However, all of these systems have one common flaw – test validity. This raises the question of how to provide relevant knowledge to students that they will recognize as relevant, which, in turn, will provide employers with quality employees. This would ensure that students have a smooth transition to the work force, employer satisfaction and overall a win-win situation for everyone.

Reflecting on this problem, it is very difficult to prevent students from cheating, in most cases, students get very creative when it comes to it. The idea is to offer them a solution in which they get the conditions to work in real-world conditions, with real-life examples of practice. Students do not like long internships or probationary work, with very little or no pay at all and employers are not happy with knowledge students possess. In a way, students can gain knowledge that will help them get involved in the work process very quickly and will free employers from waiting for new employees to start delivering results.

In terms of virtual internships, there have been several successful projects that tackled these problems, such as the ProVip and VIVET projects [8, 9]. They are a good example that content matters and that students will show interest for innovative technologies and approaches if they find value in them. These two projects partially address the issue of transitioning to the works force and the challenges that come with it. Younger generations have grown up using the Internet and online communication is completely natural for them.

Learning teamwork skills is crucial and previously has been documented using different frameworks that are based on problem based learning and collaborative approaches [10, 11, 12]. Having in mind the goal and purpose of this course, it is evident that the shortcomings of the e-learning concept itself will not significantly affect the effectiveness of the course itself, since the target group has the appropriate level of knowledge necessary to apply all the necessary elements. The students will be focused on solving specific problems, which is why the concept of the course does not rely on traditional and widespread dissemination methods, but rather on creating, in the future, a database of ready-made examples based on realistic requirements of employers. This will teach students to solve specific problems in as little time as possible and with limited support, just as it would be in a real environment. During Agile software development, teamwork and creative thinking is beneficial to everyone in the team. If workers see that their ideas are encouraged and accepted, they will be more likely to be creative, leading to potential innovation in the workplace. The creation of a collaborative work environment fosters the communication between employees and reward those that work together to solve problems [13].

In order to help narrow this gap the results of the EDUCAUSE Center for Applied Research (ECAR) from 2004 to the present were observed. This research looked at the interests of IT students, as well as their satisfaction with their studies. The research included different demographic groups, the way of using new technologies as well as the

most common use of computers, both for the needs of studies and in everyday life [14-22].

3. RESEARCH PROBLEM AND RESEARCH SUBJECT

The problem of the research is finding the most suitable way to prepare students for the fastest possible adjustment to real working conditions. Employers in the current market conditions are not ready to waste money and time while students adjust to solving problems that are part of the everyday work environment. On the other hand, educational institutions often work according to programs that are not in line with the needs of employers.

The subject of the research is to define such a model of learning that will enable students to solve real problems that are present on the market during their studies, and for such a model to be harmonized with national education strategies as well as with syllabi of different subjects.

One possible way to solve this problem is to work according to the CDIO model. The CDIO INITATIVE is an innovative educational framework for producing the next generation of engineers. The framework provides students with an education stressing engineering fundamental set in the context of Conceiving – Designing – Implementing – Operating (CDIO) real-world systems and products. Throughout the world, CDIO Initiative collaborators have adopted CDIO as the framework of their curricular planning and outcome-based assessment [23, 24].

ECAR conducted the survey on a sample of more than 64,000 students at 130 US and international institutions and it is one of the most representative and longest-running surveys on the experiences, behaviors and preferences of IT students. The research took into account demographic characteristics, age, gender, technical equipment, the way of accessing the Internet, preferences on the Internet, technical knowledge the way of using the device, experience with LMS, etc. [23].

Based on the ECAR research, students have appropriate devices and spend enough time at home doing research and homework to make this kind of model possible [23]. However, bear in mind, these results vary from country to country, especially results such as internet access and device availability.

All these characteristics represent potential variables that can be taken into account when planning and implementing questionnaires for IT students. In addition, it is necessary to carefully plan the sample size in order to obtain relevant results, but this is in the plan for some further work on this topic because it requires precise determination of research techniques, instruments and activities.

In order to assess the opinion of students and college graduates that are working in the IT industry. The questionnaire had one closed question and two open ones.

For the purposes of the research, the sample method was applied and it enables the relevant statistical information on the mass phenomenon to be determined on the basis of a small sample. The reliability problems of the sample method are reduced by determining the sample size and representativeness of selected units [25].

The research was conducted on a relatively small number of respondents, but it provided guidelines in which direction the course should be further developed and how to eliminate possible disadvantages of this concept.

The questionnaire was answered by 37 individuals out of which 16 were college graduates that are working in the IT industry and 21 were students.

The questionnaire consisted of the following questions:

1. I think that it is a good idea to assign small projects (problem-based learning) so that students may acquire and expand their programming knowledge.
2. What do you consider good about the way programming is currently taught?
3. What would you change in current programming classes?

Analysing the questionnaire results, on the first question regarding the introduction of problem-based learning through small projects, it can be concluded that both students and graduates think that it is a good idea, with graduates strongly agreeing with the statement – 75% answered with Yes (Figure 1.).

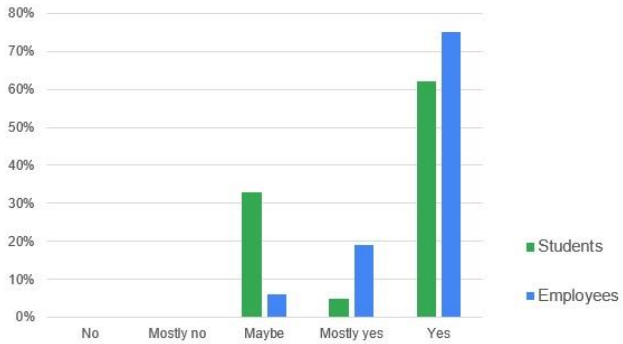

Figure 1. *Students and Employees opinion on introducing problem-based learning through small projects*

When asked the second question, what they consider good about the way programming is currently taught, both students and graduates answered similarly with the most common answers being:

- Working with professors and assistants;
- Gradual learning through teaching units;
- Small groups of students;

- The desire and commitment of the professors to impart knowledge;
- Introduction to programming is based on C language which is crucial to having a deeper understanding of how things work in the background.

When asked what they would change in current programming classes, students answered with:

- Pen and paper programming;
- A wider choice of programming languages;
- More team projects;
- A higher number of homework assignments

However, graduates had a lot to share, to summarize:

- Use industry standard software;
- Emphasis on the development of software solutions;
- Problem solving based on real world examples;
- Follow the latest trends in software development;
- Assistants should follow team-based projects and intervene when necessary;
- Do not repeat projects year over year;
- More attention to code formatting;
- Pay more attention to tools such as Git, Jira and documentation writing;
- When projects are assigned, teams should have a clear picture which way the project is heading at the beginning of the project, cooperation with other teams should be incorporated and projects should be split in parts and assigned to different teams.

The graduates had a lot more to share due to their industry experience. Their opinions are based on the difficulties they faced when transitioning from an educational institution to the industry and may be used to fill the gaps in current software engineering and programming courses. The course workflow described in this paper aims to fill those gaps and encourage teamwork-based projects.

4. THE COURSE CONCEPT

Based on the CDIO project, ProVip, VIVET and other similar projects, the results and lessons learned, a course concept has been created describing the course prerequisites and workflow.

4.1. Course Prerequisites

This course is intended for students that have already acquired object-oriented programming basics and have some experience writing code. It would be desirable if students are aware of networking concepts and have basic database knowledge, as the course is centred around working on existing projects that already incorporate these technologies.

This is why this course concept is intended for High School and College undergraduates who already completed basic programming courses, as this course require knowledge from several key areas. The tools used during the development cycle would be defined by current industry standards. Students would rely on IntelliJ IDEA, Docker, Visual Studio Code, Xcode, GitLab, Jira, Amazon Web Services, etc., as these are the tools that the industry is using to develop their software. It is important to note that these tools have student and/or free versions available. The transition from faculty to IT companies would be smoother as the they would be familiar with industry standards in terms of development tools.

Remote work, working individually, as well as working in teams will be encouraged, so students would need to have their personal laptops, faculty provided laptops or personal computer rooms available to them, as these activities will be completed outside of classrooms. This should not be a problem, as seen from the ECAR research data. Monitoring of the workflow would be achieved using issue tracking and collaboration tools, git repositories, lifecycle management and continuous integration and development tools.

4.2. Course Workflow

A course with this approach requires more time to track, not to mention a lot more time to implement properly, however, it represents a real work place environment. The projects would be divided into stories, tasks and subtasks which students would complete to earn story points. The amount of story points given depends on the difficulty of the task/subtask. Some projects may be frontend-design focused, while others may be backend focused which would be merged during the final phases of the projects, in order to create a sophisticated software solution from multiple small-scale projects which students, with their limited experience, could manage.

The course would begin with an introduction to the software students will be using during their course, registration and a demonstration of the tools and how they work, with a special focus on issue tacking, code repositories, tickets and other management and synchronization tools that will be used during the course. Students would be encouraged to hold stand up or Kanban meetings at agreed upon times and frequencies.

Once this phase is complete, the professor would switch roles. Issue tracking is monitored by the professor with intervention during key phases of the project. The professor would take on a supportive role, intervening only when deemed necessary. This role could also be described as a project manager role.

The previously mentioned software, with tickets and story points would encourage students to work both independently and as a team. Students would

complete tasks and earn points, which is great to showcase who did what and to evade some students working more, while others slack off. Issue tracking tools would serve as a source of truth. Git repositories provide version-control and encourage work coordination between students, especially when merging code. When a merge request is created, other students review the code submitted. This creates team responsibility for the code, the student who submitted the code shares this responsibility with their teammates who review it for faults, bugs, formatting issues and so on. This way, code quality is a team responsibility and it allows students to learn from each other as they make their way to the final software product.

The professor would keep his supportive/management role during the entire development process, only breaking from it once the software development phase is over and the evaluation phase begins.

During the evaluation phase the professor take on the role of the evaluator – teamwork, application code and deployment would be reviewed. Students would also deliver a lesson learned report for evaluation as it is one the most important documents of a project. The professor would also review this report and, based on all of the evidence provided from tools and reports, decides on the final grade.

A general flow of the course is shown on Figure 2.

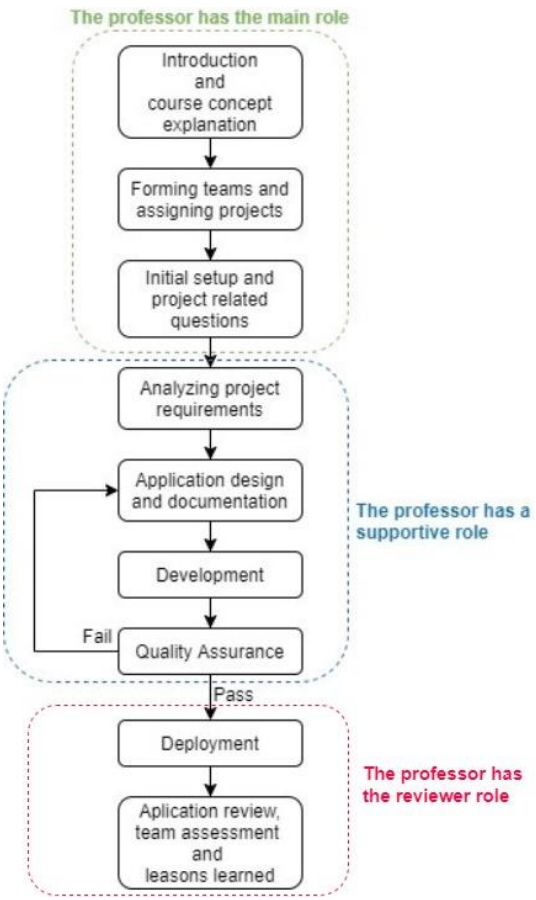

Figure 2. *Course flow*

The Ministry will evaluate students who are taking the course, which has been introduced or innovated. The project manager is obliged to submit to the Ministry the e-mail addresses of students that will be used for online evaluation within 15 days from the beginning of classes.

The results of the Ministry's evaluation and the independent evaluation will be analyzed in detail and we expect them to provide clear guidelines on how to develop these types of courses.

5. CONCLUSION

What can be concluded from ECAR and similar research? First of all, it is necessary to be well informed about study programs, accreditation documents and standards related to this area. It is necessary to precisely define the goals and steps in their realization. The questionnaire that should help achieve the goals needs to be defined in accordance with the conditions that apply in the educational institutions and industry.

Employers have a clear need for staff who are capable of solving real world problems as soon as possible. This type of course should prepare students for real world challenges in everyday work tasks. The biggest challenge is how to motivate students, as well as how to choose the most optimal course flow, with examples that will be closest to real situations.

Based on the research conducted in this paper, it can be concluded that students are open to problem-based learning and more practical classes using small project and find it useful for their future careers. This aligns with the results gathered from the IT employees, with the employees being in even stronger agreement on problem-based learning and more practical programming. Similar results have been gathered during the ECAR, ProVip and Vivet projects.

The research shows how to reach a compromise for both parties – how to create an appropriate programming course that will help students acquire the necessary knowledge and skill, while enabling employers to easily gain quality employees. In that sense, this would be a win-win situation.

During the implementation of the project, an evaluation is planned by the Ministry, as well as by the project manager and the author of the paper, which should provide guidelines on how to eliminate shortcomings in the very concept of the course.

The project manager is obliged to submit to the Ministry a final report on the implementation of the project, as well as evidence of the realized financing of the project, no later than 30 days after the end of the semester in which the project is implemented.

This research suggests in which direction programming courses should improve in order to

achieve the desired goal and the current shortcomings in teaching programming. It is evident that it is necessary to expand the research to a larger number of respondents, as well as that the concept and flow of the course should be well developed. However, an implementation of this model, further testing and result analysis is necessary.

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Alternative Software Solutions for Ensuring the Continuity of the Teaching Process in Emergency Situations

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Abstract: *The pandemic situation in the world caused by the SARS-COV-2 virus and the COVID-19 disease has changed the circumstances in which activities are carried out on a daily basis, including the higher education segment. In the Republic of Serbia, a state of emergency was introduced in a certain period, which resulted in the interruption of regular activities at higher education institutions. Faculties were forced to completely transfer their teaching activities to the online domain in a very short time, which resulted in the appearance of some specific problems. This paper analyzes some of these problems related to the inability to access computer laboratories at faculties. It is shown how these problems can be overcome in home working conditions using the principle of flipped classroom applied to the segment of work with computer laboratories. For the realization of the above, solutions based on the principles of Software-as-a-Service (SaaS), Free and Open Source Software (FOSS) and virtualization were used. The solutions were tested in a real environment during the summer semester of the 2019/2020 school year, an assessment of the success of these solutions is given, as well as some guidelines for their further integration into regular teaching processes.*

Keywords: *higher education; Free and Open Source Software (FOSS); Software-as-a-Service (SaaS); virtualization.*

1. INTRODUCTION

In accordance with the current epidemiological situation in the Republic of Serbia and in the world caused by the appearance of the SARS-COV-2 virus and COVID-19 disease as a direct consequence of exposure to this virus, a state of emergency was declared in the Republic of Serbia on March 15, 2020 [1]. On the same day, as a direct consequence of the mentioned declaration of the state of emergency, a Suspension of teaching in higher education institutions, secondary and primary schools and regular work of preschool education institutions [2] was also declared. The state of emergency in the Republic of Serbia was terminated on May 6, 2020 [3], however, certain epidemiological measures were applied even after the above-mentioned date.

In accordance with the above, during the period from March 15, 2020 to May 30, 2020, or till the end of the summer semester of the 2019/2020 school year, all forms of teaching (lectures and exercises) at higher education institutions for all levels of study (undergraduate, master's and doctoral studies) are performed remotely or in a way that does not require the physical presence of students at the faculties. This practically means that, during the mentioned period, most of the contents within the faculties, which are actively used in the implementation of accredited study programs at higher education institutions, remained inaccessible to both students and teaching staff conducting the teaching process.

Without exception, computer labs also remained inaccessible to students. These laboratories are used in a wide range of teaching activities, since in the digital age there is almost no teaching area that does not involve some use of computers in its implementation. The vast majority of implemented computer laboratories in our education system do not have the possibility to use remote access to resources in these laboratories. The absence of remote access and high representation of computer laboratories in the modern teaching process in higher education raised the question of how to compensate for the lack of computer laboratories in a new situation since most higher education institutions were not adequately prepared for this type of work with students as well as the speed of implementation of this type of teaching process.

The initial predictions were that the lack of use of computer labs would be compensated in a simple way, since the basis is the use of computers, which

are present in almost every home. However, in practice, it has been shown that the process itself hides certain difficulties at various levels that need to be well considered, analyzed and resolved in an adequate way.

It should be noted here that more comprehensive analyzes of the success of universities in the Republic of Serbia in the online regime during the mentioned emergency circumstances are yet to follow, so accordingly most data are not yet available to assess the quality of online teaching [4]. Consequently, only one small aspect will be analyzed in the following lines and it will be shown how the lack of use of computer laboratories is compensated during the performance of certain subjects in basic academic and master studies within the study programs of mining, metallurgy and technological engineering at the Technical Faculty in Bor during the summer semester of 2019/2020 school year.

2. FLIPPED COMPUTER LAB AND ITS CHALLENGES

In recent years, the application of the principle of the flipped classroom has been increasingly used in university education instead of the traditional way of teaching.

In flipped learning model the emphasis is on the student who learns the basics at home using the principles of distance learning while the classroom is reserved for additional questions, explanations, as well as the application of acquired knowledge to solve specific problems [5]. This realization of learning achieves many advantages. Perhaps one of the greatest achievements is that students now show greater activity in the entire teaching process by modifying their behavior from passive to active one [6]. Also, from a technical standpoint, using systems based on this approach can provide more relevant information about wider aspects of learning process, for example various learning styles can be detected using data provided from system logs [7].

The whole epidemiological situation has created such an environment where the use of the elements on which the work of flipped classrooms is based has become necessary in order to maintain the continuity of the teaching process. Without the possibility of using resources within the faculties themselves, work at home has become the basic premise of teaching in all segments of the teaching process in higher education without exceptions. The unavailability of computer laboratories also had to be compensated by a certain type of work at home, so a special working environment was created, which could be conditionally called a kind of flipped computer lab.

When using computer labs in the regular work process, it is assumed that each of the students has his workplace. All workplaces are identical so that the teaching process for all students takes place in equal working conditions. Also, the lecturer has his workplace within the laboratory, which is no different from the student one, so that the content presented by the lecturer on his computer can be adequately represented by the students at their workplaces. All workstations within a computer lab are almost identical in hardware, software, and configuration terms. Also, all workstations are physically in one place, so we essentially have one homogeneous environment that is easy to implement and control.

Contrary to the previous one, we now have a situation that the teaching process is realized using home computers which are owned personally by students or lecturers. These home computers are now taking on the role of workstations used in teaching. Now not all workstations are completely identical in both hardware and software terms, and there can also be enormous differences between them in terms of configuration. Also, these units are geographically dislocated from each other, and network connectivity is realized in different ways. In this case, we have the realization of a very heterogeneous teaching environment with several major challenges that must be overcome in order to achieve the teaching process adequately and under the same conditions for all students.

In order to overcome the set challenges, the first measure was to get known with the hardware infrastructure that will be used in the further teaching process in order to make adequate further decisions regarding the possibility of using appropriate software, configurations and similar. Students were interviewed via email about the important characteristics of the computer that they will use in future work from home, namely: what hardware is their computer based on, the amount of memory the computer has, which operating system it uses and whether it is a 32-bit or 64-bit operating system, network connectivity and optionally year of computer production.

After analysis of the received responses, several conclusions about the equipment which will be used in further teaching process are made:

1) All workstations have newer generation CPUs with virtualization capability,

2) High percentage of workstations have only integrated graphics,

3) All workstations have at least 4 GB of RAM,

4) All workstations use Windows operating system in version 7, 8.1 or 10, except lecturer workstation which is based on Linux,

5) Although mostly 64bit operating systems are represented, there are significant number of 32bit installation.

In accordance with the obtained results, there are several imperatives that must be strictly observed

in the future planning of the teaching process in order to achieve it in equal conditions for all students:

1) All solutions must work on the systems with less RAM (there are significant number of systems with 4 GB RAM with 32bit OS and integrated graphics, so the amount of memory which can be used is approximately about 2-2,5 GB),

2) All solutions can be used equally on Windows and Linux systems (OS independent solutions),

3) All solutions can be used equally on 32bit and 64bit operating systems (platform independent solutions).

Previous observations must be implemented at whole, partial implementation is not allowed in any case, because the ground rule was that every student has equal conditions under which he can master the intended material.

In addition to the above, the software used had to fully comply with all legal norms. A significant fact is that most of the software used within the Faculty is licensed software. Those licenses are valid only for use on computers that are owned by Faculty. Licenses are not transferable and they cannot be used on computers which are in personal ownership, so they cannot be used on student computers at home whatever the purpose is. There are some exceptions, but this is the most common situation, so special attention is taken about the type of licenses, the permitted use of the software, various restrictions and other legal terms related to the distribution, installation and use of the software in accordance with specific conditions of use during the declared state of emergency.

In accordance with all the above, three solutions have been implemented to overcome the described limitations. Two of them were used during the school year 2019/2020, while one solution is intended for introduction into the regular teaching process during the school year 2020/2021.

3. USE OF ONLINE PRODUCTS

First mentioned solution was implemented during the classes of active teaching (computer laboratory exercises) on the course Informatics II in the first year of undergraduate academic studies within the study programs of mining, metallurgical and technological engineering at the Technical faculty in Bor.

One of the areas that are realized within this course is the fundamentals of programming through the introduction to the programming language C. In normal working conditions, to master this area, within the faculty computer laboratories, Microsoft Visual Studio would be used as an IDE that allows student to insert program code and executing it. In extraordinary circumstances, this approach is not the most suitable for home use, especially considering that this course are attending first-year students. In these home conditions, students should be introduced to the method of installation, which can vary from computer to computer, since all classes are conducted as previously mentioned in a heterogeneous environment. Also significant efforts must be made in learning the IDE itself, which can be a complicated process for students who are just gaining experience in this field and get this experience by themselves and in the home condition.

In order to overcome the given problems, the domain of work was transferred to the online world using computers that students have at home. It's already known that using of online solutions offers overcoming many of the traditional constraints that can be found in common higher education systems [8]. Also there is a trend among software vendors to develop Software-as-a-Service (SaaS) solutions latest years which is based on using applications online via web browsers [9]. No installation is required by using software within web browser, so there is a simplicity for providing these solutions to students at any time anywhere where device can be connected to the Internet. According to the previous, the focus was set on finding a C compiler that could be used online via traditional web browsers, so the solution itself will be platform independent and will not require so much use of available resources.

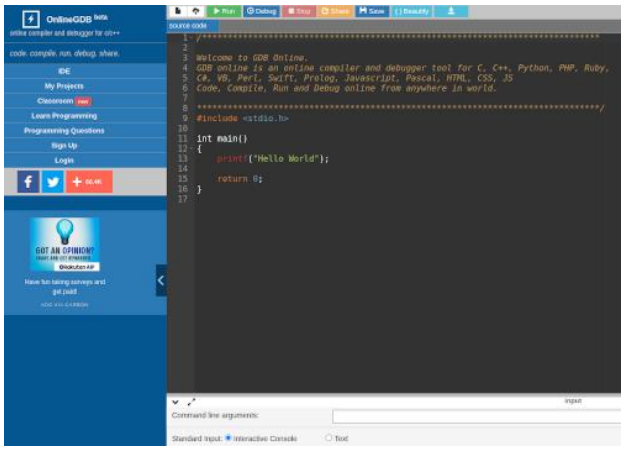

Figure 1. *Layout of OnlineGDB compiler and debugger for C programing language*

OnlineGDB [10] was used within the mentioned course as the product which satisfied presented criteria. This software represents online compiler and debugger for C and C++ programming languages which appearance is shown in Figure 1. As already mentioned, all operations are performed exclusively using a web browser. OnlineGDB has a user-friendly interface which is consisted of simple code editor which is clear, understandable and easy to use. Code editor offers option for downloading a code to local computer or to share code, which is convenient option for using in teaching purposes. Student can run or debug code which is inserted in code editor and output is also shown in the same

window in browser as well as errors and warnings that occurred during the execution of the program.

Within the mentioned online environment, there is a possibility of creating an appropriate classroom in which tasks are assigned to students involved in the classroom. This option was not used on this occasion, as the transition to online working was made approximately one month after the beginning of the summer semester, and there was a problem of harmonizing the use of appropriate data related to students in accordance with the national law on personal data protection. Accordingly, appropriate course assignments and accompanying materials were set within the faculty Moodle platform, and then students solved the assignments using the OnlineGDB platform and sent individual solutions to the course teaching staff using the share or download option. Using one of these two options, appropriate solutions are obtained adequately to the mentioned Moodle platform or are sent to the e-mail address of the lecturer by each student individually.

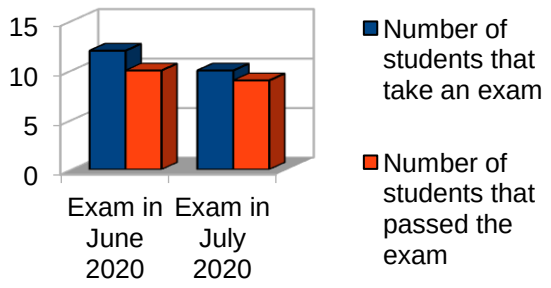

Figure 2. *Results of exams provided in June and July 2020 for course Informatics II*

This online compiler and debugger is used as a pilot software during the summer semester of the 2019/2020 school year. Students have achieved very good results using this software solution. Colloquium realized using OnlineGDB software with maximum score passed over 70 % of candidates. Results of course exams in June and July are presented in Figure 2. Course Informatics II is attended by 36 candidates. As it shown, in first two exam periods, 19 candidates are passed the exam of the 22 registered candidates. Overall score is that over 50 % of attendees are passed exams in the first two exam periods which is very good statistics.

A comparative analysis of the achieved results with previous years is not possible since this is a new curriculum of the mentioned subject. Regardless to mentioned before, analyzing the achieved results of students during summer semester and exam periods, OnlineGDB proved to be a successful software tool for the implementation of planned teaching activities. Accordingly, this solution will come into regular use in the teaching process of course Informatics II during the summer semester of the 2020/2021 school year.

4. FREE AND OPEN SOURCE SOFTWARE (FOSS)

Second mentioned solution was implemented during the classes of active teaching (computer laboratory exercises) on the elective courses Process Measurement Techniques in the fourth year of undergraduate academic studies and Process control in mineral and recycling technologies in the first year of master academic studies within the study programs of mining engineering at the Technical faculty in Bor. These two courses are highly interrelated because the master's degree course is an upgrade to the course being studied in the undergraduate academic studies. Accordingly, both courses are based in software terms on the use of the same platforms.

It was originally intended that students, while attending these two courses, be trained to work in the MATLAB software package and to during courses solve some problems in MATLAB as their personal projects. Unfortunately, due to the mentioned epidemiological situation and the adopted measures, it was necessary to give up working in MATLAB, since MATLAB is a commercial software. MathWorks, vendor of MATLAB software, offers so called student licenses, but it means that every student must buy separate license for his own computer which is inadequate approach from many points of view, economical, technical and similar. So it is concluded that at the beginning of summer semester MATLAB must be replaced with some adequate software by urgent procedure and that software replacement must be from free and open source software (FOSS) domain. If replacement will be from any commercial software domain, same issues will be encountered as in the case of MATLAB software. In short, a free or open source alternative to MATLAB had to be found.

When there are considerations about the use of free and open source software in some domain of education there is generally a fear that free or open source software will have a lack of support, will be more vulnerable and less quality and that at some point will be abandoned in relation to some similar commercial version of the given software [11]. Of course, there are cases like that, but mostly previous considerations can be related at some point to any software in some phase, whether or not it is proprietary (commercial), free or open source software. One of the key characteristic that cannot be provided by proprietary software is free redistribution [12] which is essential characteristic for software use in terms described in this paper and in this particular case which is discussed in this section.

According to the previous our software replacement is defined through some key aspects:

1) No fee may be charged for using the software,

2) Must provide some basic functionalities which are implemented in MATLAB software,

3) Must be well documented,

4) Must be redistributable,

5) If possible, it must enable easy portability of existing MATLAB codes that have already been used in the previous teaching process.

In accordance with the previous requirements best MATLAB alternative for realization of teaching process on the mentioned elective courses is GNU Octave [13]. The layout of the GNU Octave software is shown in Figure 3.

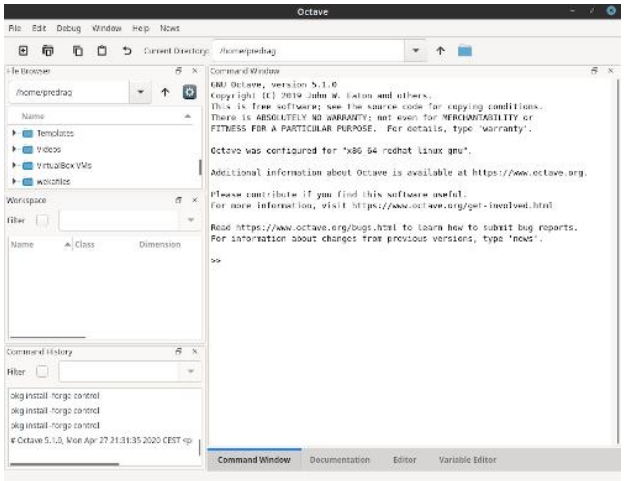

Figure 3. *Layout of GNU Octave software*

GNU Octave is software that provides various numerical computations and it can be used for numerical solution of various problems, linear and nonlinear. Octave has a number of similarities with MATLAB and thanks to these similarities, a high level of portability of the existing MATLAB code can be achieved [14]. GNU Octave is free software and is free redistribute under the terms defined in GNU GPL (General Public License) which means that software is copyrighted and that there are some limitations in distribution of the software [15]. But those limitations are not an obstacle to use software in working with students, as each of the students can without any restrictions and without any registration download the software from the official site, install it on their personal computer and freely use it to master the course.

Table 1. *Achievements of students on undergraduate academic studies*

	Student				
	1	**2**	**3**	**4**	**5**
Assignment	Max. points	Max. points	Max. points	Max. points	Max. points
Grade on exam in June 2020	10	/	10	10	10
Grade on exam in July 2020	/	10	/	/	/

Table 2. *Achievements of students on master academic studies*

	Student			
	1	**2**	**3**	**4**
Assignment	Max. points	Max. points	/	/
Grade on exam in June 2020	10	10	/	/
Grade on exam in July 2020	/	/	8	/

On undergraduate academic studies, GNU Octave software is used for work in the field of statistical processing of measurement results where students worked with common statistical functions. Students on master academic studies are used the mentioned software for work in the field of transfer functions of linear systems, as well as testing of stability of linear systems. On both level of studies, students during the semester had one assignment which are realized in the GNU Octave software. Also, control group on undergraduate academic studies was consisted of five students and on master academic studies control group was consisted of four students. Table 1 represents achievements of students on course within undergraduate academic studies, while Table 2 represents achievements of students on course within master academic studies.

As it shown in Table 1, 100 % achievements of students in the course was realized in basic academic studies in only two exam periods. On master academic studies, as it shown in Table 2, there is 75 % of achievements on exams and 50 % of achievements related to assignment.

A comparative analysis of the achieved results with previous years is not possible since these are new curriculums of the mentioned subjects. Regardless to mentioned before, analyzing the achieved results of students during summer semester and exam periods, GNU Octave proved to be a successful software for the implementation of planned teaching activities. Accordingly, this solution will come into regular use in the teaching process of elective courses Process Measurement Techniques within undergraduate academic studies and Process control in mineral and recycling technologies within master academic studies from 2020/2021 school year.

There are some estimations that the inclusion of the GNU Octave into the teaching process will bring annual savings to the Faculty of several thousand euros.

5. VIRTUAL MACHINE - VM

Previously analyzed solutions are implemented during summer semester 2019/2020 school year

in aim of ensuring the continuity of the teaching process in the current conditions caused by the epidemiological situation in the Republic of Serbia. That was a pilot solution which will be used regularly within Technical faculty in Bor in summer semester of 2020/2021 school year.

The current situation has taught employees in higher education to look at the bigger picture at the moment and to expect similar challenges in the next school year, and it is necessary to adequately prepare for these challenges. In that sense, the solution that will be presented in the following lines has not been implemented yet, but it is expected to be implemented soon, at least in the form of a pilot project.

In this situation when students practice learning from home using their personal computers and other personal resources, two great needs must be met. On the one hand, it must be possible to master the course through achieving certain teaching goals. On the other hand, using recommended software, configurations and similar technical things could not produce lack of the protection, stability, availability and security of each individual student's personal computer [16]. The above, the creation of a secure and functional environment for working on students' personal computers can be achieved by using the basic principles of virtualization. Virtualization techniques have significantly made progress in recent years, so today, using modern techniques and principles of virtualization, in a simple way various forms of training can be effectively achieved [17]. Also, virtualization brings an optimized approach in overcoming the already mentioned problems related to distance learning while reducing the whole range of side effects that can occur, such as maintenance costs [18].

A so-called virtual machine is created for a specific course or group of courses. Virtual machine is consisted exclusively from free or open source software to avoid potential distribution and licensing problems. Then, that virtual machine will be uploaded on some server on the Internet so that students can easily download it to their computer. After the downloading student start virtual machine using specialized software (for example Oracle VM VirtualBox Manager which are free to use) on his own computer. The student does not perform any installation and no adjustment of the virtual machine, all this is done for the student by the faculty staff in advance. All work is performed by the student in an isolated virtual machine environment so that the potential risk to the student's personal computer is reduced to a minimum.

For example, for particular case of using GNU Octave software described in previous chapter virtual machine will be based on some Linux distribution (for example Fedora 32). Within installed Linux will be installed GNU Octave. After installation of GNU Octave all necessary packages will be downloaded and loaded into the software. Operating system and whole software will be preconfigured so student have no obligations to set up environment, software and similar. Also within the virtual machine will be placed various examples, tutorials, manuals and other relevant documents so that student does not have to search the internet and download necessary materials.

The advantages of this approach are numerous, some of those have already been pointed out in previous lines. However, we must be consistent and mention two negative aspects of this approach, the need for a slightly larger amount of RAM on the computer running the virtual machine, as well as the need for a slightly larger free capacity on HDD or SSD for virtual machine location.

6. CONCLUSION

Most higher education institutions in Serbia have implemented online learning systems that they use in parallel with traditional forms of teaching. The Moodle platform is mostly used, but many other platforms are also used, such as Google Classroom and the like. Therefore, the system of higher education in Serbia could very quickly adapt to new circumstances that required that the entire teaching process in less than two weeks must be fully transferred to the online domain and that all teaching activities must be held online.

However, as far as computer labs are concerned, the situation is completely different. Faculties, in accordance with the standards and instructions related to the appropriate national accreditation of higher education institutions and related study programs, generally have very well-equipped computer laboratories that are functional and offer a wide range of possibilities. The mentioned computer laboratories in most cases do not have the possibility of remote access and remote work with their resources. Also, in most cases have not been considered and there are no alternative software solutions that would be applicable in terms of use in online teaching.

The current situation has led the higher education community to think about this issue and in the previous lines are presented some applicable solutions that have been tested in the actual teaching at the Technical Faculty in Bor within the summer semester of the school year 2019/2020.

The first solution was based on the use of online software in teaching based on the concept of software as a service (SaaS). The mentioned solution provided simplicity and efficiency in performing the teaching process in the appropriate course, both on the part of the lecturers and the students. Extremely good results were achieved in the implementation of this solution, so that the use

value of the mentioned solution was confirmed, which created the conditions for the introduction of these principles in the regular teaching framework in the future semesters.

When the presented solution is compared with the previous practice, the key advantages are reflected in the flexibility that the mentioned solution brings in various aspects of work. Since the entire execution of tasks in the mentioned environment requires only Internet access and a web browser, this solution is completely platform-independent, which allows execution on almost all systems, so no additional requirements need to be set related to necessary equipment. Since use is completely free, there are no additional costs that could further financially burden the faculty. Also, the interface itself is clear and easy and no additional effort is needed to explain the basic principles of working with the environment. On the other hand, two potential usage problems have been identified. If the mentioned environment would be used with its expanded possibilities (classroom), since certain data on students outside the domain of the faculty are entered, additional efforts would have to be made in harmonizing this way of use with the existing legal regulations. Also, within the environment, various advertising messages are broadcast over which the faculty has no influence, so the faculty should clearly distance itself from any marketing activities of this type and make it clear that these advertising messages do not in any sense reflect any faculty policy or opinion.

The second presented solution was based on overcoming the problems posed by the use of commercial software and the limitations of the licenses under which such software is distributed. Overcoming the identified problems was based on finding free and open source software (FOSS) alternatives to previously used proprietary software. The mentioned solution was tested in the conditions of teaching in narrowly professional subjects at different levels of education within one study program. In this case, too, the alternative solution was confirmed through extremely good results in the implementation of teaching activities during one semester, which created the conditions for the solution to be applied in the future as a permanent solution in the teaching of appropriate courses.

In this case, the dominant advantage is expressed through the fact that these types of software can be used in the teaching process free of charge and that in most cases they can be adequately distributed among students and teaching staff, which is generally not the case with proprietary software. The faculty itself does not have to provide additional efforts and resources related to software distribution of this kind, since the software is in almost all cases simply downloaded from an Internet site defined by the vendor. Some vendors require registration in order to enable proper downloads which raise personal data collection issue. Although, mostly, students register individually, it would be good practice for the faculty to at least warn students about potential risks of giving personal data and that the faculty is in no way involved in the collection and processing of those personal data. In some cases, this situation can be avoided if the faculty takes responsibility for the software distribution itself, but this can, on the other hand, create additional costs for the faculty in terms of providing additional resources.

As can be seen from the previous, both solutions meet a number of criteria that had to be met in the special conditions of teaching during the summer semester of the school year 2019/2020. This proves that teaching in higher education study programs can be performed equally efficiently in the absence of the use of commercial software while maintaining a high level of teaching and good output results.

Especially great success is expected from the introduction of the principle of virtualization in the implementation of computer laboratories. This concept will be tested during the school year 2020/2021 in real teaching conditions and it is expected after the pilot program that the mentioned concept will be introduced in regular classes during the school year 2021/2022. By introducing the concept of virtualization, the principle will be realized that regardless of the place where the intended tasks are performed (home conditions, computer laboratory or some other location), the student always has an identical environment for work in software and configuration terms. Also, the possibility of unforeseen circumstances (errors, impact on computer operation, etc.) will be minimized.

What must be especially emphasized is the fact that by using such solutions, faculties achieve many benefits not only in terms of maintaining and improving the quality of teaching, but also in minimizing the resources needed for their implementation, as well as in economic terms.

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Building the Payroll Information System for High Education Institution Using UML – Master Thesis Work

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Abstract: *The use of Students' Team work in developing the information system using the UML method to properly model the specific business processes in calculation the payroll of a high education institution and its implementation is described in this paper. The system has been developed by the book, following the lessons from the courses of the study programme Computer Science and Informatics. The existing legacy software was studied, gaps were identified and using the UML diagrams the new system was modelled. Based on the such model and using the free software components, the system was developed, tested and implemented by the students of master studies. Using the UML for initial modelling and updating the model according to the changes implemented during the system development, led to the fact that the model became the documentation based on which the system could be maintained even by developers who didn't participate in initial system development.*

Keywords: *UML, Development of Information Systems, Students' projects*

1. INTRODUCTION

In modern society, it is inconceivable to manually perform processes which require the repetition of relatively easy data processing, such as recording credit cards transactions, perform bookkeeping, recording of article sales, etc.

In order to educate students whose interests are in Information Technologies, a number of courses were designed within the different study programmes. The knowledge the students gain through the education process in the area of Information Technology (IT) and Computer Sciences (CS) is rather demonstrated through the students' practical work. In some High Education Institutions, the students of IT and CS have to work in the student team projects, with the task to develop software [1, 2], to build a solution [3], to test software [4] or to estimate the quality and usefulness of UML software modelling tools [5].

The team work is usually introduced for the students because this is how they will work once they enter the software development industry. It is rare for software engineers to work in isolation. As software engineers our students will also be assessed on their performance by others in their workplace, so they need to understand the appraisal process and how it can help to further develop their skills as practitioners [1]. In order to perform development tasks, the students had to pass programming modules covering Problem Solving, Program Design and Implementation, and Object Oriented Program Design Development. The assessments of the students' project works are sometimes performed using the different software quality models (modularization, reusability, updatability, etc.) [2], or in number and severity of software bugs found [4].

The objective of our work was to assign to the group of the best students of the Computer Science Master study module a software development and implementation project that can be implemented and really used in commercial environment. The project life cycle had to fulfil all development and implementation steps (by the book) as it would have in commercial development company with the special emphasis on modelling the system before development and implementation. The specific task was to replace old one–user system for payroll calculation (with limited number of functionalities) with the modern Web based multiple users system. The work in the project was divided between the students: collecting the user requirements, building the model, developing the Web application, developing the database, implementing the hardware and software. During the work initially created models were updated by all parties.

At the end, the work of each student was incorporated in his/her master thesis work and they later defended their master theses.

When multiple users of different profiles need to perform individual business processes on their workstations using the system, when the architecture of the system is complex, and when the system is to be developed using the object oriented approach, then it is clear that the complex modelling tool must be selected during the development. Also, a developing team with clear shared tasks must be created and more complex server – client architecture must be designed. Our team was built from two teachers (Managers and Architecture Designers) and three students (UML designer, Java Web Application designer and MS SQL Server Database Designer). Documenting the business processes, modelling the classes of the application and database and designing the system architecture was performed using the UML [6, 7] tool; and a three-tier client - server architecture was selected.

2. LEGACY SYSTEM

The information system to be replaced was developed in Visual Basic programing language, it was compiled and the source code was missing.

Access to the information system was limited to only one user at a time. Although the business processes required the parallel input of data by users of different profiles (financial department to insert the actual monthly workloads of employees, legal department to update the positions (ranks) of employees and their work experience, head of study programme department to update teaching staff semester workload, etc.), only one user (from financial department) used to log in and compile data from the paper to the GUI. He/she used to do it on particular workstation where the application and a MS Access database were installed.

The GUI was designed in the form of MS Excel tables where a user could move between the cells of two different types: enabled and disabled for modifications by user. User could modify names of employees, the number of working hours, type of employees (teaching/non-teaching staff, academic rank of teachers), working experience, etc., and based on these inputs, the application could calculate values of cells disabled for modification by user (gross salary, net salary, deductions, etc.).

The codebooks (like academic ranks of teachers, names of the banks, bank accounts of employees, codes and names of municipalities where employees live in, etc.) didn't exist, all data were stored in many redundant databases (one database for one payroll calculation) with non-normalized tables with many columns and repeating data. For each Payroll calculation a new database used to be opened and the data from the database of the previous period was initially copied into it, thus allowing modifications for the new payroll calculation.

A simple MS Access database security was implemented for default user with a user name and a password. But, unfortunately, that protection could be easily overridden by using the free tools to find or delete a MS Access user's password. This database also lacked a built-in backup service.

3. MODELING A NEW SYSTEM

For the development of the new system, the UML method was selected and the system was modelled using the diagrams of: requirements, activities, use cases, user interfaces, communication, sequences, classes, as well as diagrams of data, software components and deployment.

3.1. Diagram of user requirements

The first step in creating the new or improving the existing software is to collect user requirements as well as business rules. In the UML, they are recorded in diagrams of user requirements. The requirements are usually grouped by the larger business processes. The requirements are collected by reading the existing documents (rulebooks, reports, etc.) and on clarification meetings with stakeholders (financial department, legal department, heads of study program departments, etc.). In order to document all requirements, for each one is assigned a unique label and relations between them is documented. Figure 1 shows user requirements related to employee master data.

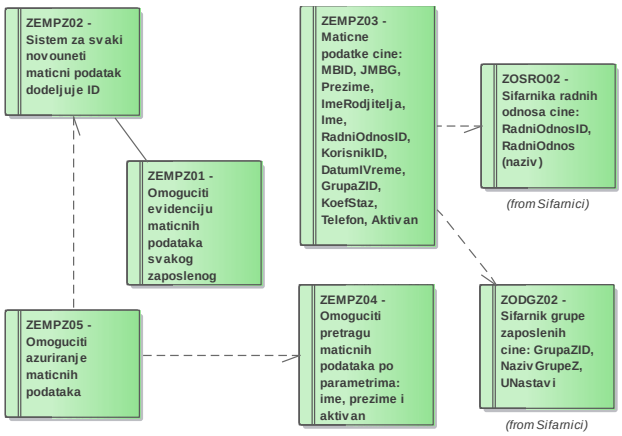

Figure 1. *Diagram of user requirements related to employee master data.*

3.2. Activity diagram

The activity diagram is diagram composed of activities, control flows, objects, object flows, decisions and partitions (swimming lanes) that show who perform activities. Activity diagrams can be used to model high-level business processes, but they can also be used to model each individual operation. These operations can be performed sequentially and in parallel. In Figure 2 is shown, a sequential flow of business activities for payroll preparation and calculation. As it can be seen there are three partitions (stakeholders - user groups): Legal department. Financial department and the Payroll system.

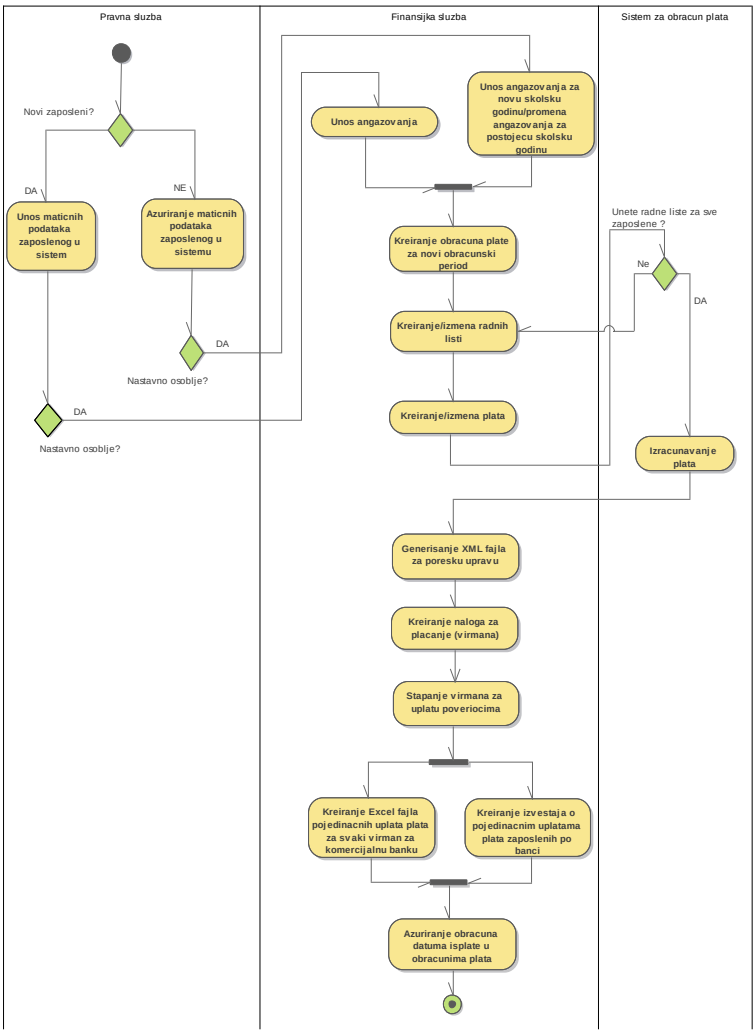

Figure 2. *Activity diagram for Payroll Calculation system.*

3.3. Use case diagram

The use case diagram describes how a software user can perform a process. The use case diagram is used to show how the system will respond to an action by the user, subsystem or external system. Each use case is described via message sequence between the system and one or more participants. The essence of this diagram is to define participants, use cases, as well as to define connections between participants and use cases.

A global (high level view for the whole system, not for individual functionalities) use case diagram is shown in Figure 3. It shows that the user must log into the system to perform any group of functionality, and depending on the role assigned to him/her, he/she will be enabled to perform only certain operations in the information system. Each user group has specific rights. There are three groups of users defined in our information system: administrator, financial and legal department user, and five high level use cases: Log in, Maintenance of the code tables and users, Evidence of the Employees, norms and workloads, Preparation and payroll calculation and Report generation.

In the UML tool we used, the icon in a use case indicates that this use case has a more detailed diagram (decomposition) related to it.

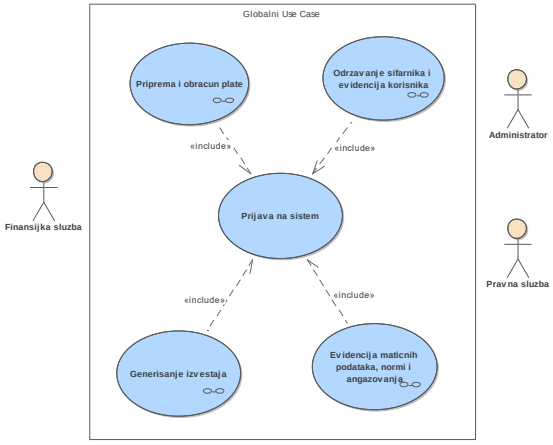

Figure 3. *Global Use Case Diagram.*

In Figure 4, the detailed diagram of the high level use case "Evidence of the Employees, norms and workloads" is presented. The user from Legal department is in charge for maintaining the basic data of employees, positions of employees, additional functions of employees (dean, vice dean,

heads of study programs, etc.), court decisions about suspensions of employees (alimony, other payments based on lost court cases, etc.), bank accounts of employees, the expected workload of employees according to the contract, etc.

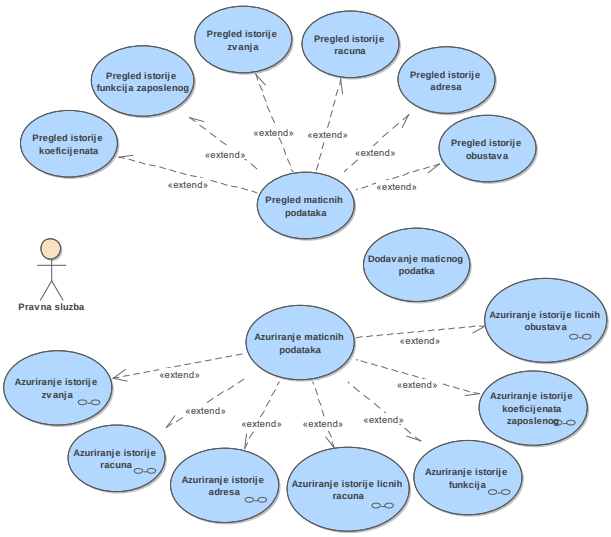

Figure 4. *Use Case Diagram of Evidence of the Employees.*

The use case is properly documented only when a ***scenario*** of using the use case is precisely described. The scenario consists of clear ordered messages (interactions) between user and a system. In order to client understand how future use cases will work, a system designer must assign the scenario for each use case (basic and alternative scenarios), and show to a client the set of all use cases of the future system with their descriptions. For example, the diagram of use cases for maintaining codebook of banks (where employees have their bank accounts) with a description of the basic and alternative scenarios is shown in Figure 5.

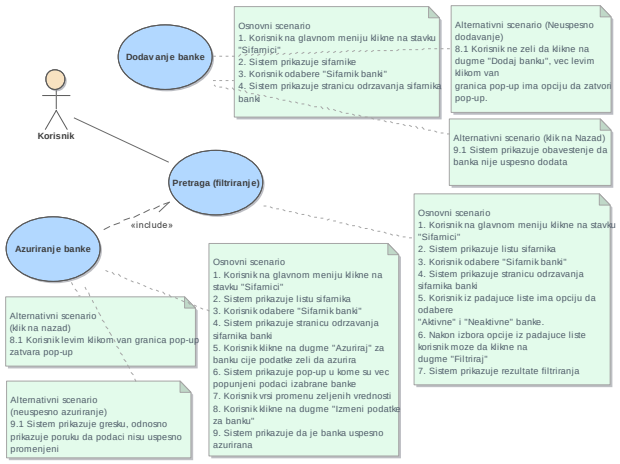

Figure 5. *The diagram of use cases "maintenance of the banks".*

A user may not understand such messages because most of them describe user actions on a GUI. That is why the scenario must have the reference on a proper user form. Usually in UML a rough GUI is drawn with its components: text boxes, buttons, drop down lists, etc. Because we have implemented the new information system, we show the real web forms in Figure 6.

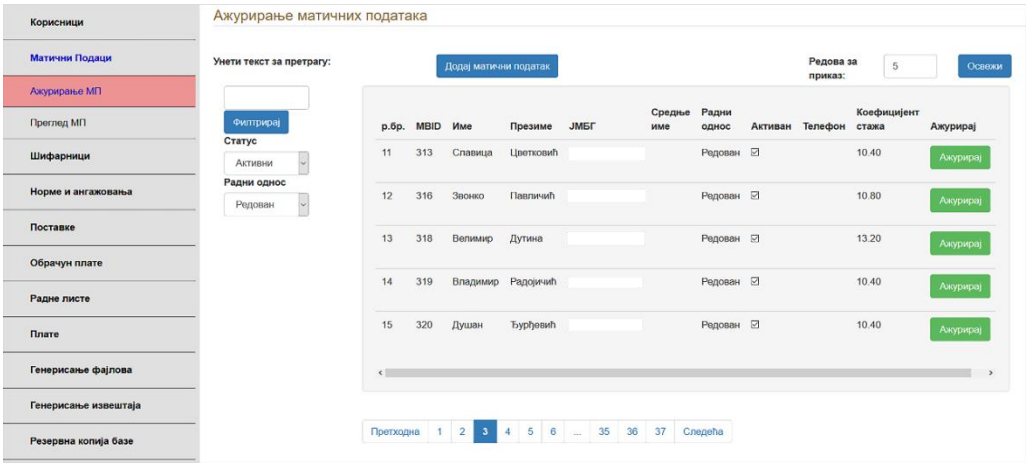

Figure 6. *User interface for selection of an employee to update his master data.*

4. APPLICATION MODELING

4.1. Communication diagram

After the client agrees to the proposed functionalities of the future system shown through the use case diagrams and the user interface layouts, the next step is to design a working structure (classes) of the system application. The first step is to create communication diagrams where for each or the groups of use cases the classes that must handle functionality of use case(s) will be identified. This diagram also shows the connections between different types of classes and entities involved in messaging. The classes are of types: Boundary classes (in our case JSP pages), Entity classes (in our case Beans – the classes which objects keep the data) and Control classes (the classes where the system logic is implemented – Servlet, Data Manager, Peer classes). In Figure 7 is shown the communication diagram with the classes needed to implement functionality of the use cases related to

maintenance of the banks. One can notice the scenario of the use case in the left upper corner.

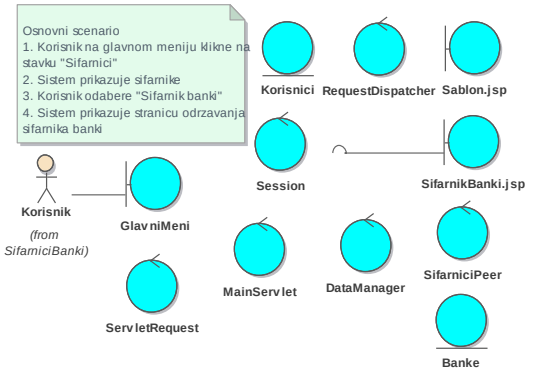

Figure 7. *Communication diagram for use case: "search for the bank".*

4.2. Sequence diagrams

Based on the proposed classes in communication diagrams, messages that are exchanged between those classes are entered into the sequence diagrams in order to implement the steps described in the use case scenarios. This type of diagram is easy for understanding as it shows the sequence of the messages between classes in time ordered from the top to the bottom. The decisions (if clauses) and loops are shown in rectangles with key words alt and loop. One can also notice the moments of creating objects of particular classes (objects appear somewhere in the middle of diagram) and the references to execution of the other sequence diagrams (rectangles with a key word "ref"). The messages in the diagram must contain exactly the structure of methods or functions calls. The message must have a clear name with input parameters and return value type, because the user who looks at the diagram (in most cases the developer) must know how to capture those parameters, send a call to a function or a method and collects back the return value of the function. One example of the sequence diagram is presented in Figure 8.

4.3. Class diagram

Class diagrams are created based on the messages posted in the sequence diagrams. Messages that exchange data between different classes become public functions and belong to the classes receiving them (to which the arrow in the sequence diagrams is oriented). The attributes of the classes are mostly private. In Control class the attributes are usually pointers to the other classes (to which current class is communicating to) or pointers of data been received from other classes; in boundary class they are GUI controls (text boxes, drop down lists, buttons, etc.) and in Entity classes they are attributes that keep data (i.e. name, address, phone number, email address, etc. for the entity Employee).

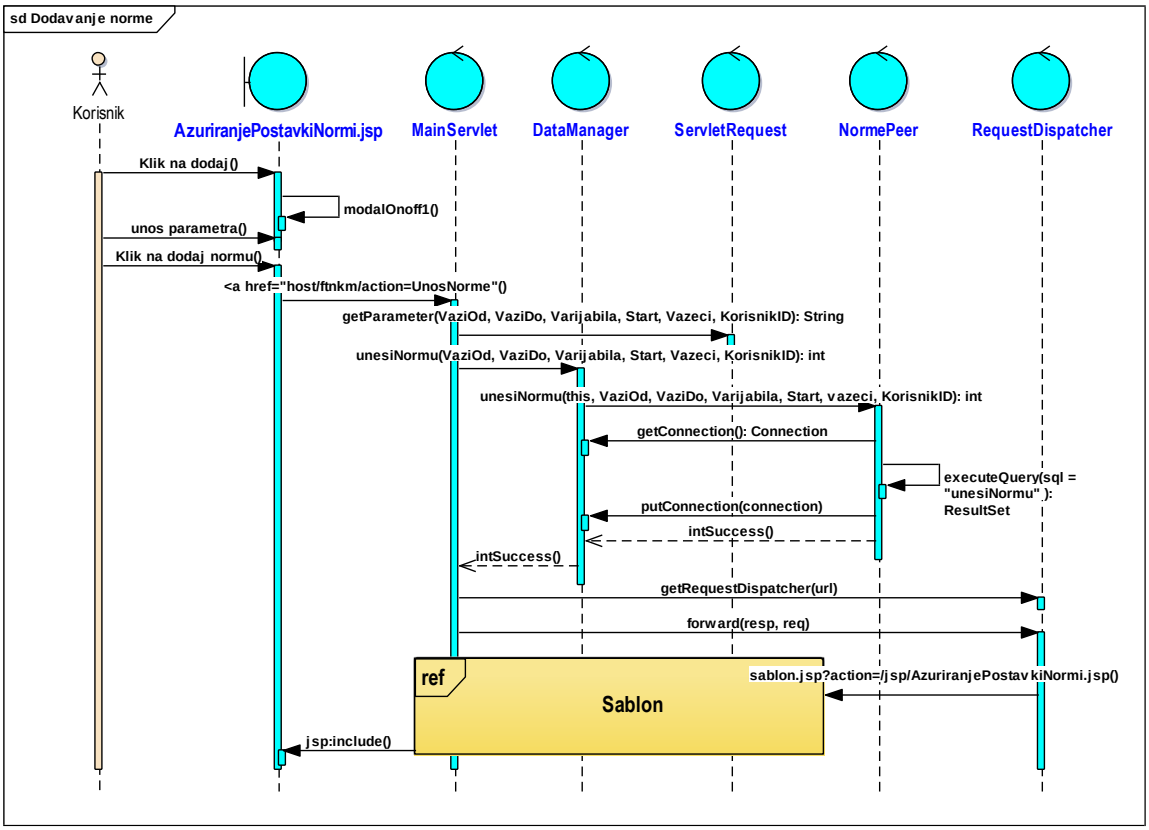

Figure 8. *Sequence diagram for use case: "Adding the work norm".*

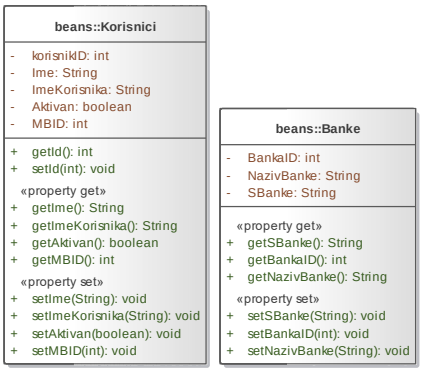

Figure 9. *Class diagram of users and bank codebook.*

Based on the messages on the sequence diagram in Figure 8, the partial class diagram with only entity classes (because of the space needed) is shown in Figure 9. UML tool can generate source code for each class in the diagram. The created class source code will have the constructor(s), list of attributes, and class functions or properties declarations with all parameters and return values. The source code will miss the implementation (a code how each function is executed) and it remains as a task for the developer. Up to this stage the functioning (the dynamic) and the classes (the structure) of an application is modelled.

5. DATABASE DEVELOPMENT

From the entity classes (by involving only attributes of the classes) an initial database diagram can be created. Through the several iterations, some attributes will be suppressed (like pointers to other classes) and relations between tables will be established. In cases where entities are related with cardinality many-to-many new tables will be created.

Our database consists of several table groups: users and roles, employees and their properties, norms and worksheets, payroll and payment orders. The database scheme of group of tables "employees and their properties" is presented in Figure 10.

Because of the paper limitation, the diagrams of database stored procedures, triggers and other objects are not presented.

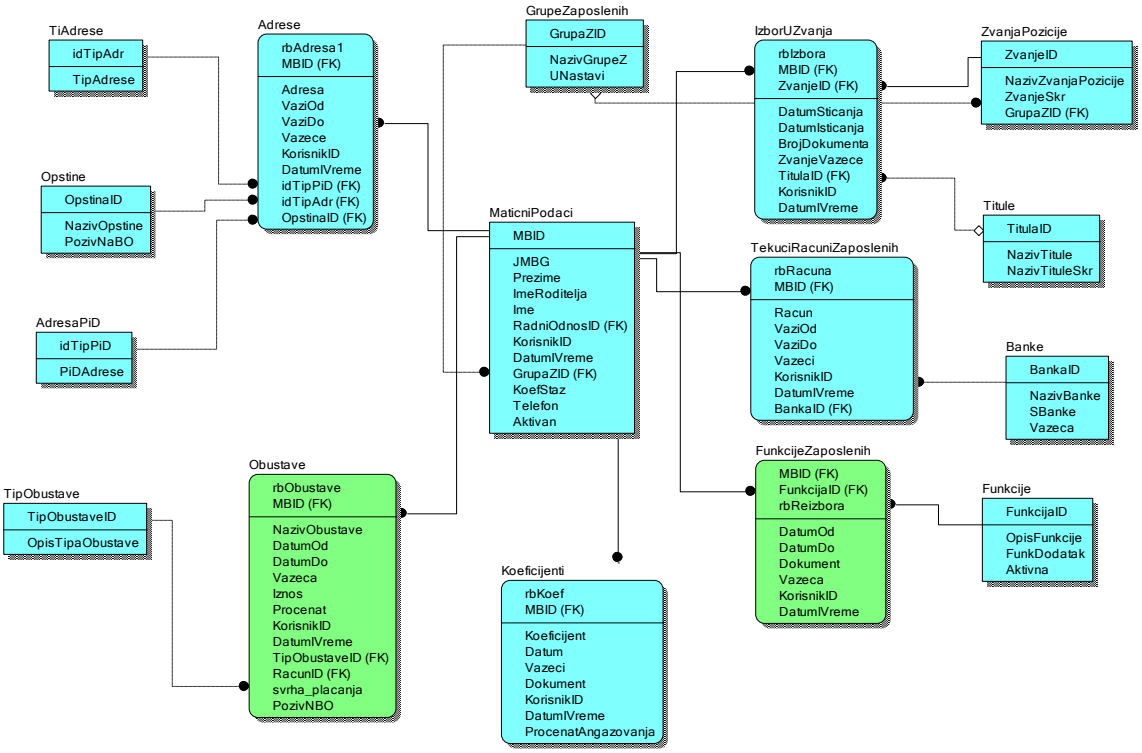

Figure 10. *Schematic illustration of database entities related to "employees and their properties".*

6. IMPLEMENTATION MODELLING

In UML modelling, it is not enough just to describe the building and dynamic blocks for application and database development, but it is also necessary to design an information system implementation model. It is important to document the software packages to be installed on computers in the production environment, and also to document how those computers are connected and configured.

6.1. Component diagrams

One of the most important features in the process of developing complex software solutions is their architecture, i.e. organisation of components that communicate with each other. Our application uses a three-tier architecture, which is composed of three logically independent tiers (presentation layer – business logic – database server) that communicate through the interfaces.

In our case, the first tier, the presentation tier, was made using JSP (Java server page) technology [8] with the HTML5 web pages [9] for presenting the content on a web browser of a client, combined with Java and JavaScript code. The standard computer network is a required medium that connects an application user to a second tier server in a computer centre.

Business logic is written in a Java programming language using a NetBeans development environment that uses a GlassFish application server to develop and run Web applications [10]. In order to application run on a server in a production environment, the following software components must be installed on the server side tier 2: Java Development Kit v8.x, GlassFish v4.0 application server configured to enable SSL, compiled application in WAR format to be attached to the GlassFish server, Jasper Reports v5.5.0 for reporting, DOM (The Document Object Model) parser for generating XML files, and for tier 3: Microsoft SQL Server Express 2014 SUBP and the payroll database to be attached to the SUBP.

The business logic tier retrieves the requested data from the data tier (using the JDBC interface [11]) and sends them to the presentation tier. The presented components are shown on Components diagram in Figure 11.

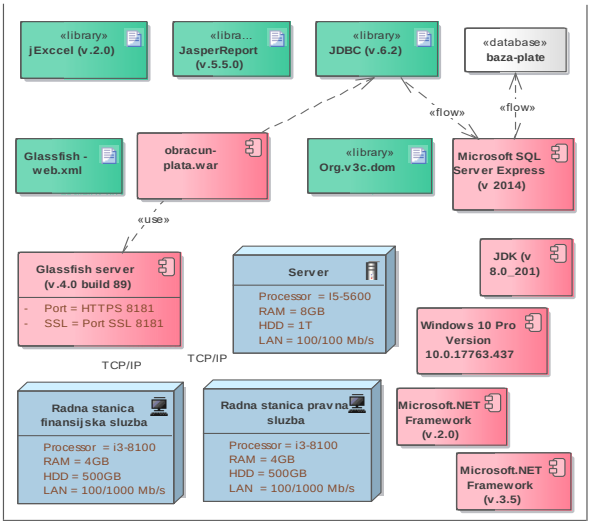

Figure 11. *Component Diagram for payroll calculation software.*

6.2. Deployment diagram

One of the tasks of a deployment diagram is to show a network architecture of the hardware components.

The server and workstations in the financial and legal departments are connected to the *Switch Linksys SE2800*, which is connected to a *Cisco* router, thus providing Internet access and communication between workstations and servers as it is a web-based three-tier application.

7. IMPLEMENTATION OF THE PROJECT

Working on the described project assignment is an example of development and implementation of a real software project through the teamwork. Students who participated on a team that implemented the project, applied the knowledge gained mostly from the following courses: Object Oriented Programming, Databases, Information Systems, Software Design, and Principles of Software Engineering in their master theses.

In addition, it was the opportunity for students to gain significant experience and to overcome in the most efficient way the problems of applying theoretical and abstract knowledge to solving practical problems. Students used the acquired knowledge, skills, tools and techniques to implement project activities to meet client requirements.

Compared to the research results presented in papers [1-5], where the main indicators were: involvement of students in tasks during the project life-cycle via contribution matrices, students' feedback obtained by questionnaires, estimation of quality of software related to modularization, reusability, updatability, etc. obtaining the number of bugs during test session, in our team work the main output was satisfaction of the customer after installing the software.

After first installation of the software for payroll calculation in very short time, thanks to modularization and reusability the system functionalities were extended to process calculation of compensations for contracted teachers from external institutions and compensations for work on scientific and commercial projects. Thanks to the proper UML documentation, the software is continuously updating with adding more functionalities by other students.

By continuously monitoring the results obtained and evaluating students' work, the teachers gained a real insight into the students' ability to participate in the real-world tasks. In the process of monitoring of students' acquired knowledge in the implementation of the project, the teachers (as part of the team) actively participated in order to project be developed and implemented in an efficient and effective manner. The teachers were controlling the UML diagrams during the analysis and project design and were giving tips for minor corrections of them. Also, teachers were assisting in the development of the application and in the development of the database, as well as in adjusting the architecture of the system in the production environment.

The key to successful customer satisfaction, and thus enhancing a business value, is good project management. During the team work on this assignment, students were able to learn how to manage the project: through the organisation,

planning and control of activities, through the division of the project into phases and tasks, through the rational alignment of all necessary resources and the coordination of performing the required activities.

As an integral part of this assignment, the students learned how to gather the necessary data, analyse customer requirements and model the future system so that the system satisfies the clients, and how to manage the risks, quality and time during the development of the system. One of the essential features of the project solution presented is using the UML (Unified Modelling Language) for initial modelling of the software and emerging it into the detailed documentation that allows easy maintenance and updating of the application and makes the system flexible for upgrading.

The core functionalities of the project were completed within the expected period of three months, and remained functionalities were developed and implemented in next three months, within which the full functionality of the system was obtained.

8. CONCLUSION

This paper describes the practical development of the real modern three-tier Information System by students of the master study programme using the UML as a modelling tool. By creating different UML diagrams, an object-oriented software is designed in a well-defined order. Using the UML diagrams, the other members of the developing team developed the web based application and the database. During the development some elements in diagrams are altered and these diagrams represent now the detailed development documentation needed to further upgrade the software.

The diagrams used confirmed the premise that:

- activity diagrams, user interface diagrams and use case diagrams can be used for making the proposal of functioning of the system to the client negotiations with the client (since any client can easily read the use case scenario and understand work on the offered user interface),
- by creating communication, sequence and class diagrams, the designer maps business rules into program building blocks in an object-oriented programming language, which are classes with their attributes and functions. Based on these diagrams a developer can easily obtain the source code of the classes and implement already identified functions and properties,
- data diagrams with a database scheme and a list of procedures, triggers and other objects can facilitate the database developer to properly design the database,
- component and deployment diagrams document the real setup of software and hardware components and enable system architect to properly configure, connect and run information system

The implementation of a project management concept has led to the fulfilment of the project goals respecting the completion of the project in the planned time and with the anticipated resources and quality in accordance with the customer requirements and later users' satisfaction.

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Professional paper
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The Role of PLM Academic Platforms in Education of the „Engineers of the Future"

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Abstract: *The growing importance of Product Lifecycle Management (PLM) as a key business strategy for achieving success demands that the workforce understands PLM and how to use PLM systems to support the increasingly complex reality. Beside technical knowledge, the engineers of future must be familiar with the PLM philosophy and use PLM solutions effectively in collaborative environment. However, the lack of engineers with these competencies makes it difficult to implement and execute PLM concept in companies. So engineer's education must take a step forward using advanced educational models based on student`s working in a real PLM environment. The paper discusses how PLM academic platforms provided by PLM software vendors can contribute to establishing of such models, indicating the educational potential of some of the most commonly used academic platforms in practice.*

Keywords: *Product Lifecycle Management; academic platforms; engineers of the future*

1. INTRODUCTION

Product Lifecycle management (PLM) is an integrated, information-based approach consisting of people, processes and technologies covering all aspects of the product life cycle, from its design through production, implementation and maintenance, to final disposal [1].

According to CIMdata, a global leader in PLM consulting, PLM is a strategic business approach that applies a consistent set of business solutions to support the collaborative creation, management, dissemination and use of product information across companies, integrating people, processes, business systems and information. [2].

PLM is an information system aimed at integration the company's functions by connecting and controlling various business processes through product data, using advanced IT technologies [3].

PLM systems include a multitude of applications covering different processes and disciplines during the product lifecycle, such as:

- Product Data Management (PDM);
- Computer Aided Design (CAD);
- Computer Aided Engineering (CAE);
- Simulation and Analysis (S&A);
- Computer Aided Manufacturing (CAM);
- Reporting and analytics;
- Portfolio Management;
- Requirements management;
- Compliance Management;
- Project Management;
- Configuration Management;
- Document Management and others.

In last decades, PLM has grown into a key paradigm for product management due to the increasingly intense process of globalization, shorter product lifecycles and increasing demand for a wide range of complex, sophisticated and customized goods and services.

The growing importance of PLM systems has also been influenced by new engineering trends that companies follow to achieve innovative leadership in their fields and as a consequence of striving to achieve excellence at all stages of the life cycle from idea, through development and production to service delivery.

On the other hand, globalization and technological progress are driving markets and highlighting the need for PLM strategies to help turn emerging markets into emerging economies, and mature markets into innovator markets—but this demands that the workforce understands PLM and how to use it to support the rapidly evolving realities [4].

In accordance with the importance of the PLM concept for prosperity and strengthening the competitiveness of companies in today's business conditions, the development of PLM competencies should be an integral part of educational strategies in the education of next generation of engineers with competencies that are in line with the requirements of contemporary industry, the so-called engineers of the future.

Since PLM is IT-based paradigm-based paradigm, preparing students for real-world professional challenges in PLM environment requires the use of a wide range of IT solutions in teaching processes. Since PLM systems include a wide range of applications that span the entire product lifecycle, from requirements management to technical documentation, which commercial price is quite high and unaffordable for most of educational institutions, PLM education is quite limited.

Engineers of the future must possess skills such as innovation, entrepreneurial vision, problem solving, critical thinking, teamwork and digital competences, which is difficult to achieve with traditional educational models.

The application of PLM academic platforms in education processes is a way to overcome all these challenges in the education of future engineers. Those platforms provide integrated software solutions that cover entire product lifecycle, which is aimed at supporting of education and preparing students to work in a PLM environment, understanding of PLM concept, and acquisition digital experience as well as competencies inherent to the engineers of the future.

2. PLM SYSTEM AS IT SUPPORT TO IMPLEMENTATION OF PLM CONCEPT

PLM systems combine different tools and technologies into a single solution that enables collaborative creation, management, exchange and use of information, data and product knowledge. In order to present in more detail the possibilities provided by the PLM concept, some of the modules and functionalities of the PLM system will be presented. Given the rather heterogeneous conceptualizations of PLM, there is no single perspective on what exactly PLM contains [10], and therefore no unique classification of the modules and functionalities provided by PLM systems.

Below are given some of the standard PLM functionalities, which are supported by most PLM systems, this list is derived from the analysis of PLM solutions currently available on the market.

Bill of Material (BOM) Management module serves product designers to create and manage a part-centric digital product, it enables product visualization, part classification, easy editing, tracking part history...

Change and Configuration Management module provides delivering a real-time view of the most accurate data about change and product configurations from single source.

Manufacturing Management module provides an unimpeded information flow between engineering and manufacturing by ensuring automation and unique source of data about product traceability, change control and security.

Product data management (PDM) module provides reliable and fast access, manipulation, tracking and control of CAD data and related documents generated during design and other engineering processes.

Systems Engineering module supports collaborative work of multiple engineering disciplines during the designing and building of complex products.

Requirements Management module helps teams, during developing complex products, to specify, verify and validate every product aspect; also, it enables automation of traceability and sharing of data about requirements and product validation, between different functions and teams.

Idea Management module enables generation, evaluation and selection of ideas for new product development in a structured way.

Process Definition and Management module relates to the functionalities enabling efficient development and management of processes and workflows including product development workflow management, engineering change management…

Compliance Management module functionality relates to the management of regulations and standards related to product compliance management.

3. PLM ACADEMIC PLATFORMS

Since PLM is not just an engineering discipline, PLM education should be extended well beyond engineering techniques, on business and operations strategies, marketing, purchasing, product support, project management, costing, manufacturing... On the other hand, researches show that PLM related curriculums are mainly based on topics such as CAD, CAE and Digital Manufacturing [4], which limits the engineers training exclusively to the product design or production phase.

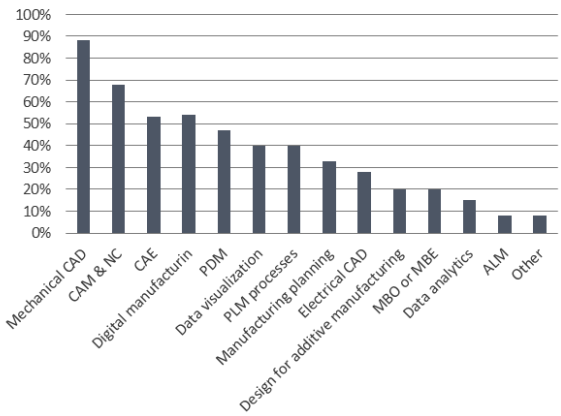

Figure 1. *Topics covered in PLM related curriculums [4]*

Such programs do not cover the entire range from planning to engineering design to manufacturing

and cannot prepare students for PLM roles beyond engineering or to understand PLM concept and how to use it to support the company growth.

PLM academic platforms provide integrated software solutions for the needs of educational processes that cover entire product lifecycle, from idea, through development and production to service delivery, and product disposal. This enables the preparation of future engineers for PLM roles beyond engineering leading to comprehensive understanding of PLM concept and how it could be used to establish an integrated management of product data throughout the entire product lifecycle or to drive company growth.

By introducing the PLM academic platform into classrooms, students are enabled to acquire skills, knowledge and advanced digital competencies by working in a real PLM environment.

It is also important to note that the use of the PLM academic platform during the educational process supports the implementation of 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. The concept and key benefits of these educational models are discussed below.

3.1. Project-based learning as a main pedagogical strategy for education of "engineers of the future"

Project-Based Learning is one of the increasingly used educations teaching which occupies an increasingly important place in modern education strategies, especially in the education of so-called „engineers of the future". Project-based learning is an education method in which students acquire knowledge and skills by exploring an authentic, interesting and complex question, problem or challenge over a long period of time. During the learning process, students are focusing on achieving the common goals through collaboration.

According to Hârtescu [5], the concept of Project-based learning organizes learning around projects and involves the students in authentic situations where they can explore and apply the subject matter to problems that are complex and relevant to the professional practice for which they are preparing.

The project-based learning is considered to be a particular type of inquiry-based learning where the context of learning is provided through authentic questions and problems within real-world practices that lead to meaningful learning experiences [6].

According to [7, 8, 9] the key benefits of project-based learning relate to:

- stimulation of self-motivation and student ownership of the problem, solution and learning;
- development of self-regulation, agency, commitment and competence;
- experience and development of teamwork;
- experience of authentic problems and professional practices;
- development of reflective skills;
- significant influence of creative thinking on students' learning outcomes;
- development of written, oral and other communication skills;
- experience of problem solving and the design process;
- exposure to the multi-disciplinary and systems nature of problems and
- coping with incomplete and imprecise information;
- improving students' problem-solving skill, critical and creative skill, communication skill, team work;
- lifetime learning, adaptation to changes, and self-evaluation.

What is more important, the authors of the study [11] find that project-based learning as related to STEM (science, technology, engineering and mathematics) curriculum led to gains in terms of enjoyment, engagement with the project and the ability to combine theory and practice effectively.

3.2. Problem-based learning as an education model for promotion of critical thinking and problem-solving skills

The Problem-based learning is one of the often-used education strategies leading to developing 21st century skills. Although this concept has been in use for more than thirty years, providing good results in various fields, its importance is especially evident in educational processes aimed at educating engineers with conceptual knowledge, practical skills and critical thinking and problem-solving skills in accordance with the needs of modern industrial trends.

Today the use of problem-based learning in engineering programs has been widespread, especially within the field of STEM education.

Yew & Goh [12] define Problem-based learning as a pedagogical approach that enables students to learn while engaging actively with meaningful problems, whereby the students are given the opportunities to problem-solving in a collaborative setting and creating mental models for learning.

Also, they indicate that Problem-based learning as a pedagogical strategy is premised on the belief that effective learning takes place when students both construct and co-construct ideas through social interactions and self-directed learning [12].

According to Arend [13], Problem-based learning consists of some basic elements, including 1) problem orientation; 2) organizing students to conduct research; 3) assisting independent and group investigations; 4) developing and presenting artifacts; and 5) analyzing and evaluating problem solving process.

As authors [12, 14, 15, 16] point out, problem-based learning benefits relate to:

- promotes self-directed learning habits;
- enables developing problem-solving skills and deep disciplinary knowledge;
- supports active and group learning;
- developing students' reflective, critical and collaborative skills;
- it is aimed at training competent and skilled practitioners and to promote long-term retention of knowledge and skills acquired during the learning experience;
- empowers students to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem
- provides opportunity for students to work cooperatively, to demonstrate effective communication skills, and to use content knowledge and intellectual skills to become continual learners.

4. PLM ACADEMIC PLATFORMS REVIEW

In this chapter, some of the most commonly used PLM academic platforms in educational institutions with PLM related courses will be reviewed. Namely, the educational potential of the academic platforms provided by Aras, Siemens and Dassault System companies will be presented.

4.1. Siemens PLM academic platform

Siemens PLM platform offers IT support for main PLM components, integrated into 350 commercial applications that addresses the full product lifecycle enabling: transforming of product development to accelerate innovation; connecting people and processes with knowledge; optimizing manufacturing for greater confidence and deploying standardized solutions with open software tools.

Siemens PLM Software also provides a global academic program that is focused on empowering the next generation of digital talent [17].

Siemens PLM Software delivers a multitude of PLM capabilities in support of education as an integrated solution that covers the gamut from planning to engineering design to manufacturing within one platform, making data more accessible for roles beyond engineering. This academic platform is aimed at preparing the next generation of engineers for the digital experience [17].

As a part of its academic program Siemens established e-Learning portal so called Learning Advantage that enables users to gain skills and knowledge in Siemens Digital Industries Software products. Learning Advantage contains on-line learning resources, such as courses and assessments that are updated whenever new PLM software versions are released.

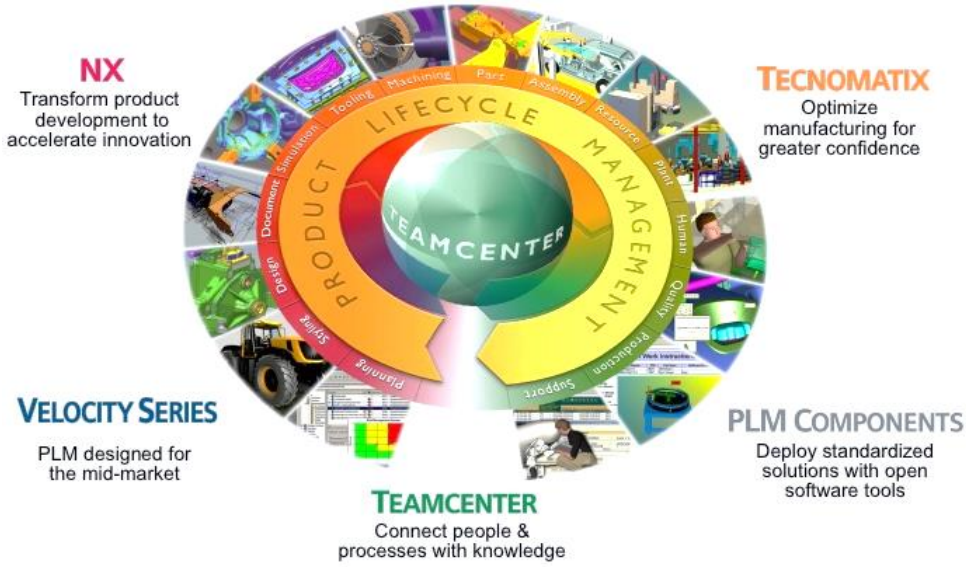

Figure 2. *Siemens PLM Platform [18]*

As in Siemens point out, the key benefits of this e-Learning portal are [17]:

- Free to any institution that has active academic licenses access to learning content and assessment tools;
- Helps students to improve their Siemens PLM Software solutions skills;
- Helps students to improve their marketability with Siemens PLM Software industry partners;

- Provides complete access to training updates and new content and
- Allows students to track course completion dates and assessment scores.

The Siemens academic partner program empowers future engineers and technologists with advance digital skills at academic institutions through different student's projects, for example:

- Student from the Katholieke Universiteit Leuven in Belgium build electric racecars useing Siemens Digital Industries Software solutions such as NX, Simcenter and Teamcenter to cover the entire product creation process chain.
- Team Bath Racing from the University of Bath designs and builds a single-seat race car to compete in Formula Student competitions around the world. During this research project they use Siemens software Simcenter Flomaster as part of the design process.

These are just some of examples of successfully implemented student projects by using the Siemens academic platform that Siemens Corporation is proud of.

4.2. Aras PLM academic platform

As Aras Corporation states, Aras academic program is aimed at providing subscriber licenses of Aras Innovator PLM platform to educational institutions so that educators and students can advance their PLM education [19].

There are many academic institutions around the world which are members of the ARAS academic community, providing future business and technology leaders with advanced training in one of most important areas for modern industry - PLM. There are more than fifty prestigious academic institutions in the program, some of them are: OHIO University, Technische Universität Dresden, PRUDE University, Politecnico di Milano, Hamburg University of Technology…

Aras academic platform provides to institutions access to Aras Innovator Platform, Aras Applications, Aras Community, Customer Support, Aras Training and access to the subscriber portal.

Aras PLM Platform is built by applications that span the entire product lifecycle, from requirements management to technical documentation.

Most of those applications are available as a part of Aras Academic package, including: Product Engineering; Program Management; Process Quality Binding; Manufacturing Process Planning; Technical Documentation; Quality Management System; Component Engineering; Requirements Management /Engineering; Aras Impresa MRO and Aras Comet SPDM. Most of those applications are of an "Open-access" type.

Having in mind the above, it can be concluded that the application of Aras academic platform in the educational process enables a comprehensive PLM education for students, offering them the opportunity to train to work with all applications that span the entire product lifecycle, in that way students can transition to the professional workforce which will be competent to implement and enforce PLM concept within companies.

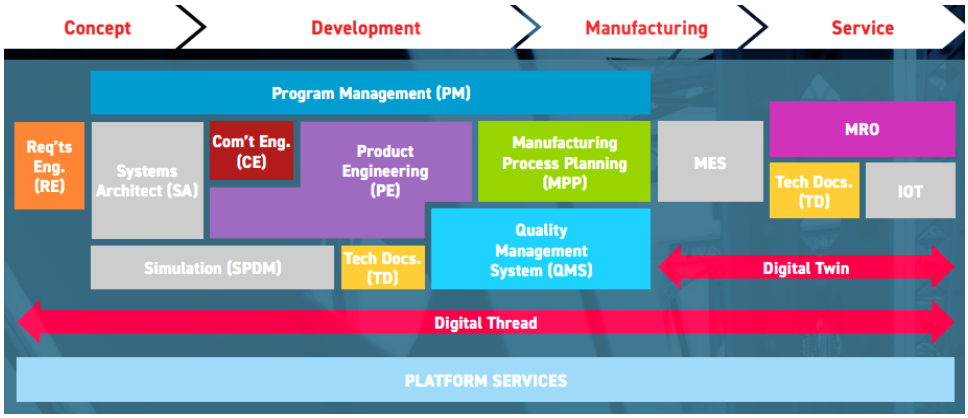

Figure 3. *Aras PLM Platform [20]*

According to [19] the major benefits of Aras PLM academic platform relate to:

Benefits for Students

- Unlimited access to flexible, scalable and upgradable PLM software
- Access to the Aras Community for project collaboration and custom curriculum
- Hands-on exposure to PLM so students can transition to the professional workforce

Benefits for Academic Institutions

- Instructional aid for teaching PLM, product development and model-based SOA programming concepts
- Development of add-ons, enhancements, new solutions and projects with the Aras Community
- Use Aras PLM to streamline institution's document management and other internal business processes

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
- Technical Documentation

4.3. 3DEXPERIENCE platform for academia

3DEXPERIENCE PLM platform offers comprehensive PLM solutions supporting wide range of processes during the product lifecycle. As integrated solutions 3DEXPERIENCE covers different areas such as Design and Engineering, Systems Engineering, Advanced Simulations, Marketing Experience, Manufacturing and Production, and Governance and Project Management within one platform.

Specialized IT solutions included in the 3DEXPERIENCE platform cover all activities and engineering disciplines related to product design and simulation, manufacturing planning, digital manufacturing, governance and project management, business and industrial innovations. This includes solutions:

- CATIA – product design;
- DELMIA – digital manufacturing;
- SIMULIA – realistic simulation;
- ENOVIA – collaborative innovation and
- 3DEXCITE - high-precision rendering and interactive immersion.

All these solutions are available within the academic platform, so-called 3DEXPERIENCE platform for academia which is aimed at supporting of education of the engineers with the comprehensive PLM experience and advanced digital competencies. By providing students with those tools in education process, they are enabled to acquire knowledge that will prepare them for real-world professional challenges in PLM environment and help them to improve their employability.

Dassault System Company describes its academic platform as advanced platform designed for a variety of industries, enabling the new practices of industry renaissance. They also state that it offers the ideal infrastructure for bringing industry practices into learning, since it encompassing comprehensive CAD, CAM and CAE capabilities, also it provides powerful solutions for managing collaborative work and joint innovation [21]. As they point out an advantage of this academic platform is that it enables the learning practices required by the future industry such as Project-based learning, (Digital) Problem-based learning, Peer learning, Experiential learning…

Figure 4. *3DEXPERIENCE PLM platform [21]*

Also, there are 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.

5. CONCLUSION

The paper discussed how PLM academic platforms can contribute to establishing of education models capable of creating a workforce which understands PLM philosophy and how to use PLM systems effectively to support the increasingly complex reality, as well as workforce able to work in collaborative PLM environment. In additional, the educational potential of some of the most commonly used PLM academic platforms in practice such as Aras, Siemens and 3DEXPERIENCE academic platforms are presented. Also, it is emphasized that the main benefit of PLM academic platform is that it enables the learning practices such as Project-based learning, (Digital) Problem-based learning and Experiential learning that play an important role in educating engineers in line with contemporary industries` requirements.

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Professional paper
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The Effects of Using the Moodle Platform in High Technical School of Vocational Studies from Urosevac in Leposavic

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Abstract: *The aim of this research paper is to show the influence of using the Moodle platform, which served as a substitute for traditional educational process, during summer semester in 2019/2020. in High Technical School of Vocational Studies from Urosevac with temporary seat in Leposavic. The need and the idea for this research came from two reasons, the first one being that in that time period teaching process was interrupted by the decision of state bodies of Republic of Serbia, and the second one being that the Institution already had Moodle platform installed on its website. Using survey questionnaire, the research was done after utilization of the Moodle platform, in period from 16.3. to 5.6.2020. In the questionnaire students stated their experiences and observations concerning this form of distance learning. After analyzing the data set the conclusion was drawn about advantages and disadvantages of distance learning and using the Moodle platform in doing so.*

Keywords: *Information and communication technologies, Moodle platform, students, distance learning*

1. INTRODUCTION

The rapid development of new information and communication technologies (ICT) in recent years has significantly affected all spheres of human life, both individual and entire human society [1]. The Internet has changed both the way and dynamics of spreading knowledge and information in all areas. It has led to changes in many aspects of life, and thus distance learning has taken on a new dimension [2].

In 2010, the Republic of Serbia adopted the Strategy for Development of the Information Society until 2020, which, partially, talks about e-education. Development of ICT application in education needs to be achieved, among other things, for:

- Establishing a modern education system that is adapted to the needs of information society;
- Teacher training in the use of ICT;
- Raising the level of knowledge and skills for using ICT among the widest population;
- Concept development education and learning through entire life; etc. [3].

Of the many platforms used for e-learning-distance learning (Moodle, Edmodo, Sophia, etc.…) the Moodle platform is the most accepted by higher education institutions in the Republic of Serbia.

Moodle (*Modular Object Oriented Developmental Learning Environmental*) is open-source system for remote control of the learning process. This platform is used by universities and colleges to improve the teaching process [4].

Today, the Moodle platform is used in more than 200 countries around the world and its installation is available in more than a hundred languages. There is also a version in Serbian in the form of Cyrillic and Latin letters.

Today, the Moodle platform is available to everyone on the Internet [5] and can be downloaded for free.

From the school year 2016/2017. the High Technical School of Vocational Studies from Urosevac with temporary seat in Leposavic also possesses Moodle platform, which is adapted to its curriculum, Fig. 1 [6]. Its intensive (active) use began on March 16, 2020. year (after the new situation and the declaration of a state of emergency in the country [7] due to the outbreak of the COVID-19 virus), which gave the authors an idea to write this paper.

2. HISTORICAL OVERVIEW OF DISTANCE LEARNING AND USE OF THE MOODLE PLATFORM

Distance learning was first mentioned in the first half of the 19th century. The first founder of

distance learning was an English teacher of scenography Isaac Pitman, who applied this learning in 1840 in his work with his students.

The first university that offered distance learning back in 1859 is also located in England. Furthermore, the practice of distance learning, which proved to be very effective, was continued by Universities in South Africa, Germany, etc.

The use of Moodle platform in the Republic of Serbia has been very modern in the last few years. The Academic Network of Serbia (TANS) was established, which supported distance learning for the purpose of building, developing and managing the educational and scientific-research computer network of the Republic of Serbia [8].

This network provides access and use of internet and IT services in the country to educational and scientific research organizations and other users, as well as connections to national and international networks.

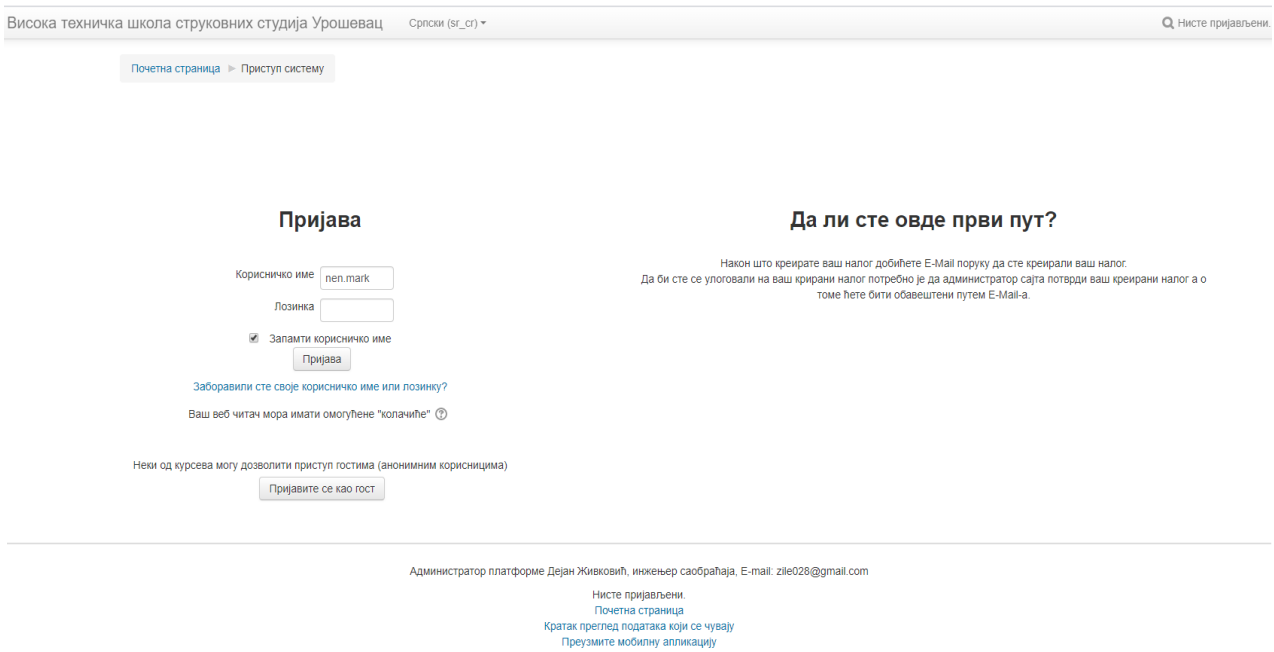


Figure 1. *Moodle platform of the High Technical School of Vocational Studies from Urosevac in Leposavic*

The research, conducted at the High Technical School of Vocational Studies from Urosevac with temporary seat in Leposavic, is based on an attempt to determine how much students are familiar with the effects of using the Moodle platform and to what extent and in what way they are motivated to learn from the distance.

3. RESEARCH METHODOLOGY

At High Technical School of Vocational Studies from Urosevac with temporary seat in Leposavic, a questionnaire survey has been conducted. The survey questionnaire is combination of already existing survey questionnaires that dealt with similar topics [1], [8], [9]. The questionnaire survey was supplemented with questions that authors thought would be relevant for research.

The questionnaire survey was created with the aim to be rational (for use and understanding), reliable and structured through questions that do not require too much time to complete. It took 5-10 minutes to complete the survey questionnaire.

Research realization: During the school year 2019/2020, in period from 08.06. to 07.17.2020, the research of students through a questionnaire has been realized, and period from 16.03 to 05.06.2020 has been observed on the Moodle platform (until the end of the summer semester). This is because in that period students could not visit the Institution due to the ban on holding lectures caused by the COVID-19 virus.

The type of research: The research has been conducted using a questionnaire in printed and electronic form.

The sample size: 158 respondents.

Target group: Students of all years of studies (basic vocational studies (BVS), specialist vocational studies (SVS) and master vocational studies (MVS)).

The survey questionnaire consisted of 14 questions in two parts. The first part of the questionnaire consisted of 4 questions and contained basic information about students. The second part of the questionnaire was related to distance learning and contained 10 questions.

Due to the two levels of study (first: basic and specialist, second: master vocational studies) it was difficult to predict in advance which group of students will be the most covered in percentage.

4. RESEARCH RESULTS AND DISCUSSION

This research started with idea of involving as many students as possible in order to get more realistic picture in terms of their attitudes and opinions about the effects of using the Moodle platform.

The research on use of Moodle platform has been conducted on a representative sample of 158 respondents-students of the High Technical School of Vocational Studies from Urosevac with temporary seat in Leposavic. Out of the total number of surveyed students, 7 survey questionnaires were excluded from the research due to incomplete data.

Out of 151 student respondents whose survey questionnaires were considered, even 86.1% of them were male, while 13.9% were female, Table 1.

Table 1. *Number of respondents-students per gender*

Gender	Number of respondents	Structure in %
Male persons	130	86.1
Female persons	21	13.9

The age structure of the respondents-students was 62.3% of students between 18-23 years of age, 17.2% of students between 23-28 years of age and 20.5% of students between 28 and more years of age, Table 2.

Table 2. *Age structure of respondents-students*

Age structure	Number of respondents	Structure in %
18-23	94	62.3
23-28	26	17.2
28 and higher	31	20.5

An overview of student respondents by gender as well as their age structure is shown in the Diagram 1.

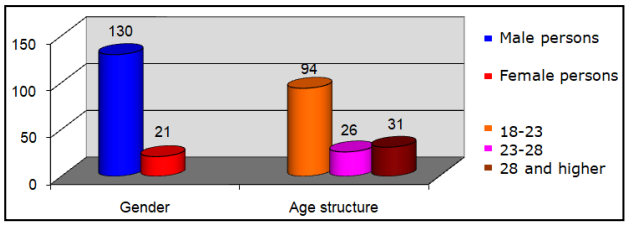


Diagram 1. *Overview of student respondents by gender as well as their age structure*

It is necessary to note that as far as high school is concerned, 45.0% of respondents-students graduated from High school, 47.7% from Technical school, while 7.3% of respondents-students graduated from one of the Vocational schools, Table 3.

Table 3. *Number of respondents-students per qualification of graduated school*

Graduated secondary school	Number of respondents	Structure in %
High school	68	45.0
Technical school	72	47.7
Other	11	7.3

Considering the number of enrolled students in different years of study, we can state that the response of respondents-students according to the enrolled levels of studies is expected. Namely, 41.1% of respondents are students enrolled in the first year of basic vocational studies, 20.6% are students enrolled in the second year and 18.5% of respondents are students enrolled in the third year of basic vocational studies.

9.9% of respondents are students enrolled in the first year of specialist vocational studies, while 4.6% are students enrolled in the first year, and 5.3% of respondents are students enrolled in the second year of master's vocational studies, Table 4.

Table 4. *Number of respondents-students per enrolled years of study*

The year of study	Number of responders	Structure in %
I (BVS)	62	41.1
II (BVS)	31	20.6
III (BVS)	28	18.5
I (SVS)	15	9.9
I (MVS)	7	4.6
II (MVS)	8	5.3

Based on Table 4 it can be concluded that in percentages there were more students from the first level of studies who participated in the survey.

An overview of student respondents after completed high school as well as by enrolled years of study is shown in Diagram 2.

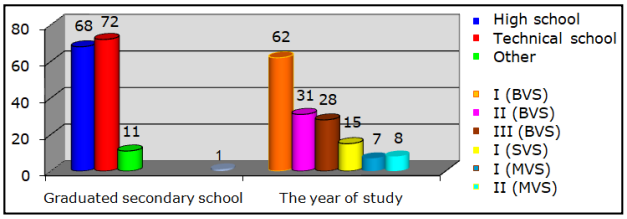


Diagram 2. *Overview of student respondents by completed high school and by enrolled years of study*

Regarding the first part of the questionnaire where 4 questions were analyzed and compared with data available to the authors in the Information System of the High Technical School of Vocational Studies from Urosevac with temporary seat in Leposavic [10] we can state that the answers are in full

agreement with the data located in the mentioned information system. This means that the response of students who used the Moodle platform met the expectations of the authors of this paper.

Respondents-students of the first level of study who visited the Moodle platform in relation to the number of enrolled students from records of the Information System of High Technical School from Vocational Studies in Urosevac with temporary seat in Leposavic available to the authors of this paper is about 30%, while at the second level is about 70%. From this it can be seen that the total number of students who visited the Moodle platform is more than 50%, which is quite satisfactory data for the period and conditions in which the research was conducted.

The second part of the survey questionnaire was designed to deal exclusively with distance learning. From the questions to which the students gave answers, we will single separate a few of the most interesting for this research and analyze them.

To the question "Do you have experience in using the MOODLE platform?" Over 90% of respondents answered that they have no experience in using it and about 10% answered that they have already used it. This is due to the fact that in the continuation of the question there is an opportunity for comment to which 100% of respondents answered that they are familiar with this platform (distance learning) and that they used it because they were already students of some higher education institutions.

The authors believe that one of the key questions from questionnaire was "Do you think that this way of distance learning-using the MOODLE platform is given priority over the conventional way of learning (blackboards, chalks, presentations,…)?". The vast majority of students here answered (over 80%) that this way of distance learning is well conceived and asked the question why it is not used everyday, not only in our Institution but also beyond? We can conclude that this question was excellently asked by the students, but that the result was unfavorable for the simple reason that distance learning is a new part of the teaching process in the Republic of Serbia and that in the last decade it was only related to obtaining accreditation for its use by NAB (National Accreditation Body).

To the question "What do you think are the positive and what are the negative sides of using the MOODLE platform?" Most of the respondents answered that the main positive side is that they can access it regardless of time and space, so this type of distance learning is practical it becomes available to everyone no matter where they are. As the main disadvantage of distance learning, students perceived in the reduced possibility of interaction between students and professors, ie. the absence of direct social contact between all participants in the teaching process.

The Moodle platform, like all other platforms, has the ability to upgrade by installing Plug-ins. The authors tried to use it in the best possible way and installed them on the Moodle platform on the website of High Technical School of Vocational Studies from Urosevac with temporary seat in Leposavic on the domain www.vts.urosevac.com. This made it possible to obtain hundreds of relevant data for the purposes of research in this paper.

In Fig. 2 shows the number of students who visited the Moodle platform on a daily basis (in the first month of the observed period).

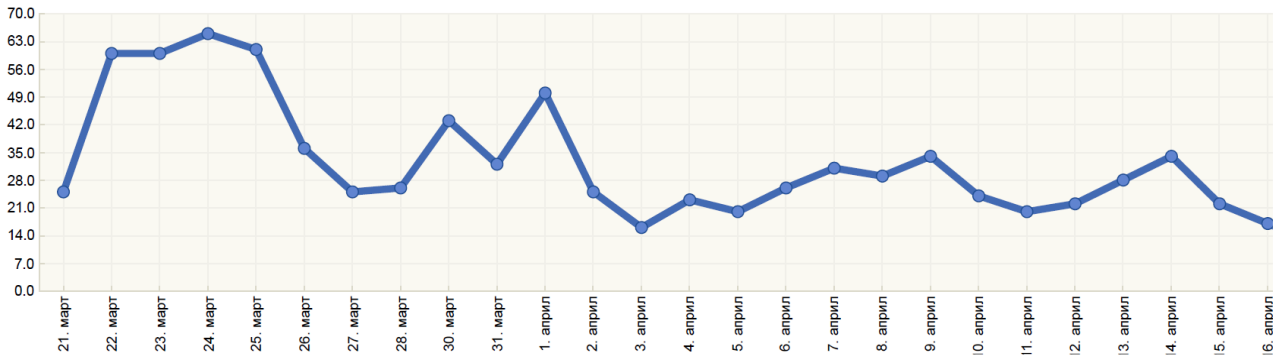
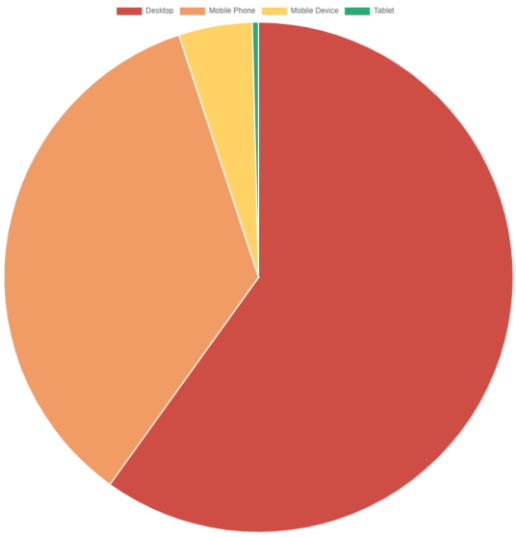


Figure 2. *Daily number of students registered on the system (first month of the observed period)*

It is very interesting to compare the number of students who accessed the Moodle platform using different electronic devices, in our case from desktops, mobile phones, mobile devices and tablets, Fig. 3. This research revealed that students mostly accessed the Moodle platform from desktop 59.92%, followed by mobile phones 35.02%, mobile devices 4.67% and finally tablets 0.39%.

Also, one of the useful data that can be obtained by installing Plug-ins is that we can see from which web browser students access the Moodle platform the most. The survey questionnaire showed that students of the High Technical School of Vocational Studies from Urosevac with temporary seat in Leposavic mostly use the Chrome browser (latest version), Fig. 4 (83.27%). This data indicates the fact that students follow modern events in the ICT era.



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Type	Percent	Count
Desktop	59.92%	770
Mobile Phone	35.02%	450
Mobile Device	4.67%	60
Tablet	0.39%	5

Figure 3. *Device types, Legend: Type, Percent, Count-total, Desktop computer, Mobile Phone, Mobile Device and Tablet*

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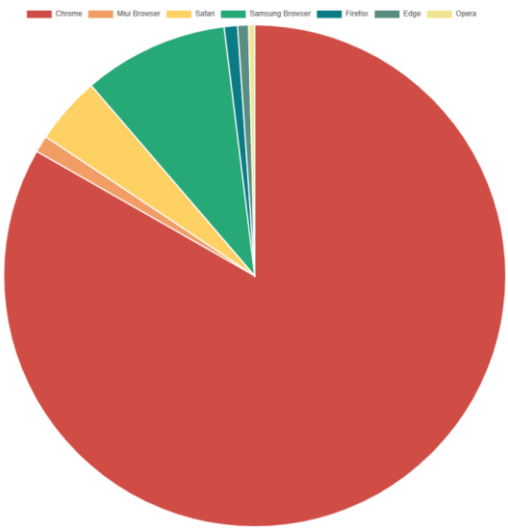

Browser	Percent	Count
Chrome	83.27%	1070
Version: 80.0	5.51%	59
Version: 81.0 ...	71.40%	764
Miui Browser	1.09%	14
Version: 0.0	100.00%	14
Safari	4.36%	56
Version: 0.0	73.21%	41
Version: 13.0 ...	23.21%	13
Samsung Browser	9.34%	120
Version: 0.0	100.00%	120
Firefox	0.86%	11
Version: 52.0	36.36%	4
Version: 75.0 ...	36.36%	4
Edge	0.70%	9
Version: 13.0	44.44%	4
Version: 18.0 ...	22.22%	2
Opera	0.39%	5
Version: 67	20.00%	1
Version: 68	80.00%	4

Figure 4. *Overview of the number of student-respondents displayed using the Browser browser*

5. CONCLUSION

Distance learning as one of the areas of e-learning is becoming a significant part of education system. In the future, it will represent the future of education and teaching. Use of modern information and communication technologies is increasingly relevant in all spheres of education.

The Moodle platform as one of the distance learning platforms is available at all times to all students who have access to the Internet wherever they are.

Based on the survey and analysis of research results, the authors believe that distance learning through the Moodle platform can be implemented in the teaching process as an additional teaching tool that would enhance the learning process and contribute to greater student motivation. For this purpose, all employed teachers at the High

Technical School of Vocational Studies from Urosevac with temporary seat in Leposavic will be proposed to use the Moodle platform for their subjects in order to improve the teaching process.

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Application of New Software Tools in Online Teaching

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Abstract: *This study examined students' attitudes about general issues related to the application of software tools in online teaching, as well as about their advantages and disadvantages. The study included 110 students of the Faculty of Technical Sciences in Čačak. The questionnaire specifically designed for this research was used for the survey. It was found that the students are well informed on software tools, that a large percentage of students use it and that the software tools has more advantages for learning than disadvantage. In this paper, the application is analyzed of the most current new software tools is analyzed. Based on the results of the research, conclusions were made regarding the improvement of e-teaching.*

Keywords: *software tools; online teaching; e-learning*

1. INTRODUCTION

Online teaching is the presentation of the educational process using information and communication technologies (ICT). This an educational process is distance learning in which the teacher and students are not physically in the same place, such as distance learning via a videoconferencing system that is transmitted to remote locations or through an online course developed in a distance education tool.

E-education can also be enriching classroom teaching, such as visualization of a topic with the help of a projector and a computer. By applying new software tools e-education encompasses a wide range of educational activities, where, in addition to the issue of infrastructure, it especially refers to the way of communication, cooperation, interactivity, the quality of teaching content, services, practices, etc.

E-learning, therefore, means using electronic applications in the learning process (computer training, web-based training, virtual classrooms, digital collaboration).

The term „e-learning" appeared recently in our country, but it quickly began to be used, gradually replacing such a concept as „distance learning".

The approach to modern e-learning is closely related to the "generation theory" [1], according to which each generation has its own typology of behavior related to information technology in general and e-learning in particular. Four generations are distinguished:

- The generation of 1945-1964 („Baby boomers" - the generation of births after the war) began to use information technology in adulthood, which led to an increase in the period of education, painful adaptation and resistance;
- Generation „X" 1965-1979 („Generation of digital adaptation"). This generation began using information technology in their teens, usually using computer games;
- Generation „Y" 1980-2000 („Born in digital"). The generation is well acquainted with digital technologies, immersion in the digital environment is a natural process, learning and adapting are intuitive;
- Generation „V" 2000 - ... („Embodied in digital"). This generation has been known for information technology and modern devices since birth.

So, generation Y and V are the main consumers of e-learning today. For them, the traditional form of education is not effective.

Hybrid teaching is a combination of online and classical teaching and it is an ideal case for educating students in the 21st century. Such classes can have different variations in use during the school year.

Online teaching can be considered as any educational (study) program that uses ICT in order to realize teaching/learning. Recently, e-education is considered to be a wide range of educational activities, with less consideration of the issue of infrastructure and much more ways of communication, cooperation, interactivity, quality of teaching content, services, practice and as describe in paper [2]. The results of the research conducted by the students of the Faculty of Technical Sciences in Čačak will be used to improve the teaching of online by using software tools.

2. POSSIBILITIES OF CHOICE OF APPLICATION OF NEW SOFTWARE TOOLS

Today, there are many software tools that are used in online teaching. The characteristics of significant software tools will be presented in section 2.1, and the new software tools applied in online teaching in 2020 will be presented in section 2.2.

2.1. Characteristics and significance of current software tools

Various online and offline tools can be of great benefit for better distance learning. There are a number of available software tools. Here are briefly described most popular:

Nearpod - *Creation, interaction and evaluation using mobile devices* (https://nearpod.com/)
It is difficult for a teacher to create interesting lessons every time that will attract the attention of all students. It is even more difficult to create lessons that promote learning through interactivity. Nearpod offers a variety of fully interactive classes designed by experts for all school levels and subjects. Also, Nearpod allows teachers to import lessons from any type of file and start adding interactive elements, web links or video clips.

Kahoot! - *Creating educational games* (https://kahoot.com/)
Kahoot! allows teachers to quickly create fun learning games with multiple choices. After creating the game, students can use any device to enter the "room" of the game using a unique code to complete tasks and compete with peers.

Buncee - *Create, present and share multimedia lessons* (https://app.edu.buncee.com/)
Buncee is a presentation tool that encourages critical thinking, communication skills, collaboration and creativity. Some of Buncee's many features include over 10,000 graphics to make learning more fun. In Buncee, there is the possibility of recording audio and video, as well as integration with YouTube, Pikabai and many other resources.

Remind - *Facilitates communication in education* (https://www.remind.com/)
It is a classroom messaging application that helps teachers, students and parents communicate quickly and efficiently. By merging school communities, Remind makes things easier for everyone. Contacts can communicate directly with each other, schedule reminders, view attachments.

Matific - *Math games for kids* (https://www.matific.com/us/en-us/home/)
Matific provides a library of amazing math resources for children ages 4-11. Knowledge is delivered in the form of exciting interactive applications designed for mobile phones and tablets.

ThingLink - *Annotation of images and videos* (https://www.thinglink.com/)
ThingLink allows you to use over 70 different types of content such as links, videos, maps, images, social media and more. It allows users to create interactive content in just three steps and use the built-in sharing link, to easily distribute content to students wherever they are and on any device they use.

Book Creator - *An easy way to create beautiful e-books* (https://bookcreator.com/)

Book Creator is a simple application for creating e-books. Teachers are enabled to develop interactive and educational learning resources that students can easily share and use. Electronic resources are very easy to update.

Explain Everything - *Team work on an interactive online board* (https://explaineverything.com/)

Explain Everything is simple in design and helps to create an interactive whiteboard for team work in real time, using animation, sound and comments.

Quizizz - *Fun quiz* (https://quizizz.com/signup/occupation)

Quiziz allows you to find quizzes by other teachers, create your own quizzes and share them with the world. Quizz is available on all devices, students can participate together, but each at his own pace. There is a possibility to analyze detailed reports in order for the quiz creator to understand where the students need help.

EducationCity - *Educational games for children and resources for teachers* (https://www.edmentuminternational.com/)

EducationCity is one of the leading online educational resources. It was created in 1999 and now has users in over 70 countries around the world. It is ideal for children from 3 to 12 years. EducationCity's interactive educational resources cover English, French and Spanish, mathematics, natural sciences and computer science. It offers different types of content, and is suitable for both group and individual learning.

Padlet - *The easiest way to organize a collaboration* (https://padlet.com/dashboard)

The Padlet is like a white sheet on the screen. Anything is placed on a blank page, then a video is loaded, a conversation is recorded, text is added or a document is transmitted - the page comes to life. The page can be visited and updated in real time by the users you have invited.

Microduino - *Do-it-yourself electronics for all ages* (https://microduinoinc.com/)

Microduino designs and manufactures digital blocks that can be connected to a wide range of digital input and digital/analog output devices, enabling

children to be taught engineering and coding. Microduino is a multi-part package that allows users to create, animate and control the objects they create.

TouchCast - *Smart video creation* (https://www.touchcast.com/)

At the heart of TouchCast is smart video, allowing you to use streaming video tools that are incredibly easy to use. Interactive elements can be used to make videos more attractive, and there is also the possibility of collaboration from anywhere in the world.

TinyTap - *Create games and learn from others* (https://www.tinytap.it/)

TinyTap is a playground for interactive educational games, allowing you to create interactive presentations, detailed study guides and quizzes using tools that are easy to use.

EDPuzzle - *Add more videos to the lesson* (https://edpuzzle.com/)

EDPuzzle allows teachers to easily customize videos by adding questions and sound to create more interesting video tutorials. Helping to overcome the classic problem of students sleeping during long videos, EDPuzzle allows you to add breaks during the video. At the end of each video segment, pauses can be added to.

Tinybop - *Games of the future* (https://tinybop.com/)

Tinybop creates elegant educational applications to arouse curiosity, creativity and kindness in children around the world. Tinybop apps inspire children to explore, create and develop, dive into great ideas, test how things work and connect with the world in which they live.

Pear Deck - *Interactive presentation service* (https://www.peardeck.com/)

Pear Deck allows you to create an interactive presentation for students in real time. Opportunities are provided for creating presentations from scratch, importing slides, inserting videos, web pages into slides, sending presentations to students at home for homework, or setting up quizzes.

Lithan – *Mentoring* (https://www.lithan.com/)

Lithan enables the updating of adult education through innovation teaching, continuous career advancement and people training, and provides training solutions for businesses. Using innovative technology, it helps adult students master their skills and develop their talents in order to be ready for the future in their work environment.

Canva - *Design for non-designers (amateurs)* (*https://about.canva.com/*)

Canva enables incredibly easy creation of professional quality graphic projects. The Internet platform brings together simple tools and a library with more than a million photos, graphics and fonts. Provides a service for making presentations, posters, blog content, greeting cards, web marketing materials, invitations, flyers and the like.

2.2. The latest software tools for different teaching approaches

Both parties (teachers and students) had to gather at the school in order for the process to be efficient and effective. With the advancement of technology, people can communicate without meeting at all or in reality (virtual connection). Here are describe top 5 online learning software in 2020: Docebo, Tutorroom, Versal, AdaptiveU, Mindflash [3].

1. Docebo (*https://www.docebo.com/*)
Docebo is one of the network platforms known to provide a wide range of services. It offers its clients training programs in various fields such as healthcare, processing and production, consulting, information technology and technology. Docebo allows users to manage lessons, share content between parties, and also takes the form of certification. Docebo can be accessed via computers and smartphones and user-friendly websites (they have applications that run on Android and iOS systems).

2. Tutorroom (*https://tutorroom.net/en/home/)*
Tutorroom is considered one of the best platforms for online learning. It has progressed by offering a top level classroom with an easy-to-use interface. The classroom contains features such as video chat, messaging and other collaboration tools. It has the best applications for teachers where the teacher can even download PDFs and follow the tests. Also, it offers educational programs for schools, network school management software, which can be run from computers and smartphones.

3. Versal *(https://versal.com/)*

Versal is an online learning platform that uses a cloud learning management system. Versal offers online courses that have hands-on training and involve user interaction. Their interface has video functions, performance evaluation, tests and report reception. Their courses are easily accessed using computers as well as mobile devices.

4. AdaptiveU *(https://www.adaptiveu.io/)*

AdaptiveU is an online learning software that can motivate a huge number of students and teachers as they learn. Teachers find and store large amounts of data that students constantly use and monitor student progress, and suggest tests. AdaptiveU can connect students and teachers through interactive videos and messages.

5. Mindflash (https://mindflash.com/)
Mindflash provides an efficient way to download video files, PowerPoint, PDF, Word and other types

of documents. Students' progress is monitored in real time, through quizzes. That is why it is designed to use a wide range of training programs. Mindflash can integrate with Salesforce (cloud-based online learning software) making it even more accessible.

So, successful online learning software must have the ability to provide a platform. The facilitates like creation, storage, delivery and monitoring of training materials increase software usisage. It must also enable the monitoring of students' progress as well as their certification. The software should also be compatible with collaboration tools.

The above described online tutoring platform examples have maximized on ensuring that these factors are have been tactfully and diplomatically considered, thus ranking them among the best.

2.3 Educational software tools for communicaton

In the modern era of learning, new technologies play a key role in learning processes. Here are a few more tools that facilitate communication between teachers and students [4]: Edmodo, Socrative, Projeqt, TED-Ed, cK-12, ClassDojo, eduClipper, Storybird, Animoto

Today, there are various virtual learning tools, they are adapted to different ages, needs and abilities of users. The main tools used in 2020: Zoom, Google Classroom, Microsoft Teams, Blackboard, Slack, Floop, SmartSurvey, Edmondo, Timely, Dewo, Todoist, Pocket, Loom, Prezi, Dropbox Paper, WeTransfer, Touchcast, Idroo, Markup Hero [5].

Zoom - *platform for online classes* (https://zoom.us/)
Zoom is a service for video conferencing, online meetings and distance learning. Anyone with an account can arrange a meeting. The free version allows video conferencing lasting from 40 minutes to 100 participants. The program is great for individual and group classes, students can access from a computer, tablet and mobile phone. Anyone with a connection or conference ID can join the video conference. An event can be scheduled in advance, as well as a recurring link, that is, for a permanent lesson at a specific time, the same application link can be made.

Google Classroom - *completely free LMS* (https://edu.google.com/products/classroom/)

The Google Classroom Platform is an online management and communication platform for teachers and students. It allows you to: create lessons, set tasks, check their progress, monitor progress, share documents, post videos on YouTube. The application integrates easily with other G-Suite applications. Teachers can: save their documents from Google Drive, use Google spreadsheets to track students' overall progress, comment on and edit student work in real time, and test students (created using Google Forms) through online surveys.

Microsoft Teams – *digital learning hub* (https://www.microsoft.com/en-gb/education/products/teams)
Microsoft Teams is the software of the global IT giant designed to create space for corporate work, communication, file sharing, meeting coordination, creating team notes and more. The program is great for small working groups, as well as for those that contain several dozen participants. Microsoft introduced the service as part of the Office 365 suite and is a direct competitor to applications such as Slack and Hangouts. Microsoft Teams is integrated with most other Windows office and business products.

3. ORGANIZATION OF RESEARCH

In the school year 2019/20, 110 students of the Faculty of Technical Sciences in Čačak were anonymously surveyed. Questionnaire with mostly closed questions was used for the survey. The survey included students from the following study programs: Information Technology (IT) - first and fourth year, Engineering Management (IM) - first year, Entrepreneurial Management (EM) - first year, Electrical and Computer Engineering (ECE) - first and second year.

The survey included questions related to the application of software tools in online teaching. The questionnaire consisted of four parts:

- Part one: A series of statements to which the students responded with YES or NO (figure 1);
- Part two: A series of statements from which students choose one answer only (table 1);
- Part three: Assessment scale with a series of statements related to the use software tools in online teaching: General about software tools (table 2); Adventages of software tools application in online teaching (table 3); Disadventages of software tools application in online teaching (table 4). It was necessary to enter the answer into the table that matches the opinion of the surveyed students for the corresponding statement the most. Possible answers were in categories from 1 (strongly disagree) to 5 (strongly agree);
- Part fourth: From the offered software tools for online teaching, students complete the tools (multiple choice): which they have used so far (table 5); tools they used in the current school year 2019/20 (table 6).

4. RESULTS AND DISCUSION

This section gives the results of the research related to the application of software tools in online teaching for students of the Faculty of Technical Sciences in Čačak.

Figure 1 presents the answers of the surveyed students on questions in the first part of the survey.

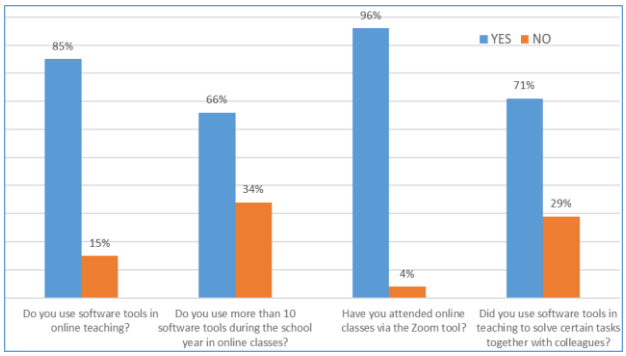

Figure 1. *Overview of the application of software tools*

More than 90 surveyed students (85%) used software tools in online classes, as many as 96% of students attended online classes via Zoom tools (as a consequence of the COVID-19!).

Table 1 presents the answers of the surveyed students on questions in the second part of the survey. Percentage of answers for every given answer of the question is shown.

Table 1. *Answers of students in the second part of the survey*

Question	YES
Through which device do you follow online classes? (*more answers*)	
Phone	29%
Tablet	3%
Desktop / laptop computer	64%
Something else	4%
How often do you access the E-LEARNING platform Moodle? (*1 answer only*)	
Daily	5%
Several times a week	81%
Several times a month	6%
Optionally	8%
How closely do you follow online classes? (*1 answer only*)	
Very carefully	31%
Pretty careful	48%
Not very carefully	21%

Students mostly follow online classes using computers (desktop or laptop) - 64%, Moodle platform is visited several times a week by 81% of respondents, online classes are followed carefully by almost 80% (quiet and very carefully).

Tables 2-4 shows the answers of the surveyed students on claims from the third part of the survey. The percentage of responses for the two dominant opinions is shown: agree and strongly agree.

Table 2. *Assessment of claims that are generally related to the application of software tools in online teaching*

GENERAL ABOUT SOFTWARE TOOLS	agree	strongly agree
Software tools are tools that fully enable the acquisition of knowledge in online teaching of a small number of subjects in studies	35%	44%
Software tools are tools that enable the acquisition of knowledge in online teaching of all subjects in studies	28%	21%
These software tools enable uninterrupted work in online teaching	38%	34%
Software tools are useful in online teaching	20%	74%
Software tools have more positive than negative aspects	15%	78%

A high percentage of surveyed students have a positive attitude towards the application of software tools for online teaching. They least agree with the statement: *Software tools are tools that enable the acquisition of knowledge in online teaching of all subjects in studies (49%).*

Table 3. *Advantages of software tools application in online teaching*

ADVENTAGES OF SOFTWARE TOOLS APPLICATION IN ONLINE TEACHING	agree	strongly agree
Diversity and dynamism of online learning content (a large number of software tools of interest)	10%	88%
Flexibility in terms of accessibility, access, place and time of learning (any time, place and device)	5%	91%
The application of software tools enables easier understanding and mastering of teaching materials, and the use of multidial didactic tools facilitates the acquisition of knowledge and opinions	20%	68%
Strong motivation to acquire knowledge	10%	86%

The advantage of using software tools in online teaching, which was highlighted as the most important, is Flexibility in terms of accessibility, access, place and time of learning (as many as 91% of surveyed students completely agree with this statement).

Table 4. *Disadvantages of software tools application in online teaching*

DISADVENTAGES OF SOFTWARE TOOLS APPLICATION IN ONLINE TEACHING	agree	strongly agree
The learning process is often not managed at all, or the role of learning leader is taken over by someone who does not meet the formal criteria	25%	51%
By applying software tools in online teaching, it gives the teacher more space to innovate and monitor individual student achievement	22%	62%
Staticity of participants in the learning process (neglect of other sources of information and knowledge - books, textbooks, tutorials ...)	10%	77%
By applying software tools for assessment, a realistic picture of the acquired student knowledge was not obtained	45%	54%

Almost all surveyed students (99%) agree that the application of software assessment tools did not give a realistic picture of the acquired knowledge of students.

Tables 5 and 6 shows the answers of the surveyed students on claims from the fourth part of the survey.

Table 5. *Application of the listed software tools*

Nearpod	Matific	Quizizz	TouchCas	Peardec
Kahoot	ThingLink	Education City	TinyTap	Lithan
Buncee	Book	Microduino	EDPuzzle	Canva
Remind	Padlet	Explain	Tinybop	

Students used almost none of the offered software tools for online learning, with the exception of Nearpod (7 students) and Peardeck (4 students). Unfortunately, the other listed software was not used by students.

Table 6. *Application of software tools in 2020*

Zoom	Slack	Timely	Touchcast	Loom
Google	Floop	Dewo	Dropbox	Prezi
Microsoft Teams	SmartSurve	Todoist	Markup Hero	Idroo
Blackboard	Edmondo	Pocket	WeTransfer	

The most popular software tools used by students are: Zoom (96%), Prezi (90%), WeTransfer (45%) and Microsoft Teams (27%). These tools are covered in the following subjects: Practicum in computer applications, Practicum in computer use, Computer applications. Other software tools were rarely used or not used at all.

As shown in papers [6, 7] it can be said that the application of software tools is necessary regardless of the subjects studied. For the exchange of experiences in the use of a software tools can be discussed via the Internet forum [8].

5. CONCLUSION

In accordance to shown, it can be concluded:

- It would be useful to monitor the of software tools and platforms for e-learning;
- With the new needs of humanity, there has been a change in the way of teaching, both in schools and universities;
- Increasingly, online classes are conducted, using software tools, who seek solutions to problems of students in online teaching.

While students used to come to the faculty regularly, listen to classes, today very often they do it from their armchairs and follow the lecturer and solve problems with colleagues from all over the world who deal with similar issues, using various software tools.

Students believe that software tools are very useful and have more positive than negative aspects.

In addition, on the basis of the study, the following general conclusions can be derived:

- The largest percentage of students use software tools during their studies for several subjects (57,6%);
- Students used almost none of the offered new software tools for online learning, with the exception of Nearpod (7 students) and Peardeck (4 students);
- Listed software tools (table 5) was not used;
- More than 85% surveyed students used software tools in online classes , as many as 96% of students attended online classes via Zoom tools at the time of the pandemic COVID-19.

Given that a small number of students applied these tools in 2020, it is necessary to process these software tools within individual courses, and then practically apply different activities. In that way, the online teaching will be significantly improved.

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Operating Systems Course Modeling Through 12 Aspects and ISO/IEC Standardization

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Abstract: *The presented model of the accredited Operating Systems course syllabus (OSs, along with Moodle course), through 12 x n dimensions (12 aspects in n dimensions): 12 topics, 12 goals and 12 expected competencies (outcomes), is fully aligned with key principles and ACM/IEEE recommendations, seen through the prism of SRPS and ISO/IEC standardization. The verification of the compliance of the proposed Moodle course content model is conducted by a comparative analysis of the course content on an international level, as well as with other universities in the region and EU countries. The results obtained during the research indicate full coverage and flexibility towards novelties of 14 standardized aspects of Information technology through the OS hierarchical structure. These aspects can be easily reduced by with and depth to 12 aspects of Operating Systems. In addition to modeling and innovating the Operating Systems course content through 12 aspects, the paper analyzes the compliance of goals and students' competencies as well as regional and international content compliance. Examples of good practice are documented by effectiveness, which is confirmed by the achieved competencies and a wide range of (possible) knowledge, by applying the model in emergency conditions.*

Keywords: *Operating systems, content model, goals, competencies, standardization*

1. INTRODUCTION

Operating system (OS) as the most important system software on the computer is the core of the computer software system [1,2]. Therefore, it is necessary for every student attending software and computer engineering to have a basic knowledge of design principles and implementation of operating systems [1]. The Operating Systems (OSs) course belongs to the group of the most important professional and basic courses, realized as a compulsory part of the classic curriculum in undergraduate academic studies (OAS) in computer science, information technology, software and computer engineering. The course may be a compulsory subject at the entrance examination for some postgraduate studies [2,3,4]. At some universities, OSs course is an irreplaceable part of postgraduate curriculums. Some curriculums contain two types of OSs courses, one which is intended for system administrators and explores the characteristics of the OSs, basic settings and setting up the environment for all users, while others relate to the implementation of functions, solving problems that may arise during implementation and trade-offs to be considered [5].

The OSs course content in most cases includes the basic principles of OSs design [6]. Content has been iterated over a number of decades, and mainly contains topics such as task management, system calls, synchronization, scheduling, memory management, and file system structure [3]. On the other hand, the topics are often aligned with Tanenbaum's book's chapters [7]. The majority of traditional OSs courses contains basic topics such as: kernel, process and thread management, interrupts, scheduling, synchronization and deadlocks, file systems, memory management, interprocess communication and device management, where special emphasis is placed on the traditional view, from a computer science perspective [8,9]. Large number of the activities in teaching OSs involves programming in C/C++ languages, due the fact that these languages allow access to certain hardware resources, while some routines are to be programmed in assembler [3].

OSs as an important area of knowledge is included in the guidelines for the curricula development for Baccalaureate Degree Programs in Information Technology and for Undergraduate Degree Programs in Computer Science, recommended by Association for Computing Machinery (ACM) and

IEEE Computer Society (IEEE-CS) [10,11]. Therefore, it is necessary to model the course content in accordance with recommendations mentioned above, and to align it with 14 standardized Information Technology (IT) areas (14 ICS2 35 areas).

The compliance of the proposed contents with the courses' contents at the international and regional level is analyzed through a comparative analysis of the course contents studied in three-year undergraduate academic studies (180 ECTS credits) in the study programs of computer science, computer engineering and information technology in Italy, Slovenia and Montenegro.

It is shown that the presented contents, goals/sub-goals (shown at the 8th area as example) and competencies that students acquire at the end of the course provide coverage of all layers in the hierarchical structure of OSs. This is a unique way to enable application of all IT areas, compared to the analyzed content models and viewed through the prism of SRPS and ISO/IEC standardization. Model is successfully implemented at the IT study program in three and four-year undergraduate academic studies, as well as in Integrated Academic Studies (IAS) at the Faculty of Technical Sciences in Čačak.

The key details of the developed and implemented model with ensuring regional and international content compliance (required by accreditation standards) are presented. After the example of good practice, explicit conclusions follow (with possible implicit deductions), as well as confirmations of the possibility of achieving a wide range of competencies and knowledge, by applying the model in the new state of emergency and Online study.

2. DEVELOPMENT OF THE OPERATING SYSTEMS COURSE CONTENT MODEL

Modeling the OSs course content is guided by the 12 objectives that the course content should meet. Therefore, it is essential to consider the goals and specific abilities that students will have upon course completion. These 12 goals, together with their associated content and competencies, are used to determine whether the set goals, in the modeling process, are fully met. Otherwise, they cannot be the basis for creating OSs course content.

2.1. The basis of the Operating systems course content model through 12 aspects

IT as an academic discipline in its broadest sense encompasses all aspects of computer technology. According to ISO/IEC standardization and hierarchical classification, IT is classified into area 35 (ICS1 = 35) and further arranged into 14 standardized areas (ICS2). OSs is an integral, mandatory part of the innovated, accredited IT curriculums of the OAS and vocational studies in Serbia. OSs course belongs to the group of professional or professionally applied subjects and "spreads over" all 14 classes of the ICS2 level (earlier there were 12 standardized areas of IT, [12]). OS segments such as nucleus and shell are also located in the structure of the computer system, from hardware to user applications. The structure (architecture) of the computer system through IT aspects (2 - 12) is shown in Fig. 1. Aspect 1 is not presented at Fig. 1 because it encompasses terminology and introduce to all IT aspects.

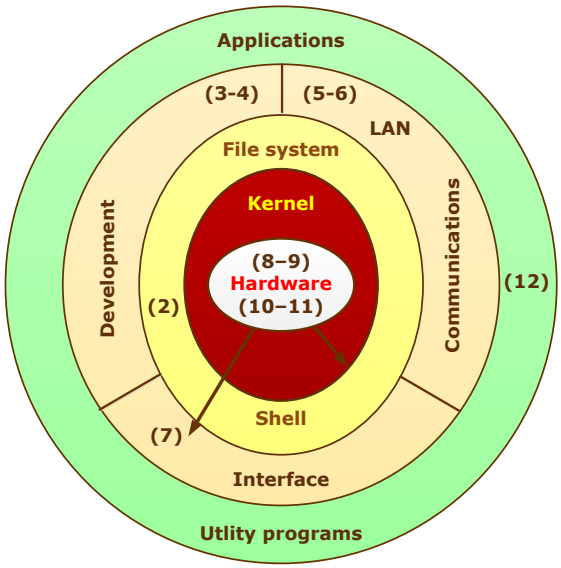

Figure 1. *The global system architecture example (OS - IT) [13]*

On the other hand, according to the ACM / IEEE recommendations for the IT curricula development, IT is classified into 5 essential domains, 5 essential + 5 supplemental domains and 4 support domains. Essential domains are: Information Management, Integrated Systems Technology, Platform Technologies, System Paradigms and User Experience Design. OSs are classified in Platform Technologies (ITE-PTF-02), and therefore require great engagement in learning process, which is closely linked to application and knowledge transfer to complex problems and situations (Level L3 in the Spiral model of the IT curriculum). For example, the L3 level requires three times more student's engagement compared to the L1 level, which is e.g. required to master the content of the Computer Architecture course [10].

According to the ACM / IEEE recommendations from 2016, OSs are studied in the curricula of the undergraduate studies in computer engineering through Systems Resource Management, which is one of the 12 knowledge areas in the Computer Engineering (CE) body of knowledge. The course contents are covered through 8 teaching topics (from CE-SRM-1 to CE-SRM-8), with a special

emphasis on system resource management: History and overview of operating systems, Relevant tools, standards, and/or engineering constraints, Managing system resources, Real-time OSs design, OSs for mobile devices, Support for concurrent processing, System performance evaluation, Support for virtualization. The last two topics are elective [11].

Starting from the fact that students should acquire basic knowledge about the basics and principles of OSs, on the platform of IT standardization and according to standardized IT segments, taking into account the key recommendations of ACM / IEEE for IT curriculum development in order to achieve quality and meet the accreditation standards for the study programs (Standard 6.3), a "domestic" content model has been developed. At the axis of developed 3D model presented at Fig. 2 are: ICS1 = 35 = IT areas, ICS2 subareas (x), OS course topics (y), ACM / IEEE, CS - CE recommendations for IT curriculum development (z), for x = y = z =1, 2, 3, ...12), [12].

The OSs course contents are represented through 12 thematic topics which are directly related to ICS2 subareas:

(1) Introduction to OSs, applying and using OSs - ICS2 = 35.020;
(2) File system, data, information, protection and security management - ICS2 = 35.030, ICS2 = 35.040;
(3) Interrupt handling - ICS2 = 35.060;
(4) System development and documentation - ICS2 = 35.080;
(5) OSs and network management - ICS2 = 35.100, ICS2 = 35.210;
(6) OSs and support for global communications - ICS2 = 35.110;
(7) OSs and graphical interface (graphic environments) - ICS2 = 35.140;
(8) Process management, synchronization problems - ICS2 = 35.160;
(9) Input/Output (I/O) device management - ICS2 = 35.180;
(10) Computer system configuration - ICS2 = 35.200;
(11) Memory management and virtualization - ICS2 = 35.220;
(12) Application support - ICS2 = 35.240.

The key criteria, in accordance to European Foundation for Quality Management (EFQM) which aim toward excellence, are situated at the spatial diagonal of 3D model. Some examples are: leadership supported by standardized terminology (1.1.1), organization with the concept of knowledge transfer (2.2.2), team support (3.3.3), OSs development (4.4.4), standardization (5.5.5), etc.

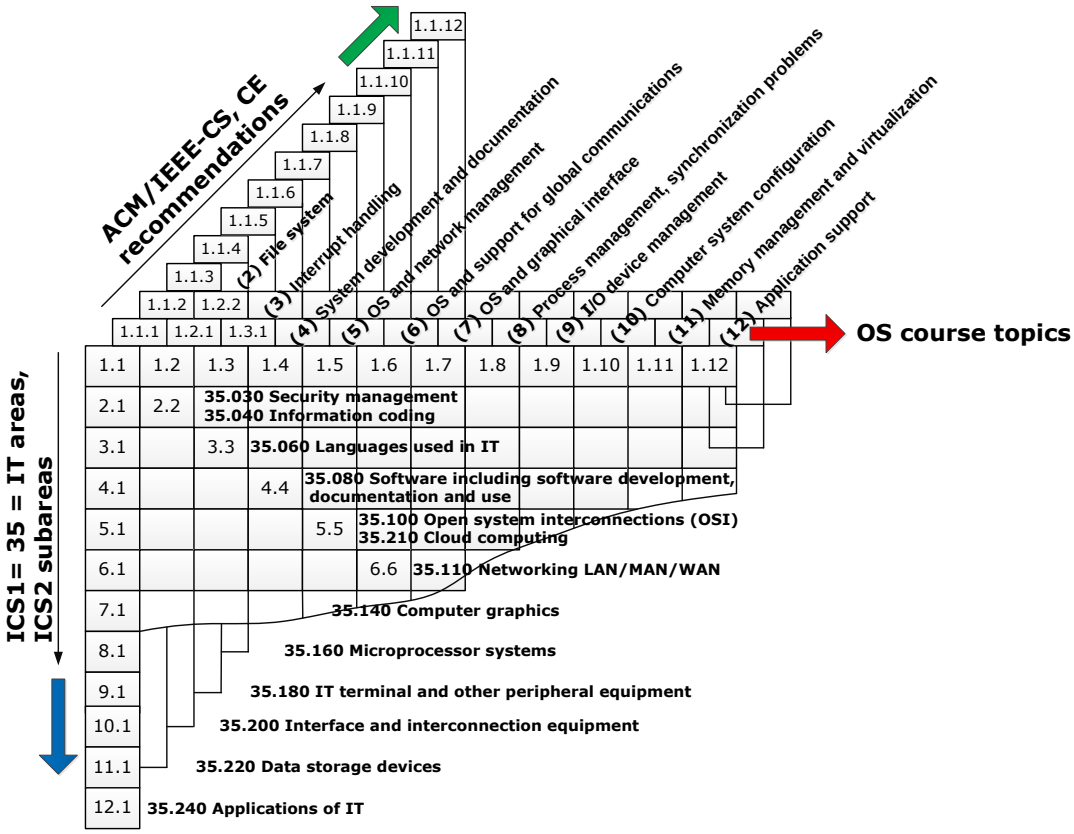

Figure 2. *Basic model of the OS course content (adapted from [12] and [14])*

2.2. Outcomes of the Operating systems course content model through 12 model aspects

The OSs course objectives (1 - 12), derived from the OSs course topics (1 - 12), cover the usage of the OSs (external objectives), as well as the design and implementation of the OSs (internal objectives). Course objectives must be defined in such a way that they are completely aligned with the objectives of the IT curriculum and could be used for measuring student's performances.

Objectivities defined in such way enable to students:
1) introduction to OS, with accompanying terminology and learning to work with different OSs;
2) data management (information and file management), including protection;
3) program execution control (language-independent programming) and interrupt handling;
4) view to the OSs from the aspects of IT and software development, and system documentation (OS documentation);
5) knowledge and skills to support global communications, including cloud computing;
6) knowledge of network OSs for network operations management in small, middle and large networks;
7) OSs from the aspect of computer graphics and elements of graphic communication,
8) resource allocation - jobs, processes and processors management;
9) peripheral management, I/O management;
10) configuring system and interface;
11) resource allocation and memory management;
12) effectiveness of knowledge and OSs application in different professional situations, especially in all standardized applications of IT.

Sub-objectives/outcomes are presented at the example of resource allocation 8), through the acquisition of theoretical and methodological bases for jobs, processors and processes management (8.x, x = 1 to 12):
8.1 define the role of the OS in system resources management;
8.2 describe the choices to be made in the file system designing and the way in which these choices affect the system resources management from the job/process aspect;
8.3 explain the basic types of interruptions and how to manage them;
8.4 give examples that illustrate why scheduling and dispatching are needed in system resources management;
8.5 explain concurrency is and why it must be supported in system resources management;
8.6 explain how simultaneous multithreading execution works and what kind of support is needed for multithreading;
8.7 define the role of key APIs at the example of WinAPI;
8.8 give the examples of runtime problems that may arise from concurrent operations, multiple tasks or system components, such as deadlock and race conditions;
8.9 list the key components of IEEE POSIX (Portable Operating System Interface) standard;
8.10 interfacing between hardware and software components, giving examples of basic concepts in concurrent processing (multiprocessor, multicore);
8.11 explain the memory hierarchy (cache through virtual memory), explain how to achieve trade-off between cost and performance, virtualization support knowledge;
8.12 evaluation of resources performances.

Objectives are accompanied by outcomes as mandatory accreditation element (also through 12 aspects), as well as competencies.

2.3. Student's competencies - through 12 aspects

By attending the OSs course, students get familiar with the purpose, characteristics and functions of the OSs and the basic principles of operation, design and implementation of the OSs, gain basic knowledge of concepts, algorithms, principles, problems and solutions related to the OSs, regardless of the type of OSs. Students should get to know and use existing systems, and eventually innovate existing systems. Depending from the input knowledge (from previous levels of education), as well as output (personal) goals, students could be able to design and implement independently their own specialized systems.

In accordance with the OSs course contents and the defined objectives and sub-objectives, appropriate competencies arise. These competencies are defined through 12 aspects:

1) professional competencies - students know how to choose the appropriate OS, describe the components operations and OSs functions, know how to install at least one OS and have academic skills to use, upgrade and maintain Windows, Linux and Unix-like systems;

2) skills for efficient file system management, development of personal functions in file subsystems, knowledge of security and safety aspects (as newly standardized IT sub-area) and successful management of threats and attacks towards the OS, through the application of various techniques for increasing security and system protection;

3) development of analytical and critical approach in research and solving problems that may occur, improvement of programming skills using scripts for OS tasks automation, efficiently managing interrupts and program execution control;

4) know the factors of OSs quality development, new OSs versions, define key criteria for OS design (e.g. efficiency, robustness, security), implement international and national standards in software engineering, such as, ISO/IEC TR 19759:2015 - Software Engineering Body of Knowledge (SWEBOK V3.0), ISO/IEC 25000, known as SPICE (Software Process Improvement and Capability Determination), SRPS ISO/IEC 12207 - IT - Software life cycle processes, and many IT novelties with over 750 new standardized sources of knowledge every year (SRPS and ISO/IEC);

5 - 6) skills for setting up connections to the local network and the Internet (in cloud - new standardized IT sub-area), skills for sharing resources with the network, manage users and groups, acquiring basic knowledge about network and distributed (clastered, cloud and grid) systems and types of migrations, distributed file systems, know the mechanisms for processes synchronization and performing transactions in distributed systems;

7) successfully use/ innovate/ compare and manage graphical environments in the OSs, appearance and personalization management, which provides creative development of innovative skills for the implementation of various procedures;

8) apply synchronization mechanisms, know interprocess communication routines in OS, know processor allocation algorithms, know how to use/innovate tools for monitoring log-based performance, as well as in real time;

9) know/ upgrade the hardware-software configurations necessary to communicate with I/O devices, know the organization, structure of I/O devices and services provided by the I/O core subsystem, have skills to manage I/O devices (peripherals), monitor I/O performances and manage errors (system calls);

10) select, install and configure systems, know the basic internal and external commands for working in the command interpreter, have the skills to set a standard set of functions (interface) for the interaction of applications and system configuration;

11) skills for memory management, such as paging, understand the importance of virtual memory, know basic and alternative techniques for loading pages and algorithms for replacing pages, manage secondary memories, know algorithms for disk schedule and criteria for selecting algorithms, apply virtualization;

12) upgrading the base for further education and training for the application of OSs and application support.

Specified 12 aspects enable the acquisition of fundamental and specific knowledge, expected student competencies (vertical - by depth or horizontal - by width), and open opportunities for subject correlations and competencies, and also for wider application in other OSs related subareas (such as competitive programming, design and application of algorithms, development and programming of embedded devices, system security and network management, etc.).

The latest provisions of the Law on higher education and the prevention of direct transition from vocational to academic studies have enabled additional "coloring" of degrees and types of studies in Serbia, with different requirements for the practice and operation of each course, including OSs.

3. INTERNATIONAL AND REGIONAL CONTENT COMPLIANCE - ACCREDITATION REQUIREMENT THROUGH 12 ASPECTS

Nowadays, OSs courses in Serbia are conducted on undergraduted academic and vocational studies in multiple accreditation areas: Computer science (Natural and Mathematical Sciences field - NM field), Computer engineering (Technical-Technological field - TT field) and Information technology (Interdisciplinary, Multidisciplinary and Transdisciplinary studies - IMT studies), through various topics, where in most cases there is no full coverage of all IT areas. The situation is similar in the EU countries, where, for example, at the Bachelor-level in Computer Engineering (BsC Corso di Laurea in Ingegneria informatica) studies at the University of Torino, the OSs course is evaluated with 6 ECTS credits and more than half of the planned topics are occupied by processes, threads and process synchronization (26 hours of a total of 45) [15]. On the other hand, in some study programs in Germany and in Scandinavian countries, OSs courses are not an integral part of the study programs in the undergraduate academic studies in computer science, computer engineering and information technology.

In order to verify the content of the OSs course, 3 three-year study programs in Computer science (NM field), Computer engineering (TT field) and Information technology (IMT studies), with 180 ECTS credits, were considered, where two of them are from the University of the European education area and one from our neighborhood (non EU). Contents of the OSs courses at the Università degli Studi dell'Aquila (Italy) for obtaining the title of BSC in Computer Science (Laurea in Ingegneria dell'Informazione) [16], from the Faculty of Electrical Engineering and Computer Science, University of Maribor (Slovenia), for acquiring the title BSc in Computer science and Information technology [17], and from the Faculty of Science and Mathematics at the University of Podgorica (Montenegro) for acquiring the title BSc in Computer Science [18], are compared with the course contents of the proposed model, performed at the Undergraduate academic studies of IT study

program, at the Faculty of Technical Sciences in Čačak (Serbia) [14]. All mentioned courses are evaluated with 6 ECTS credits. The results of the analysis are presented in Table 1, through all segments of standardized IT areas (grouped in 12 aspects, 1 - 12).

Table 1. *Comparative analysis of OSs course content through 12 model aspects*

Area	Department of information engineering, computer science and mathematics, Università degli Studi dell'Aquila, Italia System services (1 - 12)	Faculty of Electrical Engineering and Computer Science, University of Maribor, Slovenia	Faculty of Science and Mathematics, Podgorica, Montenegro	Faculty of Technical Sciences, Čačak, Serbia
(1)	Introduction to modern OSs, definition, objectives and types of OSs	Role of OSs and their basic functionality	Introduction, the concept of OS, OS as an extended machine and resource manager	Introduction to OSs, applying and using OSs
(2)	File system management	File system management, implementation of file systems	Multimedia OS, security, file systems	File system, data, information, protection and security management
(3)	System programs	Interrupt handling		Interrupt handling
(4)	OS Design and Implementation		History of OSs, types of OSs, basic concepts of OSs	System development and documentation
(5)			Multiprocessing and distributed OSs	OSs and network management
(6)				OSs and support for global communications
(7)				OSs and graphical interface (graphic environments)
(8)	Processes and threads, CPU scheduling, process synchronization, deadlocks	Process scheduling, job and process management, process synchronization, classical problems of synchronization, threads	Processors, processes and threads, interprocess communication, process and thread planning, deadlocks	Process and job management, synchronization problems
(9)		Access to I/O devices	I/O devices, I/O management	I/O device management
(10)	System calls, OS Structure	Computer systems and OSs architectures	System calls, buses, OS structure	Computer system configuration
(11)	Main memory management, virtual machines	Memory management, virtual memory, disk scheduling	Memories, memory management	Memory management and virtualization
(12)				Application support

3.1 Content compliance analysis by all standardized IT segments

Compared to the OSs course contents at representative examples presented in Table 1 (thematic aspects in columns 2 - 4), the model with 12 aspects offers full coverage of 14 standardized IT areas, in contrast to the OSs course content at the Università degli Studi dell'Aquila and at the Faculty of Electrical Engineering and Computer Science University of Maribor, where there is obvious lack of content coverage in areas 4 - 7 and 12. At the Università degli Studi dell'Aquila, the coverage of these segments is partially done through System services, and the similar situation is in thematic aspects 9 and 12. In the neighboring country, which comes from a non-European educational area, at the Faculty of Science and Mathematics in Podgorica, as an example, there is lack of thematic aspects 3, 7 and 12.

On the other hand, there is almost complete alignment of all analyzed contents in areas 1 - 4 and 8 - 11 with the contents from the European educational space, as well as with the contents that are studied in our close environment (with the exception of the 3rd thematic aspect).

4. RESULTS OF MODEL APPLICATION IN STATE OF EMERGENCY - ONLINE NOVELITIES

The presented OSs content model is completely formally and structurally aligned with modern trends and novelties in the study of OSs, offering students the latest scientific and technical knowledge and skills, necessary for their further professional development and improvement in the IT area. The model is aligned with the courses contents of from EU and non-EU countries, ACM/IEEE recommendations and fully covers standardized IT areas. It has already been successfully implemented for two decades, at the OAS IT and Integrated Academic studies at Technics and Informatics (IAS TI) at the Technical Faculty in Čačak [13], now Faculty of Technical Sciences. The presented objectives, outcomes and competencies also cover the hierarchical structure of the OS (Figure 3).

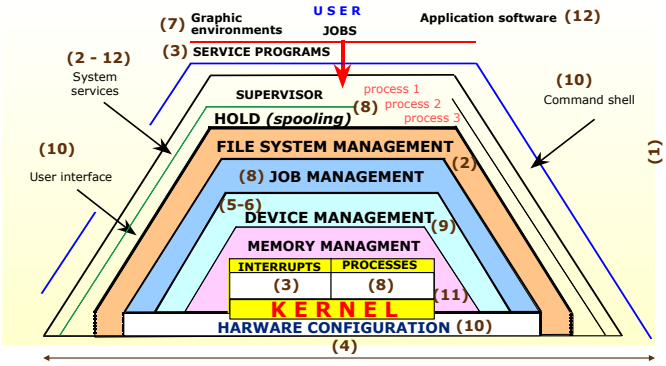

Figure 3. *A view at the basic content model through the hierarchical structure of the OS (adapted according to [13])*

In the state of emergency in Serbia, in combination with the Zoom application, the basic Moodle course for OSs at Web location of the faculty e-learning system is one example of good practice [19], with additional categories for 6 OS courses (Ubuntu, Android, Cent OS, Windows, Fedora Linux and Linux OS through 12 aspects), although the study programs OAS IT and IAS TI were not previously accredited for distance learning. Another example of good practice is the combination of basic OSs course, presented through 12 aspects at Moodle platform, and open source Web conferencing application BigBlueButton realized during the state of emergency at Academy of Professional Studies Šumadija in Trstenik (former College of Applied Mechanical Engineering Trstenik) [20]. This study program also was not previously accredited for distance learning.

Also, although the accreditation standard allows one teacher per maximum of 80 distance learning students - in all courses during one semester, this course at Faculty of Technical Sciences in Čačak has attended over 220 students. All students are allowed to choose a topic (installation of one of the OSs) and working principle of "week for week" - in all thematic aspects of the above model and concept -12.

This model and concept - 12 enabled 32 students to choose between 32 different topics (01_Android & CentOS; 02_Kali Linux ver. 2020.1; 03_Ubuntu ver. 19.10 Eoan Ermine; 04_Fedora Linux; 05_SuSe linux ver. 15.1; 06_Debian 10; 07_Mint 19.3; 08_CentOS 6.10 &-Android 10; 09_Win ser.2016; 10 FreeBSD 11: 11_Knoppix ver. 8.6.1; 12_Win ser.2019; 13_CP6 Linux; 14_Gentoo Linux 17; 15_Slackware 14.2; 16_Pappy Linux, 17_OpenMandriva LX 4.1; 18_Android 9_CentOS 7; 19_PCLinux OS 2020.1; 20_Solaris; 21_Android, CentOS & Windows; 22_Manjaro; 23_NetBSD; 24_iOS & Centos; 25_KaOS 2020.02 Linux; 26_Puppy Linux 8.0; 27_Lubuntu; 28_OpenBSD; 29_Arch Linux ver. 2020.03.01; 30_MacOS; 31_CentOS 6-iOS 12.4.5-Windows 10; 32_MX Linux 9.1), install/configure and study not only "their" OS installation, but at the same time, through the presentations of all other 30 OSs configurations, gain broader competencies. Thus, each student could compare "own" OS installation with about 30 other students, and all students had at least four OSs (1_Windows, 2_CentOS Linux, 3_OS OS on their mobile devices). Excellent performance was documented in the exam period in June 2020.

5. CONCLUSION

Based on all of the above it is obvious that the OSs course represents an essential part of the traditional curricula in three fields: Computer science (NM field), Software and computer engineering (TT field), and Information technologies (IMT studies).

Understanding major subjects (courses) in all mentioned fields, scientific areas and scientific/applied areas relies entirely on grasping the concepts and functionality of OSs. The developed "domestic" model in 12xn dimensions fully meets anticipated expectations. It is applicable to vocational studies and OAS, and is synchronized with European study programs in three different fields in Serbia, through scientific areas: computer science, computer engineering and information technology.

The OSs course content model, applied at the Faculty of Technical Sciences (previously Technical Faculty) in Čačak fully covers the structure of the OSs. It is open to innovations through 14 ISO/IEC standardized IT areas (grouped in 12 thematic aspects).

Objectives/sub-objectives and competencies arising from modeled contents and choosing "own" OS configuration enable students to get to know/ to know, to compare the basic characteristics of the most complex software products, to know functions and principles of OSs, to acquire basic and specific

knowledge and skills for using existing OSs, as well as for designing, programming and implementing their own specialized and embedded systems and applications. Understanding algorithms, principles, problems and solutions related to the OSs represents the basis for expanding knowledge and applications of acquired knowledge in other IT areas that are closely related to the OSs in the future. In that manner, described by the given examples of online teaching in a state of emergency, students develop the habit of continuously expanding their knowledge, through experiences gained by using problem solving skills (for students, teachers and associates, in width and in depth - through 12 aspects).

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A Methodological Approach to Computer Support of SWOT Analysis in Strategic Orientation

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Abstract: *This paper represents a cooperative presentation of strategic planning and program system, using a quantitative presentation of SWOT analysis in environmental strategic orientation. Identifies potential internal strengths and weaknesses and external opportunities and threats related to environmental protection. Methodologically, computer support for the calculation of SWOT analysis is presented, which can be applied in the general case of this analysis.*

Keywords: *SWOT matrix; environment; computer support*

1. INTRODUCTION

The strategic process consists of analyzing the environment, directing the organization, formulating the strategy, implementing the strategy, and strategically controlling. The first step of this process is the foundation of any strategy and involves assessing the current situation of the organization in relation to its mission, vision and goals [1], [2]. The analysis of the internal and external environment identifies relevant strategic factors that may influence the change or redefinition of the strategy according to the fluctuations and changes that are estimated to affect the organization. In addition to qualitative analysis, which is much more often used in the analysis of the company's environment, the quantitative approach gives an even more precise picture of the environment and its impact on the organization [3], [4]. If we complete the analysis of the environment of the business strategic system PSS, with software, we have facilitated and accelerated the process of analysis and implementation of the strategy [5], [6]. "The potential of advanced PSS can only be realized if system planners and developers begin to share knowledge and requirements and identify opportunities in the process of cooperative PSS development. Without such a process, the benefits and opportunities of PSS will remain untapped. "[7]

Albert Humphrey, is considered the forerunner of today's SWOT matrix. Namely, during his work at the Stanford Research Institute (1960-1970), Humphrey created a team planning method called SOFT analysis. Later, this analysis developed into what we know today as a SWOT analysis [8], [9].

SWOT analysis helps us achieve a competitive advantage. According to Bradley, by collecting, selecting and analyzing the obtained information, it is possible to achieve a competitive advantage in the target market [10]. Of course, only with a good knowledge of the matrix and environment can we achieve an improvement in the performance of the organization. It is also a very complex approach, as Grant states: "Companies should use it as a guide, not necessarily as a recipe." [11]

2. SWOT ANALYSIS

SWOT analysis is very important both in the formation of the strategy, and during its implementation, in order to correct due to deviations caused by changes in the internal and external environment. Bearing in mind that the strategy is adopted for a longer period of time, such changes are very certain and frequent in practice. The problem of this analysis can be a subjective approach, so it is important that in its development for the needs of the analysis of the environment in environmental protection, more professional people are involved, in order to reduce any subjectivity to a minimum.

This analysis is suitable for decision making in a variety of situations and has its character in the mirror, with the emergence of TOWS analysis. Namely, SWOT analysis puts the internal environment in the first place (strengths and weaknesses), and then the external one, while TOWS analysis puts the external environment

(opportunities and dangers) in the first place, and then the internal environment.

Opting for the application of SWOT analysis in order to make decisions and create a clear picture of the impact and importance of certain (internal and external) environmental factors on environmental protection and its development in the local government unit, an example of qualitative SWOT analysis and its quantitative matrix. The data obtained from this analysis can be used for decisions that are strategically important, but also to determine priority actions in the future. The approach to the development of this matrix is mainly defined through the following steps: 1) defining internal strengths and weaknesses; 2) defining external possibilities and dangers; 3) defining general goals; 4) defining different strategic possibilities and 5) implementing strategies.

Table 1. *Relationship between internal and external environment in SWOT analysis*

	Opportunities	**Threats**
Strengths	Using the power of the organization to seize opportunities	Use the power of the organization to avoid threats
Weaknesses	Overcoming weaknesses to take advantage of opportunities	Minimize weaknesses to avoid threats

The strength of the local self-government unit is a strategically very important factor because it is based on and results in the abilities, resources, skills and knowledge of human resources, both employees in the field of environmental protection and human resources of the local community. The role of forces is crucial in seizing opportunities and avoiding the dangers that come from the environment.

Weaknesses of the local self-government unit are those areas in which and due to which, the work of this local community is not at the desired level of business. Constraints in the form of lack of resources, knowledge, finances, etc., can greatly affect productivity and business performance. Weaknesses are omissions and shortcomings that may arise from a possible poor organization that prevents the quality of management and requires the elimination of these destructions and their consequences for the environment.

The possibilities of the local self-government unit represent potential opportunities that could contribute to the fulfillment of the strategic goals of environmental protection. Identifying opportunities involves observing changes that occur in the micro and macro environment.

Dangers per unit of local self-government can be current, but they can also be defined as dangers that may arise in the near or distant future for the environment. Anticipating future, dangerous conditions for the local self-government, can change the desired course of achieving the goal and establish control to a certain extent. The local self-government strategy is aimed at identifying hazards using SWOT analysis in order to take preventive actions in environmental protection.

Russian experts further developed the SWOT analysis, giving it a quantitative character. The first step of this process is the introduction of the interaction assessment of each pair of factors, in the direct dependence of the positive assessment (or the inverse dependence of the negative assessment), and the stronger the dependence, the higher the assessment [12].

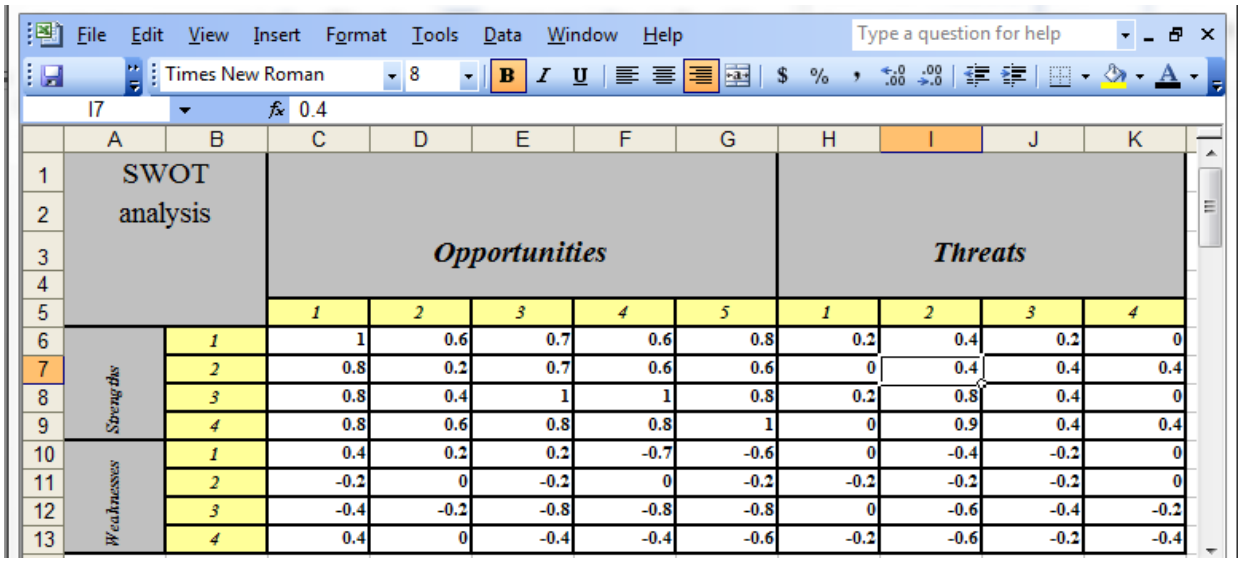
3. METHODOLOGICAL APPROACH TO COMPUTER SUPPORT

This paper presents computer support for this methodology. Fig. 1 shows the initial data that represent an estimate of the interaction of each pair of sample factors.

STRENGTHS
1. Knowledge and experience of local human resources in environmental protection
2. Expertise for key areas of environmental protection
3. Creating an expert team for environmental protection
4. Created a closed loop model at the local government level

WEAKNESSES
1. Lack of professional human resources in the local government itself
2. Lack of a human resources management sector
3. Lack of environmental sector
4. Lack of professional training of employees in the field of environmental protection

OPPORTUNITIES
1. Additional education of employees in the field of environmental protection
2. Additional education of preschool and school age children
3. Strengthening the environmental awareness of the population of the local self-government unit
4. Creating a brand of an ecological unit of local self-government



SWOT analysis		Opportunities					Threats			
		1	2	3	4	5	1	2	3	4
Strengths	1	1	0.6	0.7	0.6	0.8	0.2	0.4	0.2	0
	2	0.8	0.2	0.7	0.6	0.6	0	0.4	0.4	0.4
	3	0.8	0.4	1	1	0.8	0.2	0.8	0.4	0
	4	0.8	0.6	0.8	0.8	1	0	0.9	0.4	0.4
Weaknesses	1	0.4	0.2	0.2	-0.7	-0.6	0	-0.4	-0.2	0
	2	-0.2	0	-0.2	0	-0.2	-0.2	-0.2	-0.2	0
	3	-0.4	-0.2	-0.8	-0.8	-0.8	0	-0.6	-0.4	-0.2
	4	0.4	0	-0.4	-0.4	-0.6	-0.2	-0.6	-0.2	-0.4

Figure 1. *Assessment of the interaction of each pair of factors*

5. Support and financing of the created closed loop model by the EU

DANGERS

1. Economic crisis at the global level
2. Constant increase of pollution and waste
3. Unpredictable future and great turbulence
4. Systemic gaps in environmental education at the state level

Fig. 2 shows the results of the SWOT assessment matrix. Some characteristic parts of the budget are shown in the following listing.

Strengths - Opportunities

*D27=C27*D22*D24*
*D28=C28*D22*D24*
*D29=C29*D22*D24*
*D30=C30*D22*D24*
*E27=C27*E22*E24*
*E28=C28*E22*E24*
*E92=C29*E22*E24*
*E30=C30*E22*E24*
...

Weaknesses - Opportunities

*D31=C31*D22*D24*
*D32=C32*D22*D24*
*D33=C33*D22*D24*
*D34=C34*D22*D24*
*E31=C31*E22*E24*
*E32=C32*E22*E24*
*E33=C33*E22*E24*
*E34=C34*E22*E24*
...

Forces - Dangers

*I27=C27*I22*I24*
*I28=C28*I22*I24*
*I29=C29*I22*I24*
*I30=C30*I22*I24*
*J27=C27*J22*J24*
*J28=C28*J22*J24*
*J29=C29*J22*J24*
J30=C30*J22*J24
...

Weaknesses - Dangers

*I31=C31*I22*I24*
*I32=C32*I22*I24*
*I33=C33*I22*I24*
*I34=C34*I22*I24*
*J31=C31*J22*J24*
*J32=C32*J22*J24*
*J33=C33*J22*J24*
*J34=C34*J22*J24*
...

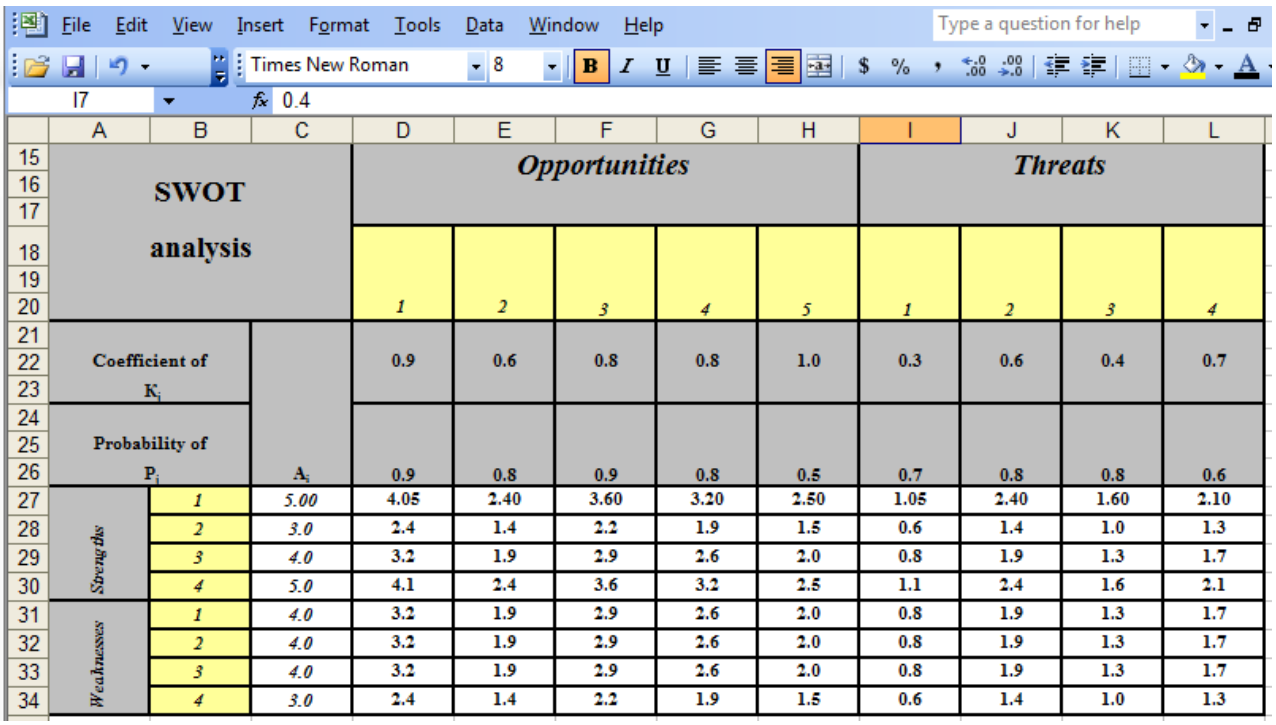
Fig. 3 shows an impact coefficient matrix, probability of occurrence and estimation of the intensity of environmental factors. The characteristic parts of the budget are shown in the following listing.

Strengths - Opportunities

*D48=C6*D27*
*D49=C7*D28*
*D50=C8*D29*
*D51=C9*D30*
*E48=D6*E27*
*E49=D7*E28*
*E50=D8*E29*
*E51=D9*E30*
...

Sum of Strengths - Opportunities

I48=SUM(D48:H48)
I49=SUM(D49:H49)
I50=SUM(D50:H50)
I51=SUM(D51:H51)



SWOT analysis			Opportunities					Threats			
			1	*2*	*3*	*4*	*5*	*1*	*2*	*3*	*4*
Coefficient of K_j			0.9	0.6	0.8	0.8	1.0	0.3	0.6	0.4	0.7
Probability of P_j		A_i	0.9	0.8	0.9	0.8	0.5	0.7	0.8	0.8	0.6
Strengths	*1*	*5.00*	4.05	2.40	3.60	3.20	2.50	1.05	2.40	1.60	2.10
	2	*3.0*	2.4	1.4	2.2	1.9	1.5	0.6	1.4	1.0	1.3
	3	*4.0*	3.2	1.9	2.9	2.6	2.0	0.8	1.9	1.3	1.7
	4	*5.0*	4.1	2.4	3.6	3.2	2.5	1.1	2.4	1.6	2.1
Weaknesses	*1*	*4.0*	3.2	1.9	2.9	2.6	2.0	0.8	1.9	1.3	1.7
	2	*4.0*	3.2	1.9	2.9	2.6	2.0	0.8	1.9	1.3	1.7
	3	*4.0*	3.2	1.9	2.9	2.6	2.0	0.8	1.9	1.3	1.7
	4	*3.0*	2.4	1.4	2.2	1.9	1.5	0.6	1.4	1.0	1.3

Figure 2. *Impact coefficient matrix , probability of occurrence and estimation of intensity of environmental factors*

Sum of Opportunities - Strengths

D52=SUM(D48:D51)
E52=SUM(E48:E51)
F52=SUM(F48:F51)
G52=SUM(G48:G51)
H52=SUM(H48:H51)

Weaknesses - Opportunities

*D54=C10*D31*
*D55=C11*D32*
*D56=C12*D33*
*D57=C13*D34*
…

Sum of Weaknesses - Opportunities

I54=SUM(D54:H54)
I55=SUM(D55:H55)
I56=SUM(D56:H56)
I57=SUM(D57:H57)

Sum of Opportunities - Weaknesses

D58=SUM(D54:D57)
E58=SUM(E54:E57)
F58=SUM(F54:F57)
G58=SUM(G54:G57)
H58=SUM(H54:H57)

Strengths - Threats

*J48=H6*I27*
*J49=H7*I28*
*J50=H8*I29*
*J51=H9*I30*
*K48=I6*J27*
*K49=I7*J28*
*K50=I8*J29*
*K51=I9*J30*
…

Sum of Strengths - Threats

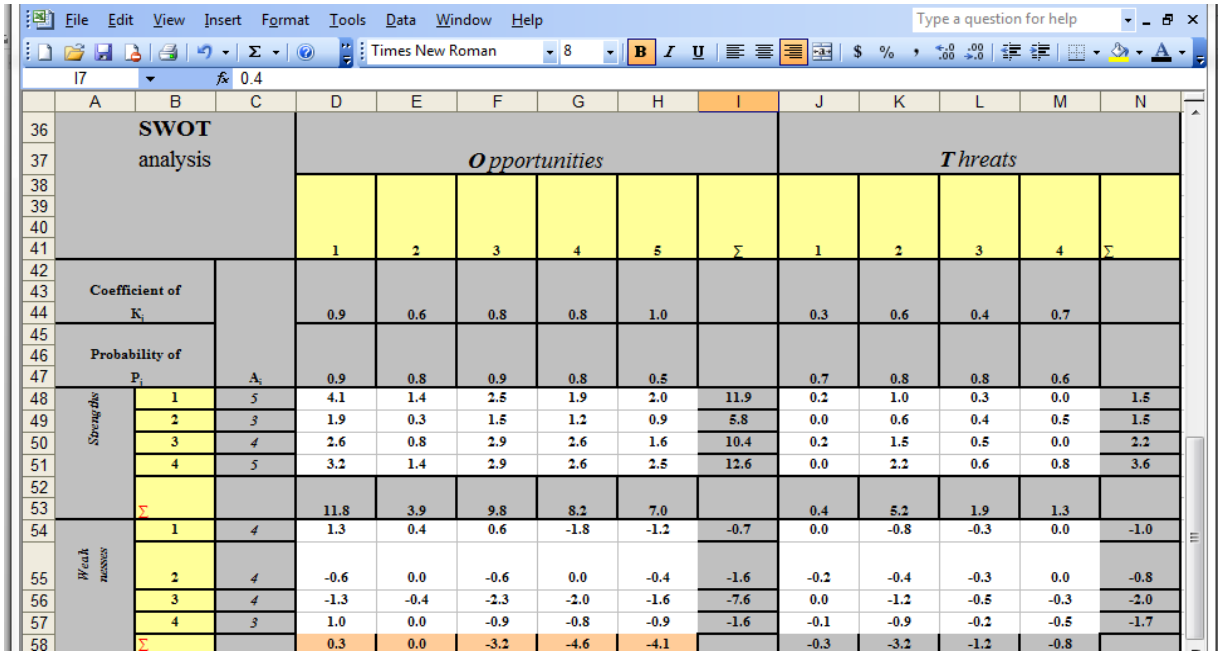
N48=SUM(J48:M48)
N49=SUM(J49:M49)
N50=SUM(J50:M50)
N51=SUM(D51:H51)

Sum of Threats - Strengths

J52=SUM(J48:J51)
K52=SUM(K48:K51)
L52=SUM(L48:L51)
M52=SUM(M48:M51)

Weaknesses - Threats

*J54=H10*I31*
*J55=H11*I32*
*J56=H12*I33*
*J57=H13*I34*
*K54=I10*J31*
*K55=I11*J32*
*K56=I12*J33*
*K57=I13*J34*
…



36	**SWOT**												
37	analysis			*Opportunities*						*Threats*			
38–41				1	2	3	4	5	Σ	1	2	3	4	Σ
42–44	Coefficient of K_i			0.9	0.6	0.8	0.8	1.0		0.3	0.6	0.4	0.7	
45–47	Probability of P_i		A_i	0.9	0.8	0.9	0.8	0.5		0.7	0.8	0.8	0.6	
48	*Strengths*	1	5	4.1	1.4	2.5	1.9	2.0	11.9	0.2	1.0	0.3	0.0	1.5
49		2	3	1.9	0.3	1.5	1.2	0.9	5.8	0.0	0.6	0.4	0.5	1.5
50		3	4	2.6	0.8	2.9	2.6	1.6	10.4	0.2	1.5	0.5	0.0	2.2
51		4	5	3.2	1.4	2.9	2.6	2.5	12.6	0.0	2.2	0.6	0.8	3.6
52–53		Σ		11.8	3.9	9.8	8.2	7.0		0.4	5.2	1.9	1.3	
54	*Weaknesses*	1	4	1.3	0.4	0.6	-1.8	-1.2	-0.7	0.0	-0.8	-0.3	0.0	-1.0
55		2	4	-0.6	0.0	-0.6	0.0	-0.4	-1.6	-0.2	-0.4	-0.3	0.0	-0.8
56		3	4	-1.3	-0.4	-2.3	-2.0	-1.6	-7.6	0.0	-1.2	-0.5	-0.3	-2.0
57		4	3	1.0	0.0	-0.9	-0.8	-0.9	-1.6	-0.1	-0.9	-0.2	-0.5	-1.7
58		Σ		0.3	0.0	-3.2	-4.6	-4.1		-0.3	-3.2	-1.2	-0.8	

Figure 3. *Results of the SWOT assessment matrix*

Sum of Weaknesses - Threats

N54=SUM(J54:M54)
N55=SUM(J55:M55)
N56=SUM(J56:M56)
N57=SUM(J57:M57)

Sum of Threats - Weaknesses

J58=SUM(J54:J57)
K58=SUM(K54:K57)
L58=SUM(L54:L57)
M58=SUM(M54:M57)

4. CONCLUSION

Opting for the application of SWOT analysis for decision making and creating a clear picture of the impact and importance of certain (internal and external) environmental factors on environmental protection and its development in the local government, a sample example of qualitative SWOT analysis and its quantitative matrix. The data obtained from this analysis can be used for decisions that are strategically important, but also for determining priority actions in the future.

If we complete the analysis of the environment of the business strategic system PSS with software, we have facilitated and accelerated the process of analysis and implementation of the strategy. The paper methodologically presents computer support for the calculation of SWOT analysis that can be applied in the general case of this analysis.

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Qualitative Analysis of Problem-Solving Process in the Field of Programming in Primary Education

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Abstract: *Digital competencies are necessary for the functioning of an individual in contemporary society and therefore it is important to develop the same in students through whole elementary education. The skills of algorithmic, computing and logical thinking are the essential part of these competencies. In order to plan curriculum content in the field of programming well, it is important to understand how students see the very process of problem solving .Therefore, the aim of this work is to identify categories of fourth grade students' behavior while dealing with problem tasks in the field of programming. Twenty-nine fourth grade students took part in this research. The technique of collecting data using video recordings of the problem-solving process was applied. Qualitative analysis of data has shown categories of behavior which might arise when dealing with solving tasks of different content and complexity. Besides behavior, the analysis of video recordings has pointed to mistakes and difficulties the students had. Given categories of behavior can be applied to development of questionnaire intended for observation of problem-solving process in this context. Identified mistakes, difficulties and students' behavior patterns can contribute at great extent to the understanding of students' way of thinking, and therefore contribute to the way of organizing teaching and planning content in this field.*

Keywords: *programming; code.org; problem solving; categories of behavior during solving problems*

1. INTRODUCTION

The development of algorithmic thinking has become a frequent topic when it comes to elementary education. It is known that learning programming languages can be complex for students of all ages and particularly for younger students who have not yet developed thinking skills. Therefore, encouraging logical thinking is important at younger age. Programming skills are the integral part of digital literacy and computing thinking [1]. Nevertheless, these skills should not be observed only in the context of digital literacy but as transversal skill applicable to other spheres of life and studying. The researches imply that learning programming at early age has positive effect on mathematical, logical [2], critical thinking [3], computing thinking, problem solving skills, creativity and imagination [4].

Syntax writing which significantly complexify the essential development of algorithmic way of thinking and solving problems is replaced with the usage of graphical environment for learning programming. Such learning environments enable students to focus on the very problem and its solving instead on syntax writing. Graphical environments are based on writing programs by building blocks using swiping technique. There is a great number of tools for visual learning of programming such as Scratch, Alice, MIT App Inventor and others. Code.org platform will be described for the purpose of this work.

Code.org is a tool for learning programming organized through courses adjusted to preschool and school children. Unlike other platforms this tool consists of beforehand structured tasks of different complexity distributed through tasks paths. Each task path includes one programming concepts such as sequences, loops, conditions and similar. The paths consist of tasks of different complexity and solving more complex tasks does not depend on prior solving of simpler ones. The environment supports monitoring of program correctness by its performing which is shown graphically. It is possible to test the program in its entirety or "step by step "where every block is marked in the program currently done. Thus, the students are enabled to find mistakes in the code. Certain tasks which are included in the courses require finding incorrect blocks in already offered programs.

Programming consists of numerous thinking activities and therefore it is necessary to determine

the way in which thinking process in younger students while solving problems is carried out. Younger students (in the first cycle of elementary education) can encounter difficulties in abstract thinking and hence be limited to solving concrete, practical problems [5].

Therefore, it is important to determine difficulties students encounter when solving problems, mistakes they make and other additional behaviors which can explain problematic points in the process of solving problems. Clear insight into learning process can, at great extent contribute to better organization of teaching and content adjustment in this field. The overview of recent research implies that there are no studies which deal with examination of the solving problem process within the context of programming of 4th grade elementary students.

Therefore, the aim of this work is to identify categories of expected behavior during solving problems of fourth grade students and development a questionnaire for monitoring process of solving problems.

2. SOLVING PROBLEMS WITHIN THE CONTEXT OF PROGRAMMING

Analog thinking can have great impact on solving problem process [6]. Mental elements, as basic units of thinking process, and combinations of the same represent the key component in the process of solving problems [7], and very determination of relations between the elements is an essential part of analog thinking. Analog thinking is explained as a process of representation of objects and information as a system of mutual connections which can be compared and combined [8]. Graphical environments for learning programming are based on building blocks, which are elements necessary for correct execution of the program where it is essential to connect relations of more blocks. In addition, when a student solve tasks which are linked by content or when more complex tasks require necessary understanding of simpler ones then analog thinking becomes more prominent. Analog thinking is recognized by its usage of existing information from long-term memory, reorganization, modification and its usage in new situations. Therefore, analog thinking consists of the following phases [9]: redirecting attention to important information, determining relations between elements, domain or elements mapping, bringing conclusions and establishing mutual principles between comparable domains. Beside analog thinking, there are following strategies for solving problems [10]: one-trial solving, multiple trial problem solving, solving problems by complete application of information leading to correct solution, partial application of information leading to incorrect solution, solving problems by testing and making mistakes and systematic testing. From the above mentioned it can be concluded that the mentioned strategies can be roughly categorized into efficient and less efficient solving problems strategies. One-trial solving can be followed by systematic testing, that is planned and targeted problem solving. Solving problems by testing and random tries is less efficient strategy which can lead to solving problems by multiple trying and mistakes repetition. While monitoring the way of solving problems using computer (simulation) the following behaviour categories are seen [11]: understanding the aim of the task before attempting solving the same; tendency to making mistakes and random tries; steps repetition; perseverance. Research has shown that during solving problems by using mind game, students age 7-11 have a tendency to solve problems by random tries, making mistakes, without prior planning [12]. Other studies have shown that these strategies for solving mathematical problems are applied by students of lower level of knowledge [13].

In relation to the above mentioned there are metacognitive processes which are integral part of the problem solving process and consist of the following subprocesses [7]: establishing the very nature of a problem; determining steps or necessary components during solving problems; determining strategies for establishing order of elements while solving problems; the choice of information mental structure; resource distribution; solution monitoring.

Other regulation strategies can be also active during problem solving and they are often, in children, manifested in using private speech [14]. According to some opinions, if the problem tasks are too difficult, the students can lose control over regulation process. Therefore, it is necessary to set optimal complexity of tasks which will consequently encourage regulatory processes in students [15]. In addition, one more strategy of self-regulation is seeking for help. However, some students do not seek for help and they do not ask additional questions even though they have difficulties when doing tasks [16].

The mistakes students make when solving problems within the context of programming can at great extent contribute to understanding of their way of thinking, as well as to determining problematic programming concepts. Recent research has shown that students encounter difficulties in learning specific programming concepts such as loops, nested loops, branching etc. [4]. The results have shown that students of 5th and 6th grade understand simple form of loops whereas they have difficulties in understanding nested loops [17]. Mladenovic and others [18], also find out that students reason incorrectly when it is expected to determine the number of repetitions of nested loops. As expected, the results of studies

point to the fact that students firstly adopt sequencing problem solving [4], [19]. The analysis of students' projects in Scratch (age 8-11), refers to the fact that almost all students' projects contained sequencing approach, and more than half projects contained iterations [19].

Difficulties in solving problem tasks and analysis of follow-up behaviors can provide clearer picture of presence of solving problem patterns within the context of programming in students in the first cycle of elementary education. Therefore, it is important to develop valid instrument for evaluation of these behaviors.

3. RESEARCH METHODOLOGY

The main objective of this research is to determine the 4th grade students' difficulties during solving problem tasks within the context of programming which require application of certain strategies, analogies, algorithmic thinking, perseverance, etc. Therefore, the integral part of the research is forming behavior categories which can be used in a questionnaire for monitoring solving problem process.

Research variables are expected mistakes and behaviors for three tasks groups:

- Mistakes students made in all three tasks groups (nine types of mistakes in total);
- Independence in finding analogies and mistakes;
- Making mistakes timing (in initial tasks, later tasks and always);
- Variety of mistakes (same, different, same and different);
- Solving tasks by random guessing;
- Number of tries of solving tasks by random guessing;
- Change of steps when solving problems, understanding of change of steps;
- Evaluation by commenting and independence in it;
- Demonstration of planned steps, independence in it and accuracy;
- Determining the number of loop repetition, number of "repeat" blocks;
- Determining necessary number of "repeat" blocks;
- Locating "repeat" blocks, use of combined, sequencing solution and solving tasks by application of nested loops;
- Understanding the relation between blocks, looking for new solution and independence in it;
- Number of tries of new solution application;
- Approaching new solution without demand.

3.1. Methods and techniques for collecting data

The selection of tasks which students will solve in code.org environments is done in the first phase. The tasks are chosen in the way that they comprise several programming concepts. Course E, which is intended for that age, is used for 4th grade students sample (https://studio.code.org/s/coursee-2018). The tasks students solved were divided in three tasks groups depending on their complexity and programming concept. The first group of tasks consisted of concept of sequencing programming. Within this group the students solved five tasks. The students were required to add blocks in already existing program in order to perform task correctly and find mistakes in offered solutions. In the other group of tasks, the students were required to draw geometric shapes by using blocks. The demands referred to accurate determining of object movement direction, accurate blocks arrangement and identification of other possible solution by using loops in order to reduce the number of blocks.

Within this group, the students solved four tasks. The third group of tasks meant solving problems by nested loops. The tasks required determining number of loops repetition, places of using nested loops and accurate arrangement of blocks realized outside the loops. The students did two tasks in this group of tasks.

Then a research in which students individually went through all categories of tasks with researcher was conducted. The procedure of solving problems and conversation between a researcher and students were video recorded. In order to ensure that all students can do the same number of tasks in determined time a pilot study with two students of different school achievement was conducted. The students first got familiar with environment and the way of using platform. The researcher gave students tasks in printed form so that they could have insight into task requirements in Serbian language. Before very start of solving tasks, the students read tasks aloud. At the beginning the students were explained that they were supposed to do the tasks individually, but they could also ask for help or additional explanations. The students were explained that they were supposed to talk aloud while solving problems. When needed, the researcher encouraged students to think and redirected their attention to the task. Work with every student lasted for approximately one hour. In the final phase, based upon the transcripts which were recorded, students' mistakes and behaviors were recognized.

The sample consisted of 29 students of fourth grade from two elementary schools: „Milan Blagojević " in Lučani and „Tanasko Rajić" from Čačak. 14 girls and 15 boys of different school achievement took part in the research.

4. RESULTS AND DISCUSSION

This chapter gives overview of research results followed by discussion. The first chapter is about qualitative analysis of transcript and the second

chapter one is about separate behavior categories based on qualitative analysis.

4.1. Qualitative analysis of transcript

Qualitative analysis of video materials, that is transcript, refers to manifestation of mistakes students made, as well as follow-up behaviors occurring during the process of problem solving. An example of transcript which describes the process of solving tasks by applying sequencing solution and loops is in the following text:

An example of solving tasks in in the second path where the student is required to apply both sequencing and loop solution:

A student is reading task text: An artist has to walk over shaded path like in previous task but changing the color of path all five times.

After a break the researcher is checking understanding of the task objective: *„What are we supposed to do in the task?* "

*The student reads silently the task text. *

*The student starts to solve the task by sequencing solution (that is, he doesn't recognize other possible solution by himself). *

The student leaves out the block „change the color ". (the students fail to understand task objective)

The researcher reminds the student of task objective: *„Shifting each step the color of field should be changed*. "

* The student is reading silently the task text again. *

The students ask a question: *„Am I supposed to change the color here*? "(*an evaluation of his own way of thinking is done*)

*The researcher confirms. *

The student comments: *„Then, it means that I drag the block here „set color* … "(step verbalization)

„…Then moves forward, then he should change the color again … "(the student repeats it three times), *„I think that is it!* "(the student performs evaluation)

The researcher reminds student that he can try the problem solution: *„Would you like to try solution?* "

*The student tries to execute the program by clicking „Run"and understands his mistake. * He comments: *„Ah, it means that I … "and adds some more necessary blocks* (planned steps are accurate)

*The student now independently tries out the tasks and concludes that it is necessary to add two more blocks. *

*The student manages to solve the task. *

*The researcher now demands that student should apply other solution, that is perform the task by using fewer blocks. The researcher suggests application of new block. *

Since he realizes there is no feedback information, the researcher encourages student to think: *„Have you noticed that some blocks are repeating*? "

The student answers: *„Yes, move forward and set color* ".

The researcher: *„What do you think, which block we haven't used so far, and we can use in order to finish the task by using fewer blocks?* "

The student: *„Well, maybe „jump forward* ", *„No, move to the right* "… "(the student doesn't understand the task, randomly chooses correct answer)

The researcher helps the student: *„ Can we use this block "repeat"* '?

The student: *„Ah, repeat four times.* "*Choose a block and drags under all other blocks. *

*The researcher repeats the task objective. *

The student: „Now, possibly the block *„set pattern*. "(misunderstanding continues)

The researcher repeats task objective and sets the question: *„How many times should blocks be repeated, move forward and change color*? "

The student: *„9 times.* "(the student counts the blocks)

The researcher: *„That is a total number of blocks, but how many times have blocks, move forward and change color repeated?* "

The student: *„5 times* "(the student gives correct answer)

The researcher continues to point to possible solution: *„Then, what should a shrimp do 5 times?* "

The student: *„Ahem, five times … "„Five times to set color, which means that him (object) five times* "(even though the student understands at the beginning which blocks are repeated several times, now he cannot determine the same)

*The researcher offers help by removing additional blocks, placing loop in its correct position and writes down the correct number of loop repetition. The student is now asked to continue with task solving. *

The student comments: *„Move forward is repeated five times …* "

The researcher encourages the student to solve the task: *„Come on, show what you have just said*. "

*The student continues to build blocks under the block repeat one beneath the other and apply sequencing solution (Figure 1). *

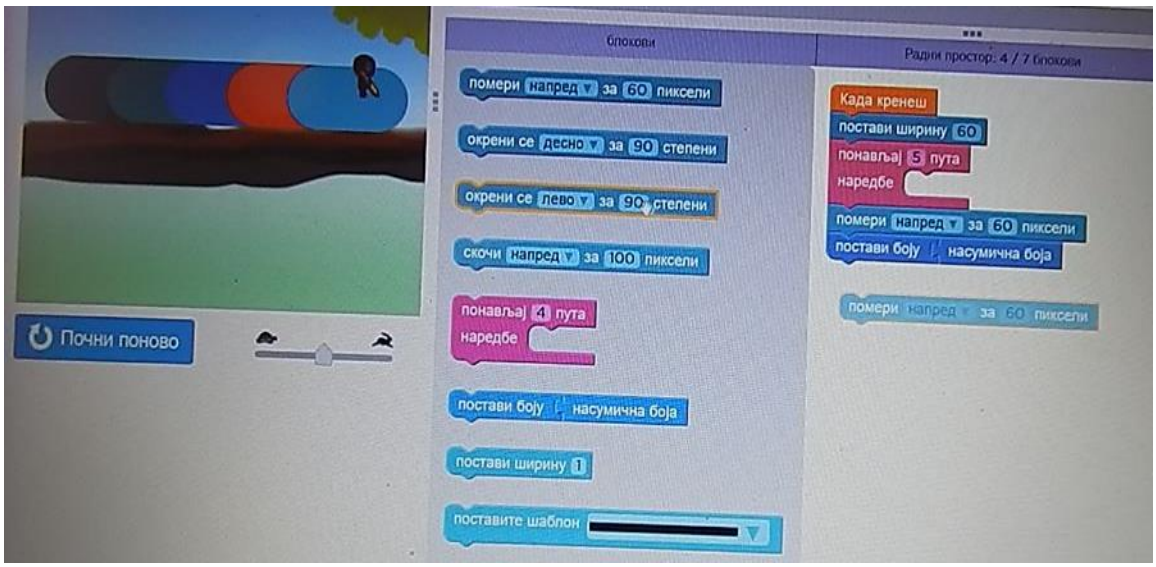

***Figure 1**. Mistakes in arrangement of blocks (inclination for applying sequencing solution)*

Certain behaviors and students' way of thinking while solving problems can be seen in above mentioned example. Certain behaviors which can be recognized in this example (and which are included in the questionnaire) refer to misunderstanding of task objective, oral evaluation of accuracy, oral verbalization of steps which are accurate and partially accurate, random guessing of correct solution, difficulties in identifying other possible solution and general understanding of task demands. Recognized mistakes in this example made by the student are the following: inclination for applying sequencing solution and besides added repeat block there is a mistake in identifying which blocks are executed in the loop, that is outside the loop , a mistake in loop positioning and how many times the loop is repeated.

In relation to the mistakes the student made misunderstanding of very task can be confirmed and therefore during the application of sequencing solution the student needed initial leading by the researcher. Trying out solution accuracy, making conclusions and applying planned steps the student finally managed to complete the task independently by using sequencing. This student also did an evaluation of his way of thinking by asking the researcher questions. However, when the student was asked to identify other possible solutions, due to task misunderstanding the student randomly chose (incorrect) solutions. Therefore, in the second phase of solving problem, due to more complex demand, the student had a tendency to find solution by random tries. After researcher's suggestion to choose "repeat" block, the student accepted mechanically the suggestion without understanding. It can be seen in the student's attempt to use "repeat" block where the number of repetitions is four. Besides, the student kept all previously added blocks outside loop which refers to wrong reasoning when it was supposed to decide how many times to use two necessary blocks. Even though the student managed to determine the number of calls of these blocks during application of sequencing solution, during application of loop he was not able to apply independently analogy to determining blocks which are executed five times.

When the researcher removed extra blocks (outside loop) and encouraged student to think over, the student wrote the correct number of repetitions, but still by applying sequencing solution under "repeat" block (Fig. 1). Besides making mistakes in identifying which blocks are executed inside the loop, the student showed additional misunderstanding by continuing placing two blocks five times each like in sequencing solution. These mistakes have shown misunderstanding of relations between blocks.

This finding is in accordance with other authors' findings which imply that students adopt first the concept of sequencing programming whereas more complex concepts are more difficult for understanding in younger students [4]. Other research also implies that students (age 7-11) when solving problems which require more thinking are inclined to adopt unplanned approach of solving problems, repeat mistakes and apply strategy of random trying [12]. On the other hand, the respondents did not have any prior knowledge in the field of programming which could also influence

application of less efficient problem-solving strategies [13].

4.2. Students' behavior categories during solving problems in the context of programming – development of questionnaire

The analysis of transcript refers to students' behaviors during solving problems and those behaviors can be categorized. Most categories can be mutual to all three groups of tasks whereas certain ones need to be adjusted to specific programming concept. Based upon shown and other transcripts the following behavior categories can be seen:

- Trying out and changing strategies category for checking frequency of mistakes repetition, type of mistakes, time when the mistakes occur (at the beginning, during doing more complex tasks , always); frequency of solving tasks by random guessing and number of tries; presence of demonstration of planned steps and independence, their accuracy; presence of changing steps during solving problems and understanding of the same; presence of skills needed for usage of analogy and independence in it;
- Locating mistake (only for the first group of tasks) category for testing the capability of students to find a mistake in offered program which does not function correctly;
- Code tracking and evaluation category for checking understanding relations between blocks; presence of oral evaluation and independence in it;
- Repetition of objective is a category for checking students' tendency to interpret wrongly task setting and independence of evaluation of the solution by asking questions;
- Showing uncertainty in taking steps category for determining whether students show uncertainty while solving tasks in situations when they encounter difficulties;
- Looking for other solution (in the second and third group of tasks) category for evaluating the students' skills for finding other solutions and their independence in it, as well as correct application of other solution;
- Understanding loops (in the second group of tasks) is a category which was used for checking independence in determining number of commands repetition, places where it is necessary to insert a loop , mistakes that can occur (wrong adding of commands executed outside "repeat" block ; beside usage of "repeat" block the student uses the same set of commands several times; mistakes in identifying which blocks are executed outside loop) and inclination to applying sequencing solution;
- Understanding nested loops (only in third group of tasks) is a category which was used for checking independence in determining number of necessary "repeat" blocks, locating these blocks, determining the number of repetitions; inclination and independence in applying sequencing, combined solutions or nested loops.

In order for further monitoring problem solving process and checking validity and reliability of observed behaviors, these mentioned categories were included in questionnaire. An example of one item for questionnaire is given in the following:

An example of questionnaire item:

<u>Tracking code and evaluation (Student follows task parts and analyses blocks: „We have added one step move forward: it means we need one more. "; he checks his solution)</u>

The student shows understanding of relations between blocks (the importance of order of blocks – e.g. accuracy in answering question „Where should we insert repeating commands when "repeat" block is used? "(before, after, inside the block)?).

While determining whether student understands relation between blocks, the student: (a) does not show understanding at all (b) shows understanding with researcher's help (c) completely understands order and purpose of certain blocks

5. CONCLUSION

In accordance to shown, it can be concluded that process of solving problems in the field of programming in younger students is important to be understood better in order to adjust these contents to their age. Mistakes made by students show how student thinks. Therefore, identification of mistakes is vital for finding out problematic points in understanding students.

Given transcript example indicates behavior categories which are observed in the thinking process of solving programming tasks in students age 10 and which can be used in a questionnaire for monitoring process of problem solving in this context. The categories refer to strategies of solving problems, understanding programming concepts, skills for finding other solutions, presenting uncertainty, tracking code and evaluation, task understanding, as well as mistakes students made.

Nevertheless, it is necessary to conduct questionnaire validity check in relation to assessments by several observers, and then by statistical analyses. Usage of questionnaire would ensure quantitative data analysis and as a consequence a clearer picture of problem-solving process would be provided. Moreover, it would be useful to monitor the same behavior categories while using other platforms for learning programming.

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EUteka Corner and Online Learning

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Abstract: *The development of information and communication technology has brought a specific model of organizational activity of economic and cultural societies - entities where knowledge and evaluation of information sources have become a key resource for success in business. These needs are caused by the development of modern society that have brought changes in the business and working environment. Since 2014, Serbian libraries have become a part of the EUteka network, jointly initiated by the Delegation of the European Union in the Republic of Serbia, the Ministry of Culture and Information of the Government of the Republic of Serbia, and the National Library of Serbia. Specifically, Užice Public Library is a part of the EUteka network of 48 public libraries in the Republic of Serbia that offer information about the European Union to its users. By this networking, in addition to print publications and communication systems, the libraries are equipped with computers, through EUteka Corner. Here the folders and resources related to the European Union are grouped in special thematic folders, starting with general information, through numerous official documents and digital archives to portals for acquiring new knowledge. The portal offer a variety of EU-sponsored online career opportunities: e Twinning (part of the Erasmus + Education, Training, Youth and Sport program) and studyportals that help millions of young people around the world explore study programs and choose the appropriate one from over one hundred thousand courses offered at many educational institutions in 110 countries.*

Keywords: *Uzice Public Library, Euteka, e-Twinning, studyportals, training, education.*

1. INTRODUCTION

Uzice Public Library is a part of the EUteka network, developed in Serbia in recent years. 48 public libraries have set up EUteka corners containing shelves filled with printed publications through which users can obtain relevant information about the European Union and the European integration process of Serbia. For the users who prefer quick and easy access to information, thematic folders are placed on the desktop of EUteka PCs, in which EU-related sources and material are grouped. Depending on the interest of the citizens, general information, official documents, digital archives, e-libraries of the institutions, numerous programs for different categories of population, learning portals and other useful information on current and future Member States are available. Through these resources EUteka Corner expands the range of services in public libraries, raises the level of media and information literacy in the local environment, and contributes to fulfilling the role of the library in the modern age by providing relevant information of general importance and promoting lifelong learning.

Learning and knowing is an integral part of human life, beginning with the first words and steps, recognizing colors, shapes and signs. Learning never ends, but it has been upgraded and expanded over the years. Prior to the advent of the Internet, access to information was limited and its flow was slower. When researching a particular topic area, it was necessary to travel elsewhere to search the library's catalogs, archives and find reliable sources of information. The Internet has annulled spatial distance and saved time by providing access to electronic resources and materials and facilitating online learning and improvement. "With the emergence of a network of all networks, opportunities have been opened for formal and non-formal education that cannot be compared to any previous form of education. Because of its characteristics, distance learning is becoming a leading way of education in the world" [1]. Its benefits are numerous. It is possible to independently organize the time and dynamics of attending online courses. It is also available to people with current or permanent disabilities because it does not require physical presence. Attendees can accomplish their day-to-day obligations and take courses at the same time. Learning costs are reduced and the learning material can be viewed multiple times. The main disadvantage of distance learning is the language barrier, as most courses are in English or another foreign language. For the last few years, experts in

specific fields, recognizing the importance, have translated voluntarily the lectures from leading online learning platforms. Many courses are free of charge, but there are some courses that require a larger amount of money. The use of learning platforms implies media and information literacy of citizens.

However, Internet, online courses, information and communication technologies that follow today's development of society have not been the initiators of the very beginning of distance learning. The main "culprit" for this type of learning was Sir Isaac Pitman, an English teacher who mailed shortened lectures in 1840. He wrote assignments on postcards and sent them to students, who then returned them to him for review. In 1858, the University of London became the first college to offer distance learning diplomas. Queen Victoria had a large part in this [2].

"In order for a university graduate to remain competitive in the marketplace throughout the working life, which lasts an average of forty years, the changes and achievements happening in the area of interest must be followed, which means acquiring new knowledge and skills." EUteka Libraries function as eTwinning portals – a virtual community of European schools and pre-schools that supports the exchange of ideas and knowledge and Studyportals – a global platform for the selection of studies and massive online courses.

2. ETWINNING INTERNET PORTAL

eTwinning is one of the European Commission's programs, launched in 2005 as a major activity within the eLearning Program. Since 2014, it has been part of the Erasmus + program for education, training, youth and sport. Its Central Support Service (CSS) is managed by the European Network of Schools and is being implemented through an international partnership of 34 European Ministries of Education. Their common goal is to develop teaching for the needs of schools, teachers and students across Europe. eTwinning is supported by 38 national support teams [3]. This virtual network supports the exchange of ideas and knowledge by modernizing teaching using information and communication technologies. Moreover, the news from partner countries involved in the platform, examples of good practice, a display of successful projects and information on various achievements can be found in the eTwinning "world". The eTwinning portal is an integral part of the Tempus Foundation, which was established in 2002 to facilitate the participation of the Republic of Serbia in the Tempus program. "Since then, the Tempus Foundation has gradually become responsible for other EU programs, such as Erasmus Mundus and the Lifelong Learning Program. The Tempus Foundation is now responsible for implementing the education component of the major Erasmus + program for education, youth and sport, as well as for implementing the youth component of this program" [4]. Erazmus + aims to promote and support formal, non-formal and informal learning, strengthening the link between education and the world of work, creating added value for the European area of education and connecting Member States in defining education policy.

"In addition to the fact that participating in eTwinning projects is a good opportunity to enhance different competences such as linguistic and digital competences, eTwinning, as part of the Erazmus+ program, opens opportunities for learning about project leadership and participation, networking and networking with colleagues from other European countries, and therefore opportunities for easier international cooperation" [5].

2.1. Accessing the eTwinning Portal

The eTwinning portal consists of three parts. The first is a public part that can be used by everyone and does not require registration. Registration and validation are required to use the eTwinning Live part, while Twinspace can only be used by registered members who started the eTwinning project. It should also be stated at registration that Twinspace will be used as one of the tools. Joining an eTwinning portal consists of two steps: pre-registration and completion of registration. Pre-registration is done on the home page of the portal [6] by clicking on the "Login / Registration" field. The box is located in the upper right corner of the screen. The registration completion link is sent to the e-mail address provided in the pre-registration and then it is necessary to click on the link or copy it in the browser to complete the process. The next step is offering newly registered members to find the institution where they are employed. If the institution is not registered, it is necessary to fill in information about the school/pre-school institution, as well as detailed information about the teacher/educator. Finally, you need to double-check the accuracy of the completed information and click on the submit button. Validation is very important because without this, members will only be able to use certain segments of the portal and, among other things, will be denied the opportunity to start projects and improve their professional development. In order for the validation to be complete, the newly registered members should submit a certificate of employment to the national support team. The confirmation format can be found on the Erazmus+ website [7].

eTwinning Live gives each member the opportunity to create their own space, starting with the user profile, through the choice of colleagues to collaborate with and share ideas and experiences, to review the basic information and activities of the

eTwinning portal member. Cards: People, Events, Projects, Groups, Partner Forums, Vocational Training, provide many opportunities for eTwinning portal users. With them, you can connect with other users, view notifications of past, present and future events and projects. An overview of the projects implemented can serve as a model for future activities or, through good practice, influence the development of ideas. Projects are launched via the eponymous card and include shortcuts: "Partner Forums" and "eTwinning Project Preparation Packages". They offer various opportunities for creating independent and partnership activities, as well as connecting with colleagues from different countries.

2.2. Twinspace

Twinspace is a part that becomes available to users only when the planned project is approved and if it is stated on registration process that it will be used as a tool in the project realization. Twinspace contains a bulletin board that is visible to teachers involved in the project, a project diary – visible on the public part of the portal, the possibility to access Twinspace of other projects, the posibility to refresh the profile and engage students who are given specific tasks and assignments.

2.3 Professional development through eTwinning

The eTwinning Portal Vocational Training tab provides users with information on the latest training, seminars and other learning opportunities available to eTwinning members. The trainings are conducted by a national support team and are dedicated to a variety of topics. These are short free courses that require you to register in advance. Seminars are streamed live. They are led by numerous experts in various fields. The national team organizes two types of seminars, which are accredited by the Institute for the Advancement of Education of Teachers, Educators and Professional Associates, and carry 8 professional development points. Seminars across Europe are also being organized to promote collaboration, networking and exchange of good practice. They also serve to support teachers and educators in their professional development.

The eTwinning web portal is presented in detail through the eTwinning manual, which is intended for teachers, educators, librarians, pedagogues, psychologists and all those involved in educational work with children in schools and pre-schools institutions in Serbia. It is published in Serbian language. In addition to the information provided, it also describes in detail examples of successful projects, as well as experiences gained through working and collaborating within the eTwinning web portal [8].

3. STUDYPORTALS

The Open Mass Online Course (MOOC) was created in 2008 at the University of Manitoba. The course was available not only to full-time university students, but also to others through online classes for free. The complete study material was available online, and consultations and exchange of views between students attending online classes were conducted through online forums, blogs and organized online meetings. An important year in popularizing Open Mass Online Courses is 2011 when Standford University began its three online courses, each with approximately 100,000 enrolled participants. This was followed by the expansion of mass online platforms, among which are the most popular Coursera, edX and others. The large offer of courses made it difficult for students to choose the appropriate program [9].

Studyportals present a global study selection platform through thousands of online courses worldwide. It was established to help young people explore study programs and choose the right one from over 190,000 courses offered at more than 3,200 educational institutions in 110 countries [9]. Before choosing an online program, students can take a 3-5 minutes test to help them choose the program according to their personal affinities [10].

The Studyportals platform uses the international experiences, both individually and socially. It is supported and cooperated by the European Commission and many national institutes. The Operations Center is located in Eindhoven, the Netherlands. Most international student associations are official partners of the Studyportals platform.

The initial interface contains a selection of disciplines by area:

- Agriculture & Forestry,
- Applied Sciences & Professions,
- Arts, Design & Architecture,
- Business & Management,
- Computer Science & IT,
- Education & Training,
- Environmental Studies & Earth Science,
- Hospitality, Leisure & Sports,
- Humanities,
- Journalism & Media,
- Law,
- Medicine and Health,
- Natural Sciences & Mathematics,
- Social Sciences.

Choosing a specific field leads to the most popular online courses at various levels (M.A., short course, Postgraduate Certificate, Bachelor) [11]. By choosing a particular course you will be given information on the amount of time to apply, the

duration of the learning periods and the cost of the course. A brief description of the content that will be covered during the lecture is available, as well as the possibilities of its application. Information regarding the accreditation is given at the end of the page [12].

When you type in search engine free courses in place where What do you want to study is written, you are offered a course with a minimum price. It is necessary to select Lowest tuition fee in the upper right corner. The selection will show a selection of courses that are free of charge and duration of study. By choosing the right course, more detailed information is obtained: periodicity of maintenance, in whose organization the course is implemented and short content that will be presented during the attendance, etc. There are numerous free short and long term courses in various fields. Each course has its own rating, as well as the offer of similar learning programs mostly available in English.

4. CONCLUSION

The Internet is much more than a collection of information. "It is a "business" tool, whether business is commercial, industrial, financial or governmental. It is a scientific tool and a source of software. It is an educational tool." Contemporary libraries are primarily represented on the Internet through electronic catalogs and digital collections that are formed to preserve cultural heritage and, more importantly, have contributed to the advancement of knowledge dissemination through free access to information. Among other things, their active role is reflected in learning support and in virtual communities. For the improvement of work in schools and preschool institutions, it is extremely useful to exchange ideas and examples of good practice outside the borders of Serbia. Online learning empowers young people to acquire education that goes beyond space and time barriers. With the development of information and communication technologies, library services are being upgraded and improved. They offer users electronic resources and materials that they can access exclusively from the library, they represent the hubs of the information society we live in. By referring users to education and training portals within the EUteka corner, libraries contribute to the development of a knowledge-based society.

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The Secondary School Student's Interest in Virtual Reality

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Abstract: *Virtual technology can be of great benefit in modern education. The paper analyzes the advantages and disadvantages of using virtual reality in secondary education and examines students' interest in using virtual reality.*

Keywords: *virtual reality; secondary school*

1. INTRODUCTION

A definition often used for VR is "technology that convinces a participant that he or she is actually elsewhere by replacing the primary sensor input with the received data generated by the computer" [1][2]. One of the key elements of VR is the virtual world, that is, an imaginary space or a simulated environment. It is an illusion that illustrates a set of objects in the environment that fulfill the imagination of the creator. Along with the virtual world, there is also the "immersion" of VR, which is the perception that someone is in another world, like an imaginary world or another point of view of our world [3]. Immersion in VR is limited only by our imagination and how we decide to create a virtual world. The challenge of computer graphics is to make that virtual world look real, sound real, trigger and react to real-time interactions, and even feel real [4]4].

It was only in 2012 that virtual reality began to be noticed worldwide. The main reason for this is due to the extremely great success of the "Oculus VR" kickstarter company, where they managed to raise 2.4 million dollars. This led to the production of the Oculus Rift, a wearable and affordable HMD (head-mounted display) with stereoscopic displays that was considered comfortable and lightweight. One of the key features of the Rift is the ultrawide field of view (100 degrees) to create the immersion necessary to experience virtual reality. One of the main concerns that has arisen is whether the general public will adapt to VR HMDs, companies are developing integrated HMDs that require consumers to buy new hardware. The solution to this problem was triggered by a new VR trend that emerged in early 2014 where instead of that unknown technology, consumers would use the power of their phones. This was first demonstrated by Google with their Google cardboard HMD which could be used by a wide range of mobile devices. This solution is not without flaws, one of the main concerns regarding Google Cardboard is the fact that head tracking uses the phone's built-in accelerometer, this causes lag, headaches and nausea for many users. There are currently many other HMDs for mobile phones on the market. However, Samsung had the idea to enhance the wireless HMD experience that uses mobile phones as a platform. Oculus VR has developed Samsung Gear VR, it is a wireless HMD specifically for Samsung and their flagship phones like Galaxy Note 4 and Galaxy S6. It has an Oculus Rift head tracking module which drastically improves the screen response time compared to head movements. This reduces the chance of the user getting headaches and nausea. Just using the product to experience VR can cause unwanted consequences, however it is obvious that special care is taken to eliminate the cause of those consequences.

Virtual reality is often used for education in areas where real situations cannot be used due to lack of access or because it is too dangerous. One example is the U.S. Army's learning environment for basic corrosion prevention protection and control and the CAVE-based system for learning mandarin. Some papers analyze the impact on training students as they are immersed in an authentic environment. Bastiaens [5] reports VR-based experiments based on training for supply chain workers using different devices. Rahimian [6] reports on the use of VR for the professional training of architectural engineering specialists.

There are not many documented reports of virtual reality usage at the high school level. Several solutions used HMD, e.g. a system that assists teachers in classroom management [7] or haptic-enhanced simulation in physics. [8] A 3D interactive virtual chemistry laboratory was also

created [9]. Large number of papers were related to university education. In one instance the traditional projector was replaced by HMD which increased motivation and control over students during the lesson [10]. An intelligent learning environment has been developed and experimented with in several computer science subjects [11]. The immersive VR environment has been reported to support the design of architectural spatial experiences [12]. The avatar-filled VR system offers a training place for student interpretation [13]. The VR application visually presents neutrino data, intended for both students and researchers [14] while another VR system based on the CAVE system offers the possibility of experimenting the effect of relativity [15]. When it comes to university education and training for adults, the results show a significant percentage of reported documents in the medical fields. Here VR is widely used on very different levels. Starting from the education of a nurse in a common immersion system [16], medical training in a virtual hospital [17], medical training [18], simulated students to remove dental caries [19], a surgical education system that uses HMD and finger tracking to show practitioners the exact movements of expert fingers during surgery [20]. Research on the use of VR in medical training and education reports on the use of VR in supporting communication between medical staff, surgical simulations, pain management, several types of therapies, and rehabilitation interventions. VR is also used directly by patients for educational purposes (e.g., adult education for oral hygiene [21] or general health knowledge for adult education [22] and for rehabilitation purposes (e.g. VR-based therapy for vestibular problems [23] or breathing exercises in people with chronic obstructive pulmonary disease) [24]. It can also encourage communication between doctor and patient [24].

2. METHODOLOGY

One of the main problems in using virtual reality in education is students' interest in technology itself. Regardless of the efficiency and results that can be achieved using virtual reality in education, if students do not want to use it or are actively trying to avoid using it, these results will not be able to be practically achieved.

Research into the use of virtual reality in education has several possible problems. In this research, one of the important problems is the reaction of students to the virtual reality environment. VR is a relatively new technology because of this most students will encounter and use this technology for the first time. Some of the risks of using VR are nausea, disorientation and dizziness. In this experiment, several measures were taken to prevent these cases. All students were informed about possible side effects, because of this they were repeatedly informed that they were not obliged to participate in the experiment if they did not want to. A specific application that is not visually intensive and that does not move quickly was chosen, in order to reduce the risk of nausea and disorientation. Also, all students were in a sitting position, this minimizes the risk of injury in case of dizziness and disorientation. During the use, a researcher stood next to them from the beginning to the end of the ride, in case of any inconvenience, the students were told to close their eyes and say that they were uncomfortable. After each use, the glasses were wiped with a single-use alcohol wipe for disinfection.

In this experiment, the main subject of research is students' interest in using virtual reality technology for learning. The aim of the research is to find the level of students 'interest in using virtual reality technology for learning, to establish the difference between the experimental and control group and gender, to find the correlation of students' interest in using VR for learning and playing.

2.1. Hypotheses

In this experiment, several hypotheses were investigated:

H0 - Students who are interested in virtual reality technology in any form will have better dispositions of using it for learning.
H1 - Students with better results are more interested in using VR for learning.
H2 - Students who have used VR are more interested in using it in learning.
H3 - There is no difference in motivation depending on gender.

2.2. Sample

Two classes from the School of Economics and Trade in Kruševac participated in the experiment. Students can pick what course they want to take when they're enrolling into the school, in this experiment students from the course of business administration have participated. In the first year we had 27 students willing to participate and in the second year 28 students, each year had a single class. Each class was divided into two groups, and each class was taught independently. There was a total of 55 participants, the control group had 29 participants and the experimental group 26, as shown in Table 1.

Table 1. *Participants by group type*

	I - year	II - year	Number	Percentage
Control	14	15	29	52,7%
Experimental	13	13	26	47,3%
Total			55	100%

2.3. Instrument and course of research

VR-BOX has been used as the main instrument in this experiment. VR-BOX is a HMD with lenses that use a mobile phone that's placed inside as a screen and the device on which the application is running. The mobile phone used is Samsung Galaxy A7 2018 with 6" screen and android operating system. The application used for the experiment is "VR Thrills" specifically "Steel runner" ride. The application and the ride were chosen for two main reasons:

1. Reducing the risk of nausea, disorientation and dizziness due to the use of VR – The roller coaster ride itself is not intense unlike other options.
2. Familiar subject matter - Students have either experienced a roller coaster ride in reality or are familiar with it, it also provides an opportunity to experience it in a safe environment.

The questionnaire contained seven demographic questions and six questions or statements related to virtual reality. Demographic questions were aimed at general information regarding students such as: Their gender, their age, what course are they participating in, where they grew up, their material status, average grades and average grade in the subject. The statements were mainly focused on students' opinions on using VR for studying, attractiveness for studying, how original the students find VR, playing games on VR, creating things for VR, ease of use. The Likert scale is used to establish students' opinions on questions or statements. The scale was from 1 (Very negative) to 5 (Very Positive).

The experiment lasted for two days; one department was done each day. Both groups had a computer science class on the same day. The first group was the control group. The control group filled out the questionnaire at the beginning of the class, they were only asked if they knew what virtual reality was to establish that they understood the topic of the questionnaire. Control groups understood the topic of the questionnaire and often compared virtual reality with 6D movies. The experimental group was first given the opportunity to test virtual reality before completing the questionnaire. After the obligatory explanation to the students about the possible undesirable side effects, each student was given a few minutes to go through the ride from the beginning to the end. Students are instructed not to communicate with each other until everyone has finished the ride and filled out the questionnaire. After all the students finished the ride and filled out the questionnaires, they were allowed to state what they thought.

3. RESULTS AND ANALYSIS

In Table 2 we see that for each question the average is greater than 3, this means that in general the participants expressed a little above the neutral answer to the questions asked. The participants had the most positive answer to the question related to the originality of virtual reality with an average of 4,05 and the least for the motivation to use it for studying with an average of 3,22. The highest degree of deviation has the question for creating virtual reality content with a deviation factor of 1,228, and the lowest deviation factor has the question for the originality of virtual reality with a deviation factor of 0,870.

Table 2. *Participants by group type*

Group statistics			
	N	**M**	**SD**
Using in studying	55	3,22	1,182
Attractive for studying	55	3,64	1,060
Original	55	4,05	0,870
Playing games	55	3,95	1,208
Creating	55	3,78	1,228
Ease of use	55	3,80	1,043

In the experiment, we had 12 male and 43 female participants as can be seen in Table 3. The highest average response for males was to use virtual reality to play games with an average of 4,25 and the lowest related to ease of use with an average of 3,58. The highest average response for women is for the originality of virtual reality with an average of 4,14 and the lowest for the motivation to use virtual reality for studying with an average of 3,16. The largest factor of male deviation is related to the issue of motivation in using virtual reality for learning with a deviation of 1,621, and the smallest is related to the issue of originality of virtual reality with a deviation of 1,357.

Table 3. *Answers grouped by gender*

Group Statistics					
Usage / Gender		N	M	SD	Std. Err. Mean
Studying	Male	12	3,42	1,621	0,468
	Female	43	3,16	1,045	0,159
Attractive for studying	Male	12	3,83	1,337	0,386
	Female	43	3,58	0,982	0,150
Original	Male	12	3,75	1,138	0,329
	Female	43	4,14	0,774	0,118
Playing games	Male	12	4,25	1,357	0,392
	Female	43	3,86	1,167	0,178
Creating	Male	12	4,08	1,240	0,358
	Female	43	3,70	1,225	0,187
Ease of use	Male	12	3,58	1,505	0,434
	Female	43	3,86	0,889	0,136

The largest female deviation is related to the issue of creating virtual reality content with a deviation of 1,225, and the smallest deviation factor is related to the issue of ease of use with a deviation factor of 0,889.

T-test analysis showed that we cannot reject the null hypothesis for any question. No statistically significant differences between the sexes were obtained with regard to the mentioned questions in the questionnaire. Thus, hypothesis 3 that there are no differences in motivation between the sexes cannot be rejected or confirmed. Sample is very unequally distributed among genders. The conclusions about this hypothesis could have significant limitations.

The control group had 29 participants and the experimental 26, as shown in Table 4. The biggest factor in the divergence of the control group was the issue of content creation in virtual reality with a deviation factor of 1,227, and the smallest was for the question of the originality of virtual reality with a factor of 0,926. The highest deviation factor for the experimental group is for the question of using virtual reality to play games with a deviation factor of 1,347, and the lowest is the same as for the control group for the question of originality with a deviation factor of 0.816.

Table 4. *Group statistics by group type*

Group Statistics					
Usage / Group type		N	M	SD	Std. Err. Mean
Studying	Control	29	3,38	1,178	0,219
	Experimental	26	3,04	1,183	0,232
Attractive for studying	Control	29	3,69	1,072	0,199
	Experimental	26	3,58	1,065	0,209
Original	Control	29	4,00	0,926	0,172
	Experimental	26	4,12	0,816	0,160
Playing games	Control	29	4,03	1,085	0,201
	Experimental	26	3,85	1,347	0,264
Creating	Control	29	3,83	1,227	0,228
	Experimental	26	3,73	1,251	0,245
Ease of use	Control	29	3,76	1,023	0,190
	Experimental	26	3,85	1,084	0,213

The results show that we cannot reject the null hypothesis for any of the questions. No statistically significant differences were obtained between the groups regarding the mentioned questions in the questionnaire, in no way can we claim that there are no average views between the control and experimental groups regarding the mentioned questions in the questionnaire. Thus, hypothesis 2 that students who have used virtual reality are more interested in using it for learning, unlike those who have not, we cannot confirm or reject it.

Table 5 shows the results of the correlation analysis. It can be observed that there are certain clearly defined correlations.

Table 5. *Correlation analysis*

		Material status	End of the year grade	Subject Grade	Using for studying	Original	Attractive for studying	Playing games	Creating	Ease of use
Material status	Pearson Corr.	1	0,152	-0,020	0,049	.332*	0,130	0,200	0,183	0,217
	Sig. (2-tailed)		0,268	0,891	0,720	0,013	0,343	0,143	0,182	0,112
End of the year grade	Pearson Corr.	0,152	1	.401**	0,001	.407**	0,221	-0,085	-0,112	0,193
	Sig. (2-	0,268		0,004	0,996	0,002	0,105	0,536	0,414	0,159
Subject Grade	Pearson Corr.	-0,020	.401**	1	0,255	0,157	.391**	0,015	-0,021	0,067
	Sig. (2-tailed)	0,891	0,004		0,074	0,275	0,005	0,917	0,885	0,645
Using for studying	Pearson Corr.	0,049	0,001	0,255	1	.367**	.700**	.411**	.404**	0,156
	Sig. (2-tailed)	0,720	0,996	0,074		0,006	0,000	0,002	0,002	0,255
Original	Pearson Corr.	.332*	.407**	0,157	.367**	1	.504**	.302*	.272*	.502**
	Sig. (2-tailed)	0,013	0,002	0,275	0,006		0,000	0,025	0,045	0,000
Attractive for studying	Pearson Corr.	0,130	0,221	.391**	.700**	.504**	1	.519**	.393**	.301*
	Sig. (2-tailed)	0,343	0,105	0,005	0,000	0,000		0,000	0,003	0,025
Playing games	Pearson Corr.	0,200	-0,085	0,015	.411**	.302*	.519**	1	.366**	.476**
	Sig. (2-tailed)	0,143	0,536	0,917	0,002	0,025	0,000		0,006	0,000
Creating	Pearson Corr.	0,183	-0,112	-0,021	.404**	.272*	.393**	.366**	1	.298*
	Sig. (2-tailed)	0,182	0,414	0,885	0,002	0,045	0,003	0,006		0,027
Ease of use	Pearson Corr.	0,217	0,193	0,067	0,156	.502**	.301*	.476**	.298*	1
	Sig. (2-tailed)	0,112	0,159	0,645	0,255	0,000	0,025	0,000	0,027	

Material status has a statistically significant correlation only on students' opinion of the originality of virtual reality.

Success at the end of the year has a statistically significant correlation on the grade from the subject and on the usefulness or attractiveness for learning using virtual reality. This indicates that students with better results find that virtual reality is more useful or attractive for studying compared to students with poorer results.

The grade from the subject has a statistically significant correlation with students' opinion on the usefulness or attractiveness of using virtual reality for studying, which further confirms hypothesis

number 1 that students with better success are more interested in using virtual reality for learning.

Motivation to use virtual reality for studying has a statistically significant correlation with students' opinions on the originality of virtual reality, usefulness or attractiveness for using virtual reality for learning, using virtual reality for playing games and creating content in virtual reality. From this it can be established that the motivation to use virtual reality is proportionally related to students' opinion about its originality, usefulness or attractiveness for studying, thinking about it as an environment for playing and creating content in it. Any positive or negative change in students' opinions on these questions / statements would directly affect their motivation to use virtual reality for learning.

Originality, usefulness or attractiveness for studying, the environment for playing and creating content in virtual reality have an essential statistical correlation. This confirms that any change in students 'opinions related to virtual reality in this context will proportionally directly affect students' motivation to use virtual reality for learning.

It can be said that the view of virtual reality is one whole, where the opinion about certain ways of using or aspects of virtual reality proportionally influences the opinion about its other aspects or way of using. Pedagogically, this allows us to approach students using different methods, i.e. we adjust them depending on the student. Positive thinking of students about virtual reality also increases their motivation to use virtual reality for learning.

With these results we can confirm the main hypothesis that students who are interested in virtual reality have a better disposition to use it for learning. The results indicate that the degree of interest of any aspect of virtual reality directly affects others.

4. CONCLUSION

Virtual reality provides the benefits of use in education, allows students to learn at their own pace, helps with permanent memorization of materials, facilitates understanding of abstract concepts, enables cheap testing of various designs, simulated environment with dangerous consequences in which students can work safely. However, the main obstacles for using VR, the concern of possible disruption in development of children, the necessary equipment and accompanying material specifically designed for subjects and additional education of teachers to use VR as a teaching tool effectively provide the challenge to implement VR as a traditional teaching tool.

There are multiple ways of expanding the research done in this paper further, obtaining a greater and more varied sample size would be one of the most straightforward ways. First step would be having a sample size for all 4 years of secondary school, we could expand that to multiple different secondary schools. Research in this paper has been done in an economic school there could be major differences in interest depending on the type of education students are doing. Research comparing secondary and university level interest also can be done to see if there’s a difference depending on the level of education. If its established that there is significant interest across the different levels of educations tests regarding the effectiveness of VR can be done to establish at what level of education would using VR be most effective.

Virtual reality as a technology has advanced a lot in the past decade but the academic body of papers seems unable to keep up with this rapid development. VR can be applied in different areas of education however the main focus is on education in the university environment. It is accepted that VR is a good tool for university education and additional specializations. The works and experiments that focused on the second cycle of education had good results; it seems that the use of VR as an auxiliary tool is effective for younger students. During the second cycle of education, the use of VR increases students' interest in the subject as well as their results on knowledge tests. This aspect should be further examined as well as the analysis of the comparison of the effectiveness of VR on students of the second cycle of education with students at universities, due to the difference in the development, VR may have different efficiency depending on age. Currently, VR is not accepted as a traditional tool for use in education, with the advancement of technology, VR tools will be increasingly accessible, which could enable greater use of VR devices in education as well as easier use of students of these devices.

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Educational Trends in Computing - Blockchain concept

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Abstract: *The paper presents the development of educational activities in the field of computing. Professional associations, primarily the ACM (Association for Computing Machinery) and the CS IEEE (Computer Society Institute of Electrical and Electronics Engineers) have recognized the need to define an educational framework at the level of computing. Over the last four decades, the working groups formed by these two associations have been submitting reports setting out recommendations regarding the structure and content of education in this field. Through these reports, the development of computing and its division into recognizable and complete areas can be followed. In addition to global changes in computing education, there have been structural changes within certain areas. It also required the identification of new knowledge necessary to meet all the requirements required by the widespread use of computers in the life of modern human. An important aspect of modern computing, above all its application is the protection of information that is processed. One of the latest approaches in data protection is the use of the blockchain concept. Accordingly, the paper gives an overview of the educational aspects of blockchain technology.*

Keywords: *blockchain, computing curriculum, cybersecurity, data science, education*

1. INTRODUCTION

Technological advances in the field of computer hardware have influenced changes in the field of computer applications as well as the development of software support necessary to put computer hardware into operation. The better hardware performance of modern computers has led to an unprecedented expansion of the field of application of computers. On the other hand, it influenced the development of specialized programming languages adapted to different fields of application. Also, there have been adjustments from the aspect of application of other components of system software, primarily operating systems.

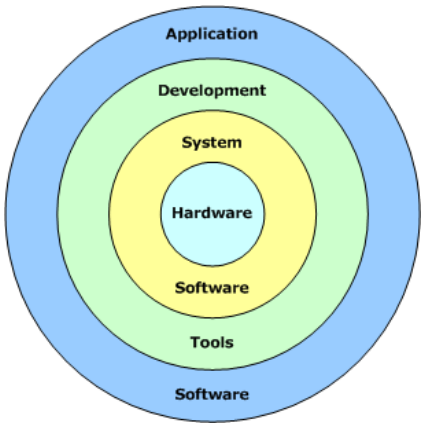

Figure 1. *Computer system model based on concentric circles*

There is no need to emphasize the scope and variety of application software. However, it should be pointed out that with the rapid development of computing came the development of a whole new field within it, and these are tools for hardware and software development. The structure of the computer system using the known model of concentric circles now looks like in Fig. 1.

The proliferation of computer applications and the frameworks in which applications run have imposed additional demands on changes in computing education. Applications in the field of artificial intelligence, data analysis, etc. have especially contributed to this. The use of computers in the conditions of a global computer network such as the Internet has fully actualized the aspect of distributed data processing. Since various transactions take place in this way, the problem of trust in the correctness of their execution has arisen. About ten years ago, the digital currency Bitcoin appeared, which introduced many innovations in the field of digital transactions, especially finance. The use of this digital currency is based on a new concept of databases that are realized on distributed and interconnected blocks (blockchain).

The subject of this paper is to present some new trends in computer education. Within the analysis that will be presented, special attention will be paid to the correlation between new trends in computing and appropriate educational content.

2. THE STRUCTURE OF COMPUTER EDUCATION

More than three decades ago, two renowned professional associations ACM (Association for Computing Machinery) and Computer Society within the IEEE (Institute of Electrical and Electronics Engineers) jointly began to present their vision of computing education to the professional public. In the document "Curriculum '68" [1], computer science was introduced for the first time as a special discipline. The discipline was divided into three areas, which corresponded to Keenan's definition of computing [2]. These areas were: Information Structures and Processes, Data processing systems, and Methodologies.

It is important to note that this document emphasizes algorithmic thinking, which should be clearly distinguished from the concept of programming. The document was criticized for neglecting the training of staff in the field of commercial data processing. And there have been cases where some of the recommended courses have been included in curricula in other areas. The situation in undergraduate studies was somewhat worse, as only 14 faculties offered classes with elements of recommended courses.

The document was innovated in 1978 and contained recommendations that are common to all undergraduate courses. Recommendations are given through topics and courses at primary and secondary level of computer education. Also, a set of elective courses was considered with the aim of completing the program of basic computing studies [3]. According to this document, the goals of computer education are: the ability to write programs, understanding the basic computer architecture, acquire knowledge in the use of appropriate tools, training for independent and team work and creating a basis for continuing education in this field. Also, the proposal of the new curriculum contained a course that treated the relationship between computers and the community.

2.1 A new look at computing

In 1981, the CS IEEE and ACM established the Computer Science Accreditation Board (CSAB). The task of this Committee was to define the criteria for certification of curricula in the field of computing.

At the same time, there was criticism of Curriculum '78. The main shortcoming was considered to be that the principles on which computing is based were not adequately founded through it. On the other hand, the consortium wanted to propose a relatively compact curriculum that could be implemented at smaller faculties. The core of their proposal consisted of six courses: algorithms, programming, data structures, computer organization, theory of computing, and programming languages [4], [5].

2.2 Joint forces

In the mid-1980s, the ACM cooperated with the CS IEEE, within which a Task Force was formed. Primarily, it was necessary to show that computing is more than programming. During the eighties, there was a turning point in computer technology. Primarily in the technology for making components and computer applications. It also required changes in computer education. In 1988, the working group presented the document "Computing as a discipline", [6]. The duality in computing is pointed out, i.e. division into computer science and computer engineering. Computing is further divided into nine sub-areas: algorithms and data structures; programming languages; computer architecture; numerical and symbolic calculation; software methodologies and engineering; databases and information systems; artificial intelligence and robotics; human-computer interaction.

In Computing Curricula 91 (CC91) computing is divided into eleven areas. In relation to the 1988 report, two areas were added: an introduction to programming and the social, ethical and professional aspects of computing. In addition to the structuring of computing in the sub-areas, the criteria for the formation of the curriculum have been defined. The criteria reflected the obligation, complexity, efficiency and level of abstraction that knowledge within the courses carries with it. Within CC91, twelve sets of courses are presented which illustrate the use of knowledge units for the formation of curricula.

2.3 A step forward

At the end of 1998, the CS IEEE and ACM formed a new working group with the aim of making a new report on the structure of the Computing Curricula 2001 [7]. The task of the working group was to review the development of computing in the previous decade on the basis of CC91 and define appropriate recommendations. In the previous decade or two, computing has changed almost dramatically. At the same time, the framework of computing has expanded so much that it is no longer possible to consider it as a single discipline.

The working group for CC2001 defined a set of 14 areas that include basic knowledge related to computer science at the level of undergraduate studies: These areas are: discrete structures; basics of programming; algorithms; computer architecture and organization; operating systems; networking; human-computer interaction; computer graphics and visual computing; intelligent systems; information management;

social and professional aspects; software engineering; computer science.

From the aspect of pedagogy, the courses are divided into the following six groups: introductory topics and courses; accompanying topics and courses; computer core; professional practice; advanced studies and undergraduate research; computing through the curriculum.

In defining recommendations regarding the structure of computer education in the near future, the working group took into account the technical and cultural changes that occurred in the previous period, especially in the previous decade. Technical and technological advances over the past decade have increased the importance of many programming topics such as: the World Wide Web and its applications; Network technologies, especially those based on TCP / IP; Graphics and multimedia; Object-oriented programming, etc.

It has already been mentioned that computer education has also been affected by changes in the cultural and sociological framework in which that education takes place. At the same time, technological changes have influenced changes in pedagogical aspects, but also in general the culture of computer education. It was with the entry of computer technology into cultural and economic trends that the battle was won for computing to become an academic discipline [6].

2.4 Final structure

The speed with which computing developed influenced the ACM and IEEE CS working group to offer the public a new document with guidelines related to defining curricula within computing after only five years. This document was named Computing Curricula 2005 (CC2005), [8].

The development of microcomputers marked the separation of computer science as a special discipline. The relationship between the mentioned areas within computing is shown in Fig. 2. The distance between the areas indicates how closely their successors cooperated with each other.

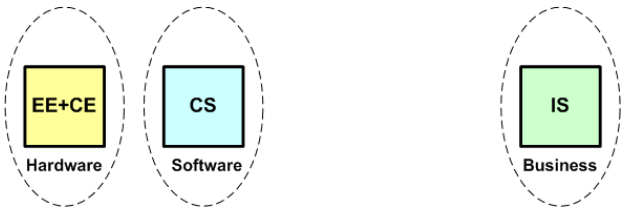

Figure 2. *Offer of educational areas within computing before the nineties*

During the 1990s, computer engineering consolidated its status thanks to the great expansion of integrated circuit-based devices. Thanks to the training for integrated circuit design jobs and their programming, a large number of students decided to study computer engineering during this decade.

Software engineering originated as a subfield within computer science. However, as computing has been increasingly used to solve a wide range of complex problems, the development of appropriate software has become increasingly important. As early as 1968, the concept of software engineering was introduced.

In the 1960s, it was observed that computers could be of great use to support the needs of the business world, such as accounting systems, payment systems, inventory systems, etc. On the other hand, in the early 1990s, networked personal computers became widely available.

During the 1990s, networked computers became the information backbone of various organizations. However, possible problems in the computer infrastructure created limitations in terms of efficient working performance. This initiated the creation of another area within computer education, information technology. At the turn of the century, the educational structure of computing could be divided as shown in Fig. 3. Dotted lines give areas connected in clusters according to the primary activity for which students are trained.

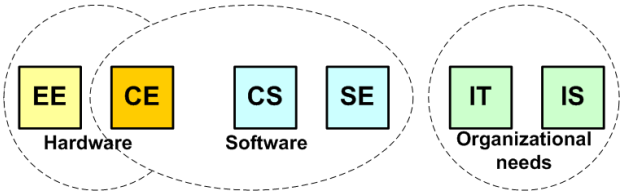

Figure 3. *Offer of educational areas within computer science at the beginning of the XXI century*

The advent of CC2005 marked a major milestone in computer education. It defined the structure of education at three levels - hardware development, software development and computer applications, primarily for business purposes.

3. NEW TRENDS IN COMPUTER EDUCATION

After the appearance of CC2005, the joint working group of ACM and IEEE CS in the following period was engaged in the development of curricula in certain areas of computer science. This is how the documents Computer Science 2013, Software Engineering 2014, Computer Engineering 2016 and Information Technology 2017 were created. The beginning of the new century was marked by data processing that could practically not be imagined outside the context of computer networking. In that period, the Internet did not become just a basic communication infrastructure in data exchange. At the same time, it became the basic computer platform for data processing. With the globalization of economic and business flows and processes, the Internet has proven to be an ideal platform for

efficient support of all the needs of modern human in all aspects of his work and living environment.

In the beginning of 2020, the joint working group of ACM and CS IEEE published a document called Computing Curricula 2020 [9], which presented the principles for defining computer curricula in the future. Compared to the previous general report, CC2020 also contains a curriculum proposal for two new areas, Cybersecurity and Data Science.

3.1 Cybersecurity

Cybersecurity is a typical example of how computing is evolving with an increasing emphasis on multidisciplinarity. Therefore, the curricula for certain areas are increasingly interconnected. The proposal and recommendations related to this area of computing were first published in the Cybersecurity Curricula 2017 report (CSEC2017) [10]. This document highlights the importance of security in eight areas: data, software, components, connection, system, human, organization, and society.

It is important to note that the report indicates that in terms of cybersecurity there is a wide range of jobs that graduates can perform. Therefore, it is necessary that the curriculum in this area allows graduates to acquire knowledge and skills in public affairs, trade, management, research, software development, operations in the field of IT security and organizational structure of the company.

3.2 Data Science

Data science is a new field in computing that is directly related to data analysis and engineering. A possible definition of data science is that it is "A set of basic principles for extracting knowledge from data ... including principles, processes, and techniques for understanding phenomena using automated data analysis" [11].

ACM carried out the first activities in this field during 2015. In February and December 2019, the working group prepared drafts of two reports marked as DS202x [12], [13]. The second report paid special attention to the competencies acquired through education in the field of data science. Accordingly, the basic knowledge is defined for gaining the required competences. This knowledge includes: computer basics; data acquisition and management; data storage and management; privacy, security and data integrity; machine learning; data mining; analysis and presentation; professional aspects.

4. BLOCKCHAIN CONCEPT

The blockchain concept was firstly introduced in 2008 paper of Satoshi Nakamoto [14], along with the Bitcoin cryptocurrency. The main point in the paper is to form a peer-to-peer system for money transfer, without any need for a third party or the middleman. The entire transaction between two parties is encrypted and secure. This is ensured by creating an environment in which every node doesn't have significant reason to compromise or attack the network.

A block in the blockchain is the collection of transactions [15]. When enough transactions are collected, the new block in the blockchain is formed. As an incentive for validating transactions, a special group of nodes called miners is rewarded when each block is created. The key security property of the blockchain is the cryptographically linked blocks. Each block contains the Hash function of the previous block, so if an attacker would like to compromise the blockchain, he would have to change all Hash signatures of all previous blocks, which is not likely possible [16].

Consensus mechanism in a blockchain is a set of rules that determine which nodes can be used as a transaction verifiers [17]. The consensus mechanisms mostly used today are: Proof of Work (PoW), Proof of Stake (PoS), Delegated Proof of Stake (DPoS) and Practical Byzantine Fault Tolerance (PBFT) [18]. Proof of Work is based on purely physical work that validators have to perform in validating transactions. This physical work is based on the heavy computational tasks that require lots of processing power to finish [14]. Proof of Stake is more energy conserving and is based on the amount of digital currency the validators hold. The more currency they hold, they are likely to become validators and contribute to the network. However, this can lead to the centralization of the network [19]. Delegated Proof of Stake is created to somewhat improve original Proof of Stake algorithm. In DPoS, the validators are not chosen based on their currency holdings, but on the elections that is performed throughout the network [20]. Practical Byzantine Fault Tolerance is a consensus mechanism that uses three phases in block creation. In each phase, a node would proceed to the next phase if it receives more than 2/3 votes from other blockchain members [21].

Since its adoption, the blockchain has been used in many industries and applications, such as: digital identity providers, voting systems, banking and financial industry, supply chains, social inclusion, E-government, healthcare, energy, education, etc. [22], [23].

5. CONTEMPORARY EXPERIENCES IN BLOCKCHAIN EDUCATION

Blockchain technology has been in its infancy for as long as half a decade. Since it promises to solve many socio-technical problems in areas such as finance, trade, ICT security, etc. further research in this area is needed. On the other hand, there is a

great lack of experts specialized in this field. Although many companies have an understanding of the potential of blockchain technology, they face a lack of appropriate experts. Even when there are attempts to introduce educational courses for this area, they are more limited to the so-called cryptocurrencies, such as Bitcoin, and less to the blockchain technology itself. And it is precisely in this technology that this potential lies, which unfortunately has not yet been sufficiently explored. On the other hand, educational courses related to blockchain technology are mostly found at the master level of education. Also, the current educational orientation when it comes to blockchain technology goes towards creating a critical mass of professionals with practical competencies for the development and implementation of products and services based on blockchain technology.

Of course, the emergence of new technologies provides space for ideas for its application in education. One of the directions in the development of education is aimed at the fastest possible transformation in terms of incorporating new knowledge into curricula. Special attention is paid to the applications of blockchain technology from the aspect of security factors of education [24].

It is interesting that the courses in which students are introduced to blockchain technology are more common in universities, which are not among the leading schools when it comes to computing. Also, blockchain-related courses are more often found in business schools than those that are technically oriented. Interestingly, many authors try to observe blockchain technology through already existing areas of computing, such as software design, algorithms and data structures, and distributed computing [25], [26].

6. CONCLUSION

The development and application of computers have created the need to train appropriate professionals. If we analyze the development of computer education more carefully, it can be noticed that it was actualized with the beginnings of the commercial application of computers. Due to that, the framework of computer education has shifted from the preparation of experts for computer design to the preparation for concrete application. The initial steps in computer education mostly were identified with the institution where it was realized.

Beginning in the 1970s, working groups formed by the ACM and CS IEEE associations presented their thoughts to the public through reports called Computing Curricula (CC). The reports were created as a result of research, which tried to determine the necessary structure and content of the curricula of basic studies in the field of computing.

With the expansion of the application of computers, it became clear that the education of computer experts cannot be realized through a single curriculum, but that it is necessary to diversify computing as a discipline into more compact units. In this way, students interested in the field of computing were offered a certain type of specialization from the very beginning of their studies. Despite the division of computing into certain areas, we must not ignore the fact that there is a smaller or higher level of overlap between them, which also has an impact on the structure of computer education. The draft of the latest CC2020 report looks at computing through seven areas: Computer Science, Computer Engineering, Software Engineering, Information Systems, Information Technology, Cybersecurity and Data Science.

In addition to the structural approach, the mentioned CC reports also provide recommendations regarding the content of the courses through which the necessary knowledge is acquired in each of the considered areas. The structure and content of the recommended curricula are defined with the aim of monitoring trends in the development of computing and appropriate education. In order to emphasize the importance of certain trends in computing, in the paper is shown the way of incorporating new technologies into educational practice on the example of blockchain.

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Analysing of Software Tools for Designing and Simulating of Digital Circuits

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Abstract: *This paper describes the results of individual and comparative analysis of three software tools for designing and simulating of digital circuits: Cedar Logic Simulator, Deeds-DcS – Digital Circuit Simulator and Proteus 8 Demonstration. As a result, we obtained certain conclusions that could help students of Electrical, Computer and Mechatronics Engineering undergraduate study programs at the Faculty of Technical Sciences Čačak, University of Kragujevac and also students from other Universities to choose the appropriate software tool for designing and simulating digital circuits. For the purpose of individual analysis of these simulators, we designed an example of digital circuit that includes two 4-bit PIPO (Parallel Input Parallel Output) registers, ALU (Arithmetic Logic Unit) and 7-segment display by each tool. The results of analysis showed that the best performance has Deeds-DcS – Digital Circuit Simulator, then Proteus 8 Demonstration and finally Cedar Logic Simulator.*

Keywords: *designing; simulating; digital circuits; analysis of simulators; CEDAR Logic Simulator*; Deeds-DcS – Digital Circuit*; Proteus 8 Demonstration*

1. INTRODUCTION

Designing, simulating and testing of digital circuits using simulation software tools is very important for students who listen to subjects such as Fundamentals of Computer Science, Digital electronics [1] and etc. Economic pressures on universities and the emergence of new technologies have spurred the creation of new systems for delivering engineering laboratories in education, in particular simulations and remote-access laboratory systems [2]. When students completed virtual labs and were then given a face-to-face practical, they performed better than those students who completed the same lab in a traditional (face-to-face) manner [3].. Therefore using these software simulators, students will gain more practical knowledge and experience of theory. The usage of different simulators can lead us to the conclusion which is the best simulator for students' education. Different software tools are used for designing and simulating of digital circuits. Some of the most common are Logisim [4], Xilinx ISE Design Suite [5], LogicWorks [6], LOGiX [7], Digital-ProfiLab [8] and many others. Measurement the advantages of using Logisim in achieving course learning objectives and outcomes as well as student satisfaction with this innovative teaching method was presented in [9]. Results confirmed that students are interested in using this software tool because of its simplicity of use, effectiveness, free availability, system independency, and its ability to check and to simulate the functionality of the designed circuit using only a hand tool. Easy usability is an important consideration especially for first-year students. Students should focus on learning contents of the courses and not to master the features of a tool [10].

In this paper, we analyzed the following tools for designing and simulation of digital circuits: Cedar Logic Simulator [11], Deeds DcS - Digital Circuit Simulator [12] and Proteus 8 Demonstration [13]. The main goal of this paper is to test these three software tools in order to determine which of these tools is the best for targeted user group (in this case students of technical faculties).

The example of digital circuit used in this paper has two 4-bit PIPO (Parallel Input Parallel Output) registers named A and B that have possibility of self-incrementing and self-decrementing. Outputs of registers are inputs of 4-bit ALU (Arithmetic Logic Unit), which was designed by 4-bit Full Adders. Outputs of ALU is 7-segment display and also C, N, Z and V indicators. Realization of this digital circuit trough mentioned simulators is excellent for student's understanding of practical application of

designing digital circuit's theory but also for tracking results of tested simulation. These understandings are very important for any future engineer.

2. DESCRIPTION OF DIGITAL CIRCUIT EXAMPLE

As we already mentioned the example of digital circuit consists of two 4-bit PIPO registers named A and B, where each of them has possibility of self-incrementing and self-decrementing. Registers A and B are implemented using 4 JK flip flops, where *i-th* inputs J_i and K_i are defined by equation (1). Signal *NOP* is defined by equation (2) and it has active value when all control signals are not active. When *NOP* signal is activated, value of state of *i-th* register Q_i will not change because $J_i = K_i = 0$ [14]. For parallel reading, the output of *i-th* register Q_i is multiplied by control signal *RD* (READ). Figure 1 presents *i-th* bit level of register A (it is the same for register B but for this register, A tags should be replaced with B tags).

ALU is designed by Full Adders and it is capable of providing 8 different binary operations (Table 1). [15]. Three control select inputs are named S_1, S_0 and C_{in}. In Table 1 Y_i is *i-th* bit of *B* input and is defined by equation (3). Indicators *C*, *N*, *Z* and *V* that describe the result of ALU's operations are defined by equation (4) [14]. Figure 2 presents *i-th* bit level of Full Adder that is used for designing of ALU.

$$\begin{aligned} J_i &= NOP \cdot 0 + LDI_i + INC \cdot C_i + DEC \cdot \mathrm{E}_i \\ K_i &= NOP \cdot 0 + LD\overline{I_i} + INC \cdot C_i + DEC \cdot \mathrm{E}_i \end{aligned} \quad (1)$$

$$\mathrm{NOP} = \overline{(\mathrm{LD} + \mathrm{INC} + \mathrm{DEC})} \quad (2)$$

Table 1. *Specification for ALU* [15]

S_1	S_0	C_{in}	Y_i	F
0	0	0	0	$F = A$
0	0	1	0	$F = A + 1$
0	1	0	*B*i	$F = A + B$
0	1	1	*B*i	$F = A + B + 1$
1	0	0	$\bar{B}$i	$F = A + \bar{B}$
1	0	1	$\bar{B}$i	$F = A + \bar{B} + 1$
1	1	0	1	$F = A - 1$
1	1	1	1	$F = A$

$$Y_i = S_0 B_i + S_1 \overline{B_i} \quad (3)$$

$$\begin{aligned} C &= C_4 \\ N &= F_3 \\ Z &= \overline{F_0 + F_1 + F_2 + F_3} \\ VADD &= A_3 B_3 \overline{F_3} + \overline{A_3} \overline{B_3} F_3 \\ VSUB &= \overline{A_3} B_3 F_3 + A_3 \overline{B_3} \overline{F_3} \end{aligned} \quad (4)$$

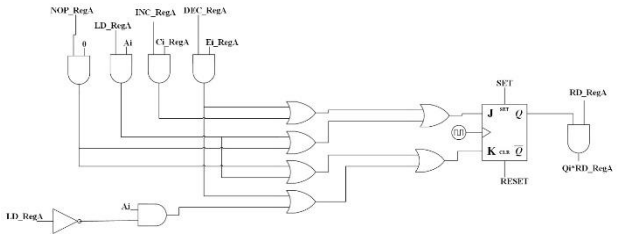

Figure 1. *I-th bit level of A register*

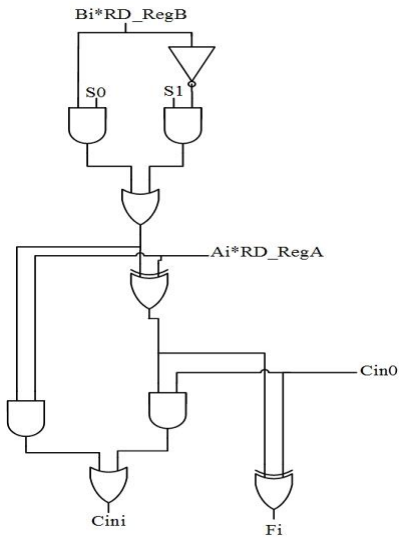

Figure 2. *I-th bit level of Full Adder*

3. CEDAR LOGIC SIMULATOR

Figure 3 presents starting window of CEDAR Logic Simulator. From figure 3 on starting window you can see:

1. Menu Bar – includes different options for saving and editing file, view settings, help and etc.;
2. Available libraries – includes different operations and settings for designing and simulating of digital circuits;
3. Toolbar – includes the most important settings from Menu Bar but also includes options for starting and stopping of simulation and also settings for managing value of Clock half period;
4. Pages – enable splitting of scheme to more than one page (page 1-10);
5. Working area – The area in which users design digital circuits;
6. Available logic elements – graphic interpretation of logic elements with multiple inputs. The usage of logic elements for designing digital circuits is done by ''drag and drop'' mechanism at working area.

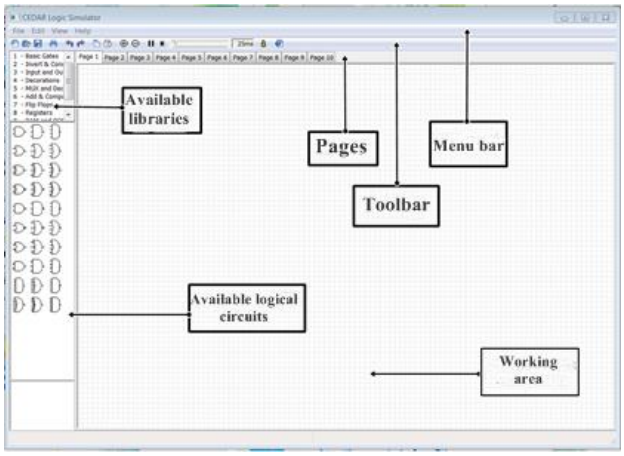

Figure 3. *Starting window of CEDAR Logic Simulator*

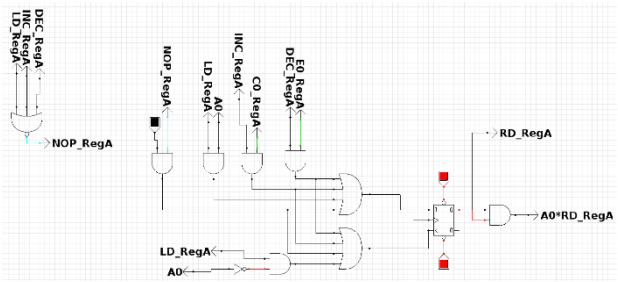

Figure 4. *Zero-bit level of register A realized in Cedar Logic Simulator*

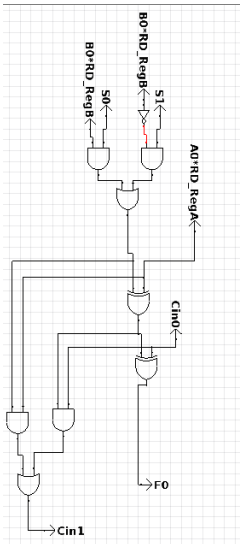

Figure 5. *Zero-bit level of Full Adder realized in Cedar Logic Simulator*

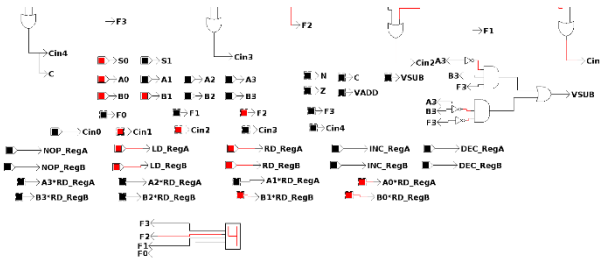

Figure 6. *Result of operation when $S_1S_0C_{in}$=010, A=0001 and B=0011 in Cedar Logic Simulator*

4. DEEDS-DcS – Digital Circuit Simulator

Figure 7 presents starting window of Deeds-DcS - Digital Circuit Simulator. From figure 7 on starting window you can see:

1. Menu Bar - includes different options for saving and editing file, view settings, simulation settings, additional tools, help and etc.;
2. Toolbars – First toolbar includes the most important options from Menu bar but also includes options for Error Check, starting simulation and option for choosing Deeds-FsM Simulator (Finite State Machine Simulator) or Deeds–Mce Simulator (Micro Computer Emulator) that are included in Deeds software package. The main features provided by the Deeds-FsM and Deeds-McE are finite state machine editor/simulator, embedded micro-computer emulator, assembler/interactive debugger module, VHDL converter and FPGA module. This toolbar also includes tools that are used for designing and simulating of digital circuits. Second toolbar includes graphics icons that enable different options (included in drop menus) which are needed for designing and simulating of digital circuits;
3. Working area – The area in which users design digital circuits;
4. Status Bar – Shows description when user's cursor crosses over some icon.

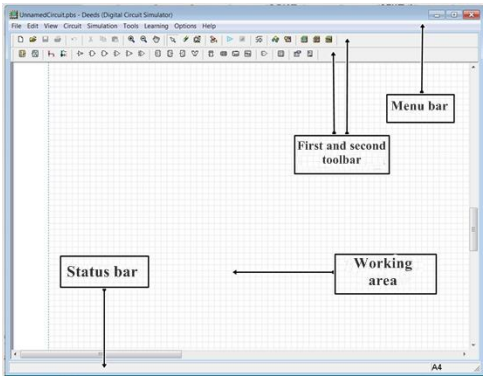

Figure 7. *Starting window of Deeds-DcS – Digital Circuit Simulator*

Figure 8 presents *i-th* bit level of register, while Figure 9 presents *i-th* bit level of Full Adder used to design scheme described in Chapter 2. In Figure 8 and 9 are presented schemes for block elements (build components that can be reused in another circuit). Figure 10 presents realized scheme for following block elements: *VADD*, *VSUB*, *Z* indicators and *NOP* signal.

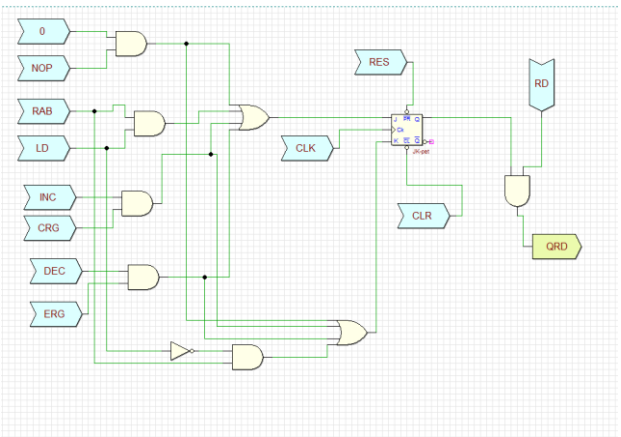

Figure 8. *I-th bit level of register realized for block element in Deeds-DcS - Digital Circuit Simulator*

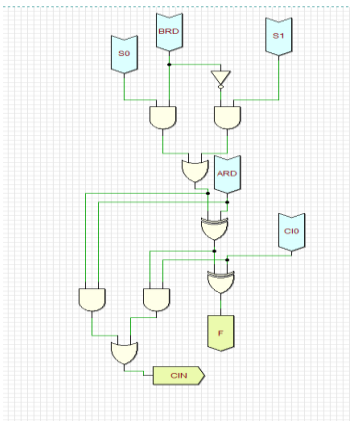

Figure 9. *I-th bit level of Full Adder realized for block element in Deeds-DcS - Digital Circuit Simulator*

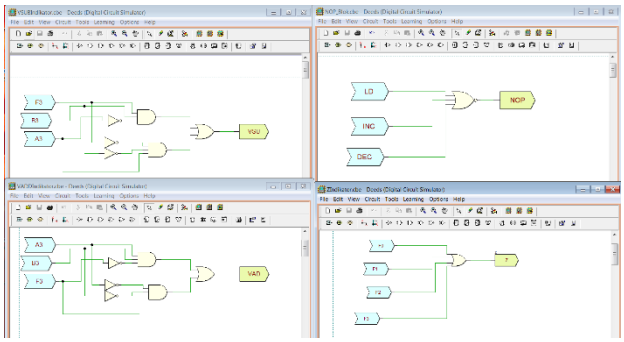

Figure 10. *VADD, VSUB, Z indicators and NOP signal realized for block element in Deeds-DcS - Digital Circuit Simulator-u*

Example of digital circuit, described in Chapter 2 is realized by block elements. Figure 11 presents one part of the realized schema, after the animation for the following control and input signals: $S_1S_0C_{in}$=010, A=0001 and B=0011 is started.

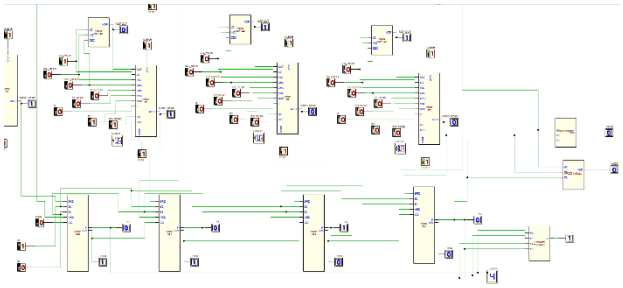

Figure 11. *One part of realized schema and started animation in Deeds-DcS - Digital Circuit Simulator-u*

5. PROTEUS 8 DEMONSTRATION

Figure 12 presents Starting window of Proteus 8 Demonstration. From figure 12 you can see:

1. Menu Bar and Toolbars – includes different options for saving and editing file, view settings, help and etc.;
2. Overview Window – enables overview of schema from bird's perspective;
3. Object selector – presents list of selected objects (components) which a user can choose for designing of schema;
4. Editing area – The area in which a user designs schema;
5. Vertical Tool Mode Toolbar – includes the most important options for designing and simulating of digital (and other) circuits.

Figure 13 presents zero-bit level of register A, while figure 14 presents zero-bit level of Full Adder realized as described in Chapter 2. Figure 15 presents result that is shown on 7-segment display for the add and increment operation, which is generated for the following values of select control and input signals: $S_1S_0C_{in}$=011, A=0001 and B=0001.

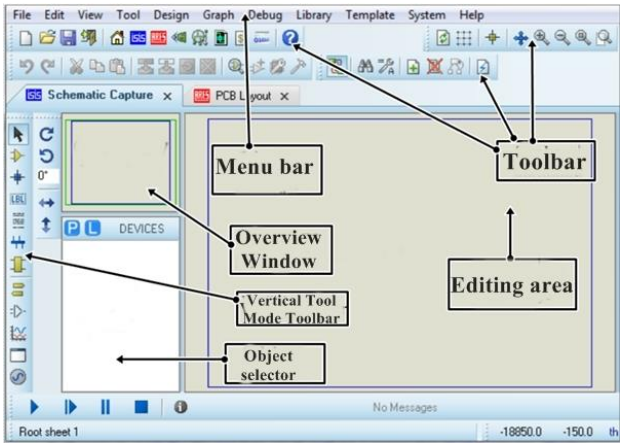

Figure 12. *Starting window of Proteus 8 Demonstration*

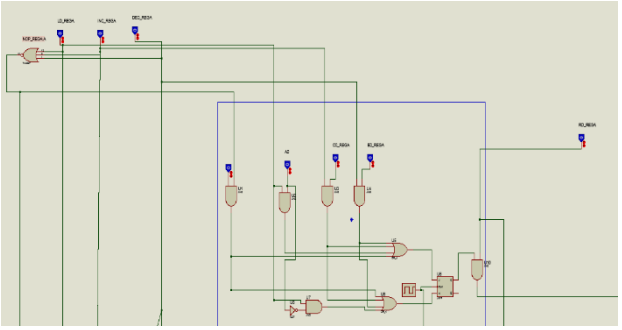

Figure 13. *Zero-bit level of register A realized in Proteus 8 Demonstration*

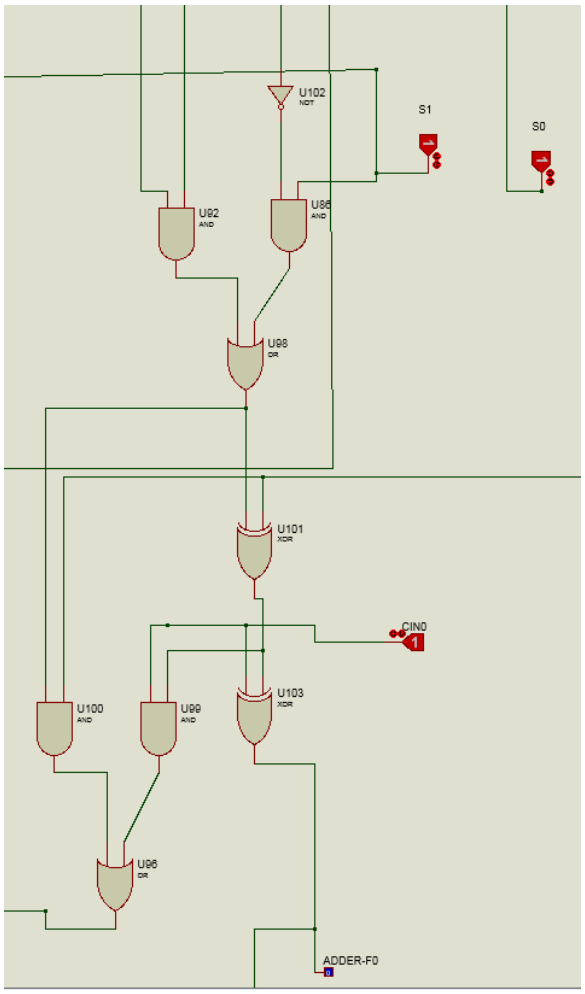

Figure 14. *Zero-bit level of Full Adder realized in Proteus 8 Demonstration*

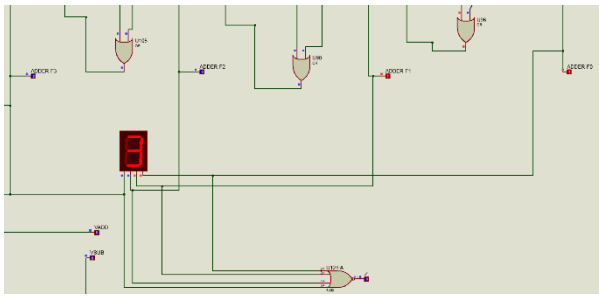

Figure 15. *Result of operation displayed on 7-segment display when* $S_1S_0C_{in}$=011, A=0001 *and* B=0001.

6. RESULTS OF ANALYSIS

This chapter describes list of advantages and disadvantages according certain parameters chosen for analysis of simulators that were described in the chapters before. These parameters are:

1. License required to use a tool;
2. The tool has all (or almost all) modules realized as one whole module;
3. Possibility of tracking input and output signals;
4. Possibility of reducing complexity of the designed scheme;
5. Documentation;
6. Additional tutorials and manuals;
7. Error detection mechanism;
8. Usage of a tool can be described as: the most simple, simple or medium easy.

Advantages of Cedar Logic Simulator:

1. It is free. That means that it does not need the license for using;
2. It has the possibility of tracking input and output signals;
3. It has the possibility of splitting schema – Which reduce complexity in designing schema;
4. It has documentation that describes basic terms for using of this tool;
5. Usage of this tool is described as the most simple.

Disadvantages of Cedar Logic Simulator:

1. It does not have all modules realized as one whole module – This simulator does not have realized T and RS flip-flop and also does not have demultiplexer which is very important disadvantage of this simulator;
2. It does not have additional tutorials and manuals;
3. It does not have mechanism for error detection.

Advantages of Deeds DcS- Digital Circuit Simulator:

1. It is free – it does not need the license for using;
2. It has all modules realized as one whole module;
3. It has the possibility of tracking input and output signals;
4. It has the possibility of hierarchical designing by creating block diagrams of the designed digital circuits. In this way it reduces complexity of the designed scheme;

5. Documentation – It has very detail documentation that describes basic terms for using of this tool and also examples;
6. It has additional tutorials and manuals- which is extremely important for users to understand how to use the tool correctly;
7. It has mechanism for error detection;
8. Usage of this tool is described as simple.

Advantages of Proteus 8 Demonstration:

1. This tool can be partly used without license. For using all features and possibilities of the tool, the license is needed;
2. Documentation – It has very detail documentation that describes basic terms for using of this tool;
3. It has additional tutorials and manuals- which is extremely important for users to understand how to use the tool correctly;
4. It has mechanism for error detection;
5. It has possibility of tracking input and output signals.

Disadvantages of Proteus 8 Demonstration:

1. It does not have all modules realized as one whole module;
2. It does not have possibility of splitting schema, Also, it is not possible to build block elements of the designed digital circuits and this lack reduces efficiency in designing of schema;
3. Usage of this tool is described as medium easy.

7. CONCLUSION

Based on the results of individual and comparative analysis of these three software tools (simulators) according chosen parameters, the most efficient tool was Deeds DcS- Digital Circuit Simulator, then Proteus 8 Demonstration and finally the least efficient was Cedar Logic Simulator. The first ranged tool has no disadvantages according chosen parameters. The second ranged tool is not completely free for students because of its great and rich library, mechanism for error detection, additional manuals and tutorials etc. Although it really deserves second place, because it is better than Cedar Logic Simulator. At the other hand it is slightly worse choice than Deeds DcS-Digital Circuit Simulator, because it is not completely free and it cannot build block elements which would help at reducing complexity of designing schemas.

Deeds DcS-Digital Circuit Simulator and Proteus 8 Demonstration are recommended to be used for students at technical colleges whose major field is either Computer or Software engineering or for the users that would like to get familiar with VHDL programming, microcontrollers etc. On the other hand, due of the absence of certain modules and its simplicity, CEDAR Logic Simulator is recommended for students of those faculties where e.g. subjects such as Fundamentals of Computer Science or Digital Electronics were an optional subject or where these teaching units were covered on a smaller scale comparing to the technical faculties.

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Information Technology Skills Level of Students at Electrical Faculty in East Sarajevo

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Abstract: *The paper investigates current status of Information Technology (IT) skills level of students studying at the Faculty of Electrical Engineering in East Sarajevo. Competitiveness on the labour market of the future engineers of the Faculty are narrowly related to their level of competences and skills in usage of modern information technologies. This paper is a research that included all students from the first to the fourth year of the study profile Computer Science and Informatics. Totally, eight areas have been identified to be of additional value for the students in the teaching process at the faculty. The focus was on the students' perception of professional IT skills that they have to possess when they start to work for a future employer. Based on the results of the research, amending of current curriculum of the profile Computer Science and Informatics at the Faculty of Electrical Engineering in East Sarajevo has been proposed.*

Keywords: *Information Technology skills; On-line survey; Electrical Faculty*

1. INTRODUCTION

What an optimal level of *Information Technology (*IT) skills of the first cycle of studies students is, so as the level of required competences to be competitive on the labour market is a question that brings a whole list of answers. One option is to say that optimal level of IT skills is that students have basic knowledge and skills in the field of IT software development or database administration. One of the answers is that systematic approach to improvement of knowledge of students is through the improvement of quality of the study programme on 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 is for the students to acquire skills and competences during their university education that will be adjusted to future EIES uttering 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". As far as students at the Faculty of Electric Engineering are concerned, it is obvious that they have knowledge related to hardware configurations and developmental software tools of the latest generation. However, the curricula must be adjusted with the accelerated technological development. Primarily, the focus should be on those developmental software tools that are in demand on the labour market in BiH, so as in other eastern European countries. 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 curricula, and has led to reengineering and improvement of education practice to meet industrial needs".

In the interest of creating knowledge-based society, it is of vital importance to plan development of IT professionals through the university curricula in a systematic and unified way in line with the world standards dictated by the

industrial needs. Engineering disciplines require balance between teaching standards and curricula, based on which students enhance their professional IT skills, and daily tasks employers expect them to be enabled to carry out when registered in the labour market as graduate 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 knowledge of 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-teaching 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". On basis of 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 experimental analysis, Zhang and Zuo in [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, students' 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 prevented from attending lectures for justified reasons.

This research aims to identify the basic needs of students and, through their recommendations that are the result of the research, to incorporate them into improved curricula in the future. Authors will identify which IT tools and skills today are most needed to be incorporated into the curriculum in the first cycle of study in the future through using of web-based distance learning platforms. These results would serve as a basis 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 programme Computing and informatics, as given in Section 3 (Table 1).

This paper is structured as follows: After Introduction, there is a discussion on optimal level of IT skills of the first cycle of studies students, so as the level of required competences to be competitive on the labour 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 curricula 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

Accordance 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". Based on the above statements, in our research in the first phase we focused on identifying the precise areas of knowledge that students have in order to make certain recommendations for the improvement of the whole system of strengthening IT skills and possible update of curriculum based on the research results.

In brief, The Faculty of Electric Engineering in East Sarajevo is the oldest high school 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 it began 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 school 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 participate in a research 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 labour market for IT staff in BiH, in order to attract as many students as possible to decide to attend 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, participants in this research 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%). As regards 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 between 18-22.

2.1. Research question

This research seeks to determinate current status of IT skills level of students. The questions in the research are divided into two groups and asked in a sequenced order. This sequence follows the programme and scientific development of a graduate IT electrical engineer and covers the areas from the use of programming languages and technologies that the student currently uses to the use of modern relational databases. Based on that, the first group of questions, the following section refers to the students' perception of what else they should learn in the faculty in order to improve their IT professional skills. Throughout our study, a quantitative method 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 analyse 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 analysing 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 version 59.0.1, Google Chrome version 69.1 and Microsoft Edge version 44.18362.449.0. All participants are executed on machines with installed Windows 10 operating system or smart devices with usage of Android or IoS operating system. A questioner is written in Google forms tools that allows on line collecting information from students.

Surveying of the students was conducted at the Electrical Faculty in East Sarajevo from 1 October 2019 to 31 December 2019. 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.

A total of 105 students from the Faculty filled in the web questionnaire and the results related to our research are as follows:

The first set of questions referred to the current level of knowledge of students when it comes to IT skills related to the knowledge of programming languages that they could learn in the educational process at the faculty.

When asked if during their ETF training they mastered the following IT skills in using programming languages and their associated tools, 105 users selected at least one or more of the answers shown in Figure 1.

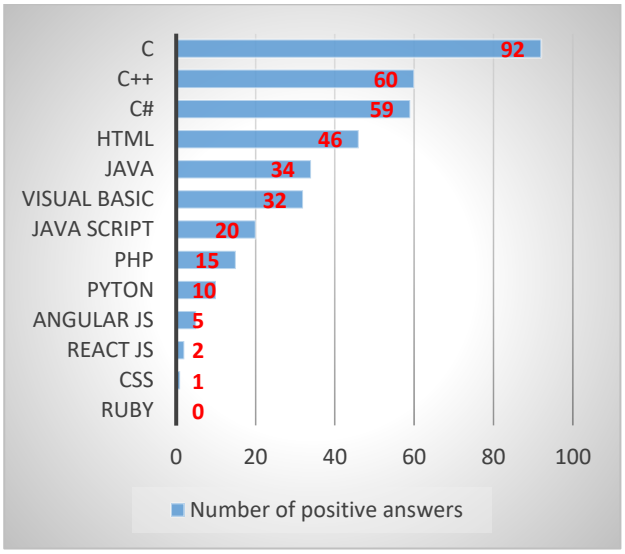

Figure 1. *Current knowledge of developer tools*

As indicated in Figure 1, the first three places took software tools related to Microsoft developer software tools as part of .NET technology. That is not surprising at all being aware that these tools are mostly used by the teaching staff at the ETF throughout the teaching process as well as during the previous education of the participants.

On the other hand, when asked about programming languages and tools they want to improve in the future, and that you have not used so far in the ETF teaching process, the participants answered as shown in Figure 2

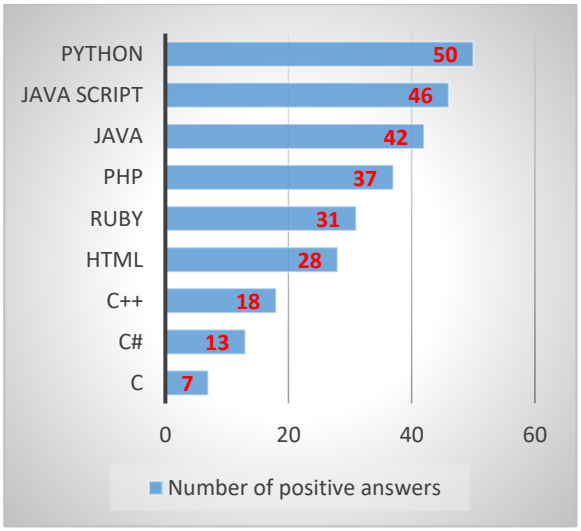

Figure 2. *Developer tools for future improvement of IT skills*

If these two Figures are compared, it is obvious that during the ETF classes, students did not acquire those IT skills they expect to be necessary in their future professional work. As indicated on Figure 2, the first three places are Python, Java Scrip and Java programming languages which are not represented in a large percentage in Figure 1, which represents the mastered IT skills of students through the teaching process at ETF. This result, which I see in Figure 2 with Python in the first place, is completely in line with Belani's claims [15], "Python is a software tool recognized by the IT community as one of the most promising IT skills of the present that an IT professional should have. ". Also Belani in [15], state that, "Python can be used for web and desktop applications, GUI-based desktop applications, machine learning, data science, and network servers". Furthermore, this programming language is supported by the IT community and offers several open-source libraries, frameworks, and modules that make application development simpler. Java as a representative (Back-end) and Java script as (Front-end) developer tools are also at the top of the respondents' priorities as software tools that are available to the IT community as open source solutions. Java for example object-oriented programming language does not require a specific hardware infrastructure, is easily manageable, and has a good level of security. Moreover, it is easier to learn Java in comparison to languages such as C and C++ whose skills participants have already mastered, as given in Figure 1, (87.6% mastered C and 57.1% mastered C++.).Therefore, participants are very familiar with the needs of the market as regards IT skills and software tools required in their future professional work, based on data that address market needs and can be accessed online and through their interaction with employers. After the first two sets of questions regarding the developer of programming languages for the development of application solutions, the third set of questions were if they have IT skills in the administration and maintenance of databases. The students also provided multiple answers to the question as shown in Figure 3.

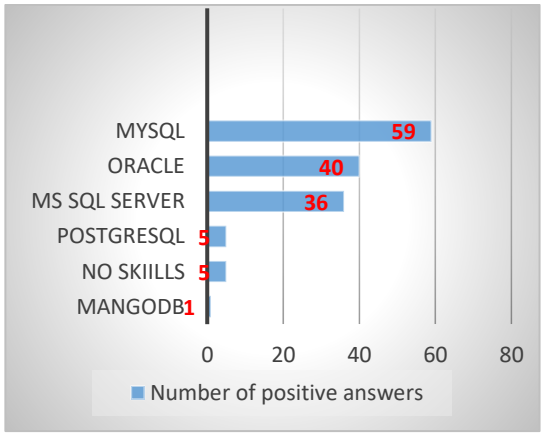

Figure 3. Display the knowledge of data base systems

This question was asked for practical reasons, because authors wanted to have an insight into this area of IT, i.e. working with databases. Knowledge of this area in synergy with previously mastered

developer tools programming languages and other IT skills makes an engineer become a full stack of a web developer. A full stack web developer is a person who can develop both client and server software. In order for an engineer to develop modules related to server software, it is mandatory to understand the mechanisms of database operation and their technical and technological abilities. Analysing the obtained answers shown in Figure 3, it is obvious that the majority of responders, namely 59 or (56.2%), have skills related to the MySQL database. It can be noted that, according to the collected results of this research, IT skills in working with other types of databases such as Oracle and MS SQL Server are at a relatively small level, namely Oracle 40 or (38.1%) and MS SQL Server 36 or (34.3%) participants. This fact leads to the conclusion that it is necessary to improve the current curriculum at the Faculty by increasing the number of subjects dealing with database systems in order to increase IT skills in this area.

Finally, after analysing the previous areas, authors came to the final question in this questionnaire, and it asks about the areas of IT professional skills which are considered to be essential in the future professional work within the next five years.

Participant responses are shown in Figure 4.

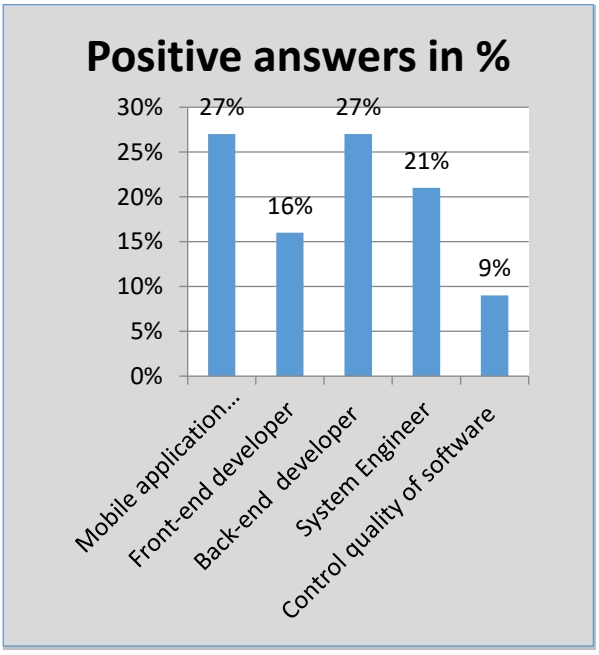

Figure 4. *IT skills perspective in next five years*

By analysing the data in Figure 4, it is visible that, according to the answer of the respondents, three areas stand out: two areas *Mobile application* and *Back-end developer* took 27% each, while *System engineer* took 21% of the overall participants. The results of the answers to this question coincide with the answers shown in Figure 2, where the participants identified *Developer tools* to be improved and incorporated in the ETF curriculum.

Through data analysis, authors were able to identify eighth (8) new areas for improvement IT skills that are presented in Table 1 as a direct result of the responses of the participants given in Figure 2,3 and 4.

Table 1. *Proposal of IT skills to be included in curricula of existing courses in ETF*

No.	IT skills	Area
1.	Working and developing practical knowledge in Python programming language	Back-end developer
2.	Working and developing practical knowledge Java Script programming language on website's user-facing code	Front-end developer
3.	Working in Java programming language	Back-end Developer
4.	Administration and maintenance of Oracle Relational Database Management System-RDBMS	Database administration-DBA
5.	Administration and maintanece of MS SQL server	Database administration-DBA
6.	Programing with Mobile application developer tools	Mobile App Developer
7.	Learning practical skills of server-side languages in area covered by Back-end technology	Back-end developer
8.	Installing, configuring, testing and maintaining operating systems, application software and system management tools	System engeneer

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 above process 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 programmes at the ETF. These eight areas should be incorporated in the curricula 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 labour 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 modern 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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Use of Merlin System and Recorded Instructions in Engine Room Simulator Training

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Abstract: *This paper presents the introduction of the e-learning in a form of use of the Merlin system and recorded materials as a response to COVID 19 lockdown into the teaching process of the course named Engine room simulator and onboard training in the final year of undergraduate study of a Marine Engineering. Merlin system was used for consultations and explanations in live sessions, while recorded materials were used by students for introduction and familiarization. Feedback of e-learning was arranged in a form of questionnaires, both for students and instructors to recheck both sides of the learning process. Over 60% of students claimed that regular classes are much easier to understand after preparation through e-learning and that introduction of the e-learning had a beneficial effect on their final course results.*

Keywords: *ER Simulator; simulations; training; Merlin; recorded materials*

1. INTRODUCTION

Engine room simulator and onboard training is a course in the final year of undergraduate study of a Marine Engineering at the Faculty of Maritime Studies of the University of Split. The course consists of two parts, ER (Engine room) simulator training and training on board the ship. The course itself follow rules and regulations set up by the IMO (International Maritime Organization) and its STCW convention (International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978) [1].

The Faculty is equipped with several Engine Room Simulators where students are simulating real machinery problems and situations. One of the simulators is Kongsberg K-SIM ERS-L11 MAN B&W-5L90MC VLCC [2] (Figures 1 and 2). Simulators serve to train students in the environment similar to the real where they can try (and often fail) to operate various machinery and learn proper procedures and behavior in various situations. According to the [2] "*the learning objective is to understand and operate the entire engine room system in a safe, timely and cost-effective manner*".

In order to be able to perform any action on the Simulator a student must be familiar with the its operation principle and the location and functioning of the associated equipment. It is the same in real life, any Marine Engineer must be familiar with layout of the ER and the machinery, and possess good knowledge about the operation principles of various ER machinery.

Figure 1. *Kongsberg Simulator Control Room*

Our marine engineering students learn machinery operation principles during numerous courses in lower years of the study. ER Simulator commands and layout of the machinery is another required condition for successful start of simulations.

Figure 2. *Kongsberg Simulator Classroom*

ER Simulator layout and commands familiarization is intended to be first lesson of the course and should be finished during first week. In reality, this task often requires more time, which takes the time intended for training of students with various real scenarios. Often students learn to operate Simulators after their regular classes in order to better familiarize with the system and its operation. COVID 19 crisis prevented those activities and forced teaching personnel and students to try and accept new training practices. Those practices aimed to reduce familiarization time and enable students to learn about simulator layout and function using remote learning, therefore reducing significantly contact time and time on the Simulator needed for the familiarization.

2. E-LEARNING

In order to diminish time needed for familiarization with the Simulator and minimize contact time, a new approach has been introduced. Although due to IMO and STCW requirements [1], students have to attend at least 95% of the simulator training exercises in person, all additional contacts are transferred to online system, creating parallel e-learning system. E-learning can be described as technology-based learning where learning materials are delivered electronically to remote learners via a computer network [3]. Introducing this new approach to the course is *"a complex phenomenon, entangled with multiple factors related to technology, the learning process, and administration"* [4] and required significant amount of time from teaching personnel as well as from students.

2.1. Recorded materials

In order to minimize contact time (during consultations and during additional learning and familiarization lessons) and to promote faster learning process all exercises were recorded, using the Simulator and a recording program named Bandicam [5]. The program allows to record computer screen and instructor voice giving all explanations in form of the AVI file (Figure 3).

Figure 3. *A screenshot of the recorded "AVI" file*

Instructors recorded 74 exercises in the AVI (Audio Video Interleave) format. Those videos show all situations which should be analyzed during the course. Apart from videos additional help was created by introducing an instruction book with explanations on the simulator and simulations, giving the instructions to questions how, when and where (Figure 4). The Instruction book strictly follows AVI files and helps students in the replication of the exercises in the same way as various checklists help on board the ship.

1.1.74 Data Sheet #74 (NOx secondary reduction)

Test Director Action	Expected Result
Load Condition: **Sea Speed**	Speed levers, instrument readings and lamp push buttons reflect the appropriate condition.
Go to MD 14, check NOx values.	As selected.
Start SCR (Data sheet #44).	As selected.
Go to MD 14, check new NOx values.	As selected.
Make a conclusion.	As selected.
Compare NOx reduction methods, advantages and shortcomings.	As selected.

Figure 4. *Excerpt from PFST Simulator Instruction Book*

2.1. Merlin

Merlin [6] is an e-learning system established, developed and maintained at the e-Learning Center of the University Computing Center of the University of Zagreb. That system is a common platform for e-learning projects in university teaching in Croatia. Its presentation tools allow placing all teaching materials in the system and making them available to students. System also facilitates communication with and among students using forum, chat or messages in the system.

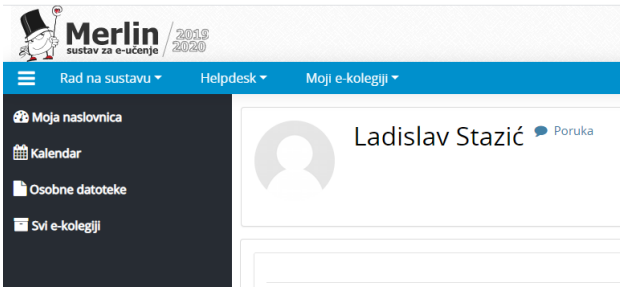

Figure 5. *Part of the Merlin Screen*

System beside presentation and communication allow supervision of the student activities, providing insight into activity of the participants during the course, what features of the system were monitored, how often, etc.

Introduction of the course, familiarization with the Simulator and consultations with the instructors were organized through this e-learning platform. Sessions were performed on regular, scheduled basis. Results of the e-learning were checked during normal (in person) classes where overall student behavior and knowledge was evaluated.

3. RESULTS

At the finish of the classes, all students and three course instructors had to fill questionnaires in regards Simulator and newly introduced additions to the learning process. Students had to fill a research questionnaire [7] (Table 1) with the intention to establish their "*view on the topics*" [8] i.e. if recorded materials and e-learning improved their understanding of the Simulator and its layout. Students had to answer the questionnaire with 0 or 1, depending weather the sentence is truth or false. On the right side of the Table there is a column with the number of students validating the sentence as truth followed with the number of all questioned students.

Table 1. *Student questionnaire and results*

Sentences	Results
I watched all Simulator AVI files.	36/38
I watched Simulator AVI files several times, repeatedly.	19/38
I attended Merlin consultations and e-lessons regularly.	26/38
I find Simulator AVI files useful tool in familiarization with the Simulator.	36/38
Watching Simulator AVI files helped me to replicate the exercises.	32/38
I was able to replicate every exercise only by watching Simulator AVI files.	4/38
E-learning and Simulator AVI files had a beneficial effect on my final course results.	23/38
Simulator AVI files must be incorporated with Merlin consultations and instructor explanation.	28/38
Regular classes are much easier to understand after preparation through Simulator AVI files and Merlin consultations.	26/38

From the Table 1 it is visible that 94.7% of students claimed that watched all recorded AVI files. All those students claimed that AVI files helped them in the familiarization with the Simulator. Answers on other questions are variating, but majority of answers were beneficial towards use of the recorded materials during e-learning process.

Smaller questionnaire was created for instructors, requiring their opinion on the use of the AVI files and results that e-learning produced. Intention of this was to determine instructors' opinion on e-learning effects, and to recheck students' results and to obtain another view on the same issue.

Table 2. *Instructor questionnaire and results*

Sentences	Results
This student watched Simulator AVI files and learned about the system before exercises on the simulator the system.	20/38
Student was capable to perform the exercise alone, without your help.	5/38

Instructors identified just 52.6% of students where they were certain that they used AVI files and only small fraction of students which were able to perform exercise without help from instructors.

4. DISCUSSION

Results of the questionnaires are bringing forward several results. One result is that although almost all students claimed active participation and watching of AVI files, instructors were able to detect only about half of students which showed decent knowledge about Simulator to verify students claim. Percentage of students where instructors detected knowledge about the simulator coincide closely with the number of students who claimed that they watched AVI files several times, repeatedly. Therefore, the impression is that significant number of students on this question exaggerated their activity with AVI files.

Another result which questionnaires showed is that 10% of students thought that, after watching recorded lessons, they were capable of performing the exercise without instructor assistance. That result was confirmed by instructors, according their opinion that percentage was slightly higher (13%).

Overall findings are that the majority of over 70% of students claimed benefits of this addition to the regular teaching, at the same time more than 60% of them are thinking that this approach had beneficial effect on their final course results.

5. CONCLUSION

COVID 19 crisis brought new developments into ER Simulator teaching process where the course remote sessions are introduced for consultations together with possibility to download and play all lessons in advance. Recorded lessons, in form of AVI files, accelerated ER Simulator familiarization, thus improving and simplifying learning process. Feedback of students after finishing the course was wholly positive, majority of students found introduced changes as a big step in the right direction, with 10% of students finding that this new approach enabled them to finish the course without any additional lessons or help.

Another interesting issue brought forward is not connected to questionnaires. Students showed much higher interest in the on-line consultations, which were attended much more than normal consultations in instructors' office. This was caused because students had their instructors available "nearby, only one click away".

All listed results are just beginning of the monitoring of the effects of e-learning process and connected recorded lessons on overall knowledge and behavior of students and instructors. As all changes are fresh, prepared and introduced in last few months, there should be significant improvements in the quality and quantity in the future. Considering future improvements, it is expected that next monitoring results will show that more students marked as true the answer "*E-learning and Simulator AVI files had a beneficial effect on my final course results"*

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Implementation of GNU Octave in a University Course of General Physics

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Abstract: *This paper presents some examples of the implementation of an open-source software GNU Octave, within a General Physics undergraduate course. The examples refer to writing a program in a Script Editor for cases that include: 1) solving equations* symbolically *for a two-body or a multi-body system, 2) different ways of restriction of a tabular and graphical display of obtained results to the ones that are physically logical for a given problem and 3) creation of animations which describe certain physical phenomena and processes. The coding was directed to prompt the user for specified values of various input parameters, after running the script, in order to interactively reach conclusions concerning the investigated physical dependences. The presented examples can be a good basis for the creation of small applets in the field of General Physics. Such an application of programming in the field of General Physics and other fundamental educational areas at technical faculties are an excellent pedagogical tool, enabling a better understanding of both the programming process and the phenomena in specific physical and technical fields.*

Keywords: *Octave; m-file*; *animation; function file; physics*

1. INTRODUCTION

GNU Octave software is a multifunctional computer tool featuring as a higher-level programming language for data processing in the form of matrices. Its mathematically-oriented syntax is good enough for the development of algorithms relevant for machine learning [1], yet sufficiently intuitive to be easily mastered. The mentioned software also contains convenient tools for data visualization (graphical and tabular display of results), with the possibility of further upgrades and build-in functionalities to adjust the effects for visualization and animation. Octave belongs to the open-source software, within the GNU project and it can be run on different operating systems such as Microsoft Windows, Linux, macOS, or BSD. The possibilities that it offers, especially with a number of additional packages from the entire Octave Forge collection (e.g.: Symbolic Package, I/O package, etc.) which are available on the Internet, make it quite comparable to certain commercially popular computer tools, in view of software content and quality. Therefore, Octave is one of the major free alternatives to software packages such as MATLAB, and in some segments even to software such as Scilab, Origin or FreeMat [2-5]. Octave GUI (Graphical User Interface) is developed to have a working environment analogous to the one in the MATLAB software package [1-7]. Despite the various tutorials related to Octave software [1-5], there is a lack of tutorials in which specific problems in the field of general physics are presented as examples. Therefore, having in mind the importance of correlation of teaching in informatics fields with specific examples from natural and technical subjects, not only in the higher years of undergraduate studies, but also within general basics in the first year of studies, some applications of the software GNU Octave that are related to examples in general physics are considered in this paper.

2. MAIN PRINCIPLES OF GNU OCTAVE

GNU Octave offers two basic modes of work. In the first mode, one can keep entering commands in the Command Window and Octave executes them immediately. In the second mode one can write series of commands and statements in the Editor Window and save them into a script file (a so-called m-file, due to the .m extension), executing the file later as a complete unit, which also includes writing functions and calling them. The basic data type in Octave is a matrix, which general format can be expressed as (mxn), where *m* is the number of rows and *n* is the number of columns of the matrix. All elementary operations are defined to support working with matrices. Vectors and matrices are used to store sets of values, all of which are the same type. Since defining vectors in Octave software involves creating one-dimensional arrays of *n* numbers ((1×n) or (n×1) matrices), an ordered one-dimensional array of possible (given)

values of any physical quantity can be considered in the Octave as a vector (row or a column vector), regardless of whether the given physical quantity is classified as a scalar (e.g.: time, coordinate, angle, energy, etc.) or as a vector physical quantity (e.g.: speed, acceleration, force, etc.). Appart from regular matrix algebra, where matrices should be conformable for a certain operation (e.g. for multiplication, division, or squaring) within the mathematical expression in the code, performing of element-by-element operations on matrices is possible, too. The matrix syntax, lists of basic arithmetic and relational operators, lists of special characters, special variables and constants, as well as the list of most built-in functions, are the same or very similar as in the MATLAB software package [1-7]. The same observation can be made for the typical decision making structures (including *if*, *else* and *elseif* commands) and various repetition control structures such as loop statements (e.g. *for* loop, or *while* loop) for managing the process of executing some part of a script file [1,6]. Regarding solving a system of equations symbolically, the shortest method, which usually gives the most simplified expressions as solutions, involves the use of the *solve* command. It implies the prior application of the *syms* function for the definition of a set of symbolic variables. The commands for differentiation with respect to a particular variable, as well as for performing integration, are of the same form within the Octave software and in MATLAB [1,6]. However, unlike MATLAB where the short command *table* provides an easy tabular display of results (e.g. values of directly and indirectly measured quantities), in Octave such a formatted display of results is possible only by applying several other (more complicated) methods, including the use of a couple of *fprintf* statements [1,6]. The function *fprintf* can also be used to save data from the created table, in the form of a *txt* file. Although most of the commands for plotting 2D/3D graphs and subgraphs, are the same in both mentioned software packages, there are still some differences. One of the advantages of Octave is that in one call of the *plot* command (in one command line) a significantly larger number of variables can be specified than in MATLAB, including a number of parameters for setting colors and other properties of lines and points on the graph. However, in MATLAB the additional so-called *set* commands may be necessary for a more detailed specification of the mentioned graph properties (e.g. for the linewidth, etc.). On the other hand, one of the shortcomings of the Octave software is the lack of an appropriate solution for adjusting an angle of axis labels on graphs, as well as the lack of an adequate solution for updating ("refreshing") a legend on the same graph after several consecutive runs of the given script file with changed input data. Commands for printing text on a graph, either by specifying coordinates for text positioning (via the *text* command), or by using the keyboard (via the *gtext* command and via clicking on the chosen spot in the created Figure), are completely analogous in both Octave and MATLAB and can be modified in order to "refresh" the text record on the graph, for each entering of new values for certain input variables [1,6].

3. METHODS

Octave version 5.1.0 and the Octave Symbolic Package 2.8.0 (Octave-forge-symbolic 2.8.0) were used to create examples in this paper [1]. The symbolic package was necessary for finding the general form of solutions for a system of equations (symbolic solutions). The command *solve* was used for these purposes. Two methods were used to define scalar variables. The first method involved application of an assignment operator (operator =) and an assignment statement, which defines a scalar variable as: a numeric value, a string (a separate sequence of characters placed between single quotes), a mathematical expression, or a function (e.g. by calling a specific function file). The second way refers to setting the input scalar variables via the command: *input*( ), where the appropriate string should be written in parentheses, inviting (prompting) the user to enter the value of a given variable after starting the execution of a written set of commands (after the *RUN* command). This value can generally be not only a numerical value, but also a certain mathematical expression, or a string which indicates the color, linestyle or marker on the graph, etc. Some independent variables were defined as a range of a values, i.e. as row vectors with equidistant elements (equally spaced elements), in cases when it was of interest to consider the output values of a dependent variable for a whole range of values of a given input variable. To define a vector with equally spaced elements the colon operator was mostly used to iterate through these values (e.g. t=first element: increment: last element), but the *linspace* function (t=linspace(first element, last element, number of elements)) was applied as well. Depending on the type of different input variables, operations on individual elements of given vectors (matrices) were used (when it was necessary) for the calculation of dependent variables, which mainly referred to the usage of operators such as:. *, or ./, or. ^. For the purpose of tabular presentation of results, formatting was performed using a specific block of *fprintf* functions. Within this, the visual appearance of the table was adjusted using the command '\t to separate the columns and the command \n' (new-line character) to display the following text in a new row. The formatting also included setting the name of the table and columns, as well as setting the number of potential digits and the number of decimals (using commands of the

form % 7.4f or% 6.3f, etc., where the mark *f* refers to the floats type of placeholder, the number after the dot refers to the number of decimals, and the number in front of the dot refers to the so-called field width i.e. to the number of potential digit places to be used in printing the results). Additional commands for writing tabular data to a txt file were also applied. For graphical representation of certain physical dependencies, the commands *plot* and *plot3* were used, with or without commands for subgraphs, depending on the needs in the considered task. The appearance of lines and points on the graph, the labels and other properties of the axes, as well as appearance of the text on the graph, were adjusted to spruce up the graph. Limiting the graphs in order to display only those values that have a physical meaning, as well as achieving an animation effect, was done in several ways, which is shown and discussed in the third section. The usage of *text* and *gtext* commands instead of the classic *legend* command, especially for the purpose of comparing multiple curves (lines and/or points) on the same graph, where the curves are obtained for different input values, is also discussed in the next section.

4. RESULTS

4.1. Example 1

The system shown in Figure 1a has been considered as a first example. The following assumptions were made: a friction between the body 1 and an inclined plane is present, the masses of the pulley and the thread are negligible, the thread is inextensible and the friction in the pulley is absent. Creation of a script file for this example has involved writing a multi-part script. The first part of the script has covered solving of the equation system, obtained by the application of Newton's second law in the direction of the system acceleration and in the direction perpendicular to it, for each of the two bodies in the system. Solving the problem assumed obtaining the solution algebraically, i.e. in symbolic form, for acceleration and tension in the thread, for the case of the direction of motion indicated in Fig. 1a. The intention was to present the solution in two forms: first, in unicode form, that looks like a usual handwritten equation, and second, in flat form, suitable for further use in calculations of actual numerical values in the Editor. The second part of the script was aimed at: a) calculation of the numeric values of the acceleration and thread tension, for certain values of independent variables, b) presentation of the results in a formatted table in the Command Window, and c) setting a condition that enables the occurrence of a special warning in the case of obtaining negative values of any elements of the row vector assigned to acceleration. The last mentioned fact implies that if any element of the acceleration row vector is negative, the notification that only positive values of accelerations have a physical meaning for the assumed direction of motion of the system, should appear in the Command Window. To achieve that goal, first, certain fixed numerical values were assigned to gravitational acceleration, the mass of the body 1 and the dynamic coefficient of friction, i.e. those variables were defined as scalars in Octave script. The angle of an inclined plane was defined within the certain range in degrees, as a row vector in Octave script, while the so-called *input* function was used to define the value of mass m_2 in kilograms. The third part of the script-file was related to the creation of a 2D graph, with two subgraphs, which presented the dependence of system acceleration and thread tension on the angle of the inclined plane, but only for those elements of the row vectors that corresponded to non-negative (≥0) elements of the row vector assigned to acceleration. Along with that, the intention was to prompt the user for an input of arbitrary color, linestyle and marker on the graphs after running the script, as well as to enable display of information about the new input values of m_2, on each subgraph. Instead of the *legend* function, which is not appropriately editable in Octave software on the same graph, in the case of multiple execution of a script file, an editable *text* command has been chosen, which enabled display of the newly entered value of variable m_2 (via *input* function) on a graph, in the selected (entered) marker color. Additionally, standard font size adjustments for tick labels, axes labels and subgraph titles, as well as adjustments of grid line appearance and *x*-axis range, in accordance with the specified range of angles of an inclined plane, were done. Fig. 2 shows a script that meets the above requirements. In order to enhance the visibility and the comprehensiveness of the commands, the colors in the displayed script are set according to the typical colors of MATLAB script. For the sake of simplicity of writing marks within the script, the sign *k* was used for the dynamic coefficient of friction in the script, while the usual symbol μ was entered only in the graph title. For the purpose of comparing the results obtained for different values of m_2, after repeated running of the script, the commands were adjusted to allow drawing of a new curve on the same graph for each new execution of the script file, i.e. for each change in the value m_2 defined via the *input* function. A rather complex form was chosen for the title of the graph, in order to demonstrate the possibilities to write the title in two lines. Fig. 1b shows graphs derived from the above script, for two different

inputs of the m_2 value.

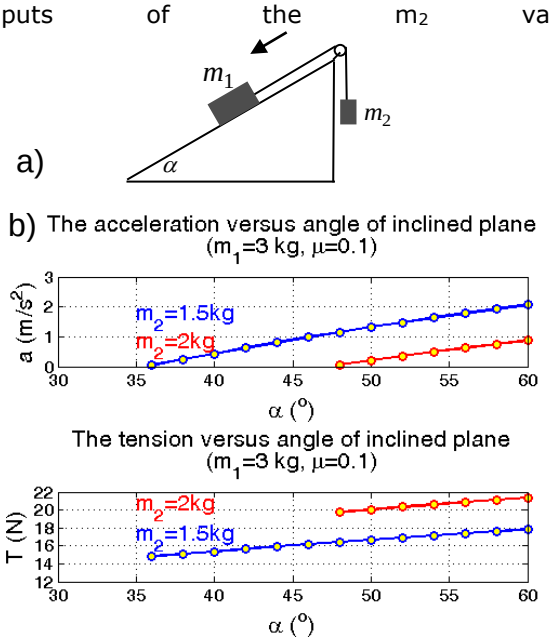

Figure 1. *a) Two-body system on an inclined plane; b) Two subgraphs which present the acceleration and the tensile force versus angle of inclined plane, respectively, for two inputs of the m_2 value.*

Since separation of the obtained results into those that are physically logical and those that are illogical is important from the aspect of application in physics, special attention has been paid to the various forms of conditioning within the script that enable display only of physically logical results for the assumed movement direction of the system. For that reason, several ways of the mentioned conditioning have been considered in this example. For instance, it can be noticed that instead of the conditionality defined by the underlined commands in the script in Fig. 2, usage of the following commands was also possible, in order to achieve the same effect:

alpha(a<0)=[ ]; T(a<0)=[ ]; a(a<0)=[ ]; (1)

If the mentioned conditioning (presented in the first or second form) were stated in front of the block of fprintf commands for tabular formatting, only the values corresponding to the non-negative acceleration elements (a≥0) would be seen in the table.

In order to obtain a graph only with dots, but in animated presentation, several changes in the script in Fig. 2 should be made. Namely:

- specification of the linestyle and linewidth would not be needed in the *input* command "UserLMC" and in the *plot* command, respectively;

- in front of the commands for the first subgraph, opening of the *for* loop should be performed, i.e.

```
disp 'PART 1 - Solving a system of equations symbolically'
y='a (acceleration (m/s^2))',    z='T (tension (N))'
syms g m1 m2 k alpha y z,      sympref display unicode
[y,z]=solve(m1*y==m1*g*sin(alpha)-k*m1*g*cos(alpha)-z,m2*y==z-m2*g,y,z)
sympref display flat,   y,z
disp ''PART 2 – Obtaining the values of acceleration and tension, for the given independent \
variables; formatted presentation of the results within the table in the Command Window ''
g=9.81,   m1=3
m2=input('Enter a value of m2 in the range from 1 to 2 kg: m2=   ')
k=0.1,    alpha=30:2:60;
disp 'The masses are in (kg), the acceleration is in (m/s^2), the angle is in degrees.'
a=g*(m1*(sind(alpha)-k*cosd(alpha))-m2)/(m1+m2);
T=g*m1*m2*(1-k*cosd(alpha)+sind(alpha))/(m1+m2);
fprintf('\tResults\n')
fprintf('\tAlpha (degree)\t\tAcceleration (m/s^2)\tTension (N)\n')
fprintf('\t%6.3f\t\t\t%6.3f \t\t\t %6.3f\n',[alpha;a;T])
if any(a(:)<0)     % if any(a(1,:)<0)
disp 'Only the obtained positive acceleration values are acceptable for the assumed motion direction!'
end
disp 'PART 3 – Creating a graph'
UserLMC=input('Enter a mark for the color, marker and linestyle on the graph:  ')
UserTC= input('Enter a text color label on the graph, the same as for the marker color: ')
alpha(a<0)=NaN;     a(a<0)=NaN;     T(a<0)=NaN;
subplot(211)
plot(alpha,a,UserLMC, 'linewidth',1.5,'markerfacecolor','y')
set (gca,'fontsize',14),    xlabel('\alpha (^o)','fontsize',18),    ylabel('a (m/s^2)','fontsize',18)
title({'The acceleration versus angle of an incline','(m_1=3 kg, \mu=0.1)'},'fontsize',16)
grid on,     xlim([30 60]),      hold on
text(35,0.8*max(a),['m_2=' num2str(m2)  'kg'], 'color',UserTC,'fontsize',18)
subplot(212)
plot(alpha,T,UserLMC, 'linewidth',1.5,'markerfacecolor','y')
set (gca,'fontsize',14),     xlabel('\alpha (^o)','fontsize',18),       ylabel('T (N)','fontsize',18)
title({'The tension versus angle of inclined plane','(m_1=3 kg, \mu=0.1)'},'fontsize',16)
grid on,    xlim([30 60]),       hold on
text(35,0.9*max(T),['m_2=' num2str(m2)  'kg'], 'color',UserTC,'fontsize',18)
```

Figure 2. *Part of the script file for example* 1

the following command should be entered: for i = 1: length (alpha)

- at the end of the script for the second subgraph, the so-called *pause* command that specifies the time interval between drawing adjacent points should be entered, as well as the command for closing the *for* loop;

- the plot command for the first subgraph should be changed in order to display: alpha (i) and a (i) (instead of alpha and a) and the analogue modification should be entered in the *plot* command for the second subgraph.

To avoid slowing down the animation, both text commands should be placed after closing the *for* loop. It would also be convenient to use the simplest forms of titles of the subgraphs, or to omit titles. It should be noted that instead of conditioning that are presented by the underlined commands in Fig. 2, or by the commands marked as equation (1), additional alternatives are possible. Namely, the analogous restriction could also be achieved through the *for* loop if the commands shown in Figs. 3a and 3b are used in front of the *subplot* commands. This would also imply the application of marks alpha(i), a(i) and T(i) within the further commands for plotting, as well as closing of the entire block for drawing of graphs via a double command *end* (or via *endif*, *endfor* commands).

a)
```
for i=1:length(alpha),  if a(i)>=0
```

b)
```
for i=1:length(alpha),   if a(i)<0
a(i) = NaN;  T(i)=NaN;   else
```

Figure 3. *The alternative parts of the script*

4.2. Example 2

Example 2a

In the second example, a 3D animation of a projectile motion trajectory (with no air resistance) in the Cartesian coordinate system (DCS) has been considered, where the projectile was launched at an angle θ from the origin of the coordinate system and motion was performed in the x-z plane. The intention was: 1) to prompt the user to enter the values for the initial velocity (in m/s) and for the launch angle θ (in degrees) within the limited range ($0<\theta<90$), as well as 2) to enable a tabular display of results in the form of a txt file and 3) to create an animated graph (Fig. 5a). In order to visually compare the results obtained for different values of υ_0 and θ, the commands that allow drawing of a new animation on the same graph for each running of the script, were included as well. The function *input*( ) was also used for choosing a marker color, marker symbol and marker size on the graph. The *rotate3d on* command was applied to enable manual rotation of a graph, in order to achieve different observation perspectives. Instead of the *legend* function, an editable *text* command was used to enable the appearance of labels of the input arguments on the graph in the selected marker color and to show "refreshed" values of the initial velocity and angle θ (entered after each running the script). The upper limit for the uniform row vector that defined time values, was set to the time of flight, according to the relevant equation. Saving a created graph, as an image in tiff or gif format, was also planned. Fig. 4 shows one of the forms of the relevant script.

```
g=9.81;  x0=0;  z0=0;
v0=input('Enter a value for initial velocity in the range 2-5 m/s:  ')
theta=input("Enter a launch angle of a projectile \
in the range from 30 to 60 degrees:   ")
tR=2*v0*sind(theta)/g;   % time of the flight
t=0:0.01:tR;

v0x=v0*cosd(theta);   v0z=v0*sind(theta);
x=x0+v0x*t;      z=z0+v0z*t-(1/2)*g*t.^2;      y=0;
UserMC=input("Enter a mark for the marker color  \
and marker type on the graph:   ")
UserMS=input('Enter a mark for the marker size on the graph:    ')
UserTC=input ("Enter a mark for the color of the text on the graph,\
the same as the marker color:  ")

file1 = fopen('Results.txt', 'w');
fprintf (file1,'\tResults:\n');
fprintf (file1,'\tTime\t\tx coordinate\tz coordinate\n');
fprintf (file1,'\t%6.3f \t\t%6.3f\t\t%6.3f\n', [t; x; z]);
fclose (file1);

for i=1:length(t)
plot3 (x(i),0,z(i), UserMC, 'markersize',UserMS),       hold on,
if i==1
set (gca,'fontsize',12),     xlabel ('x coordinate [m]', 'fontsize',14)
ylabel ('y coordinate [m]', 'fontsize',14)
zlabel ('z coordinate [m]', 'fontsize',14)
title ('3D animation of a projectile motion trajectory', 'fontsize',16)
grid on,     ylim([-1 1])
text (0.01,0.7,max(z),['v_0='num2str(v0)'m/s,\theta='num2str(theta)'^o'],
'color',UserTC)
end
pause(0.01),   end
rotate3d on,        print(figure(1), 'Figure_projectile motion.tiff')
```

Figure 4. *The script file for example* 2a

Example 2b

The case of simultaneous movement of two projectiles is more interesting than the previous one. In this case, the trajectory of each projectile is shown as an animated line, in the color picked for the projectile (Fig. 5b). The movement of projectiles starts at the same time, but the time of flight is different, due to the different initial arguments (initial velocity and launch angle) which can be entered by the user after running the script. The scaling of coordinate axes remains fixed during the animation. An editable *text* command was used in the same way as presented in a previous example. This example implies the usage of the majority of commands presented in Fig. 4, but individually for each of the 2 projectiles. However, it is necessary to introduce numerous new commands as well. For instance, in order to achieve the effect of animated drawing of a line, it is necessary to define a row vector assigned to the *y* coordinate of each projectile (zero vector, of the same length as vectors t and z). Since row vectors t_1 and t_2 are generally not of the same length, and since it is not possible to know in advance which length will be the longer one, the iteration from 1 to n1=min([length(t1); length(t2)]), and subsequent iteration from n1 to n2=max([length(t1); length(t2)]), within the one

unified *for* loop (by application of *if* and *elseif* - content of *h=plot3*( ) command in front of the first

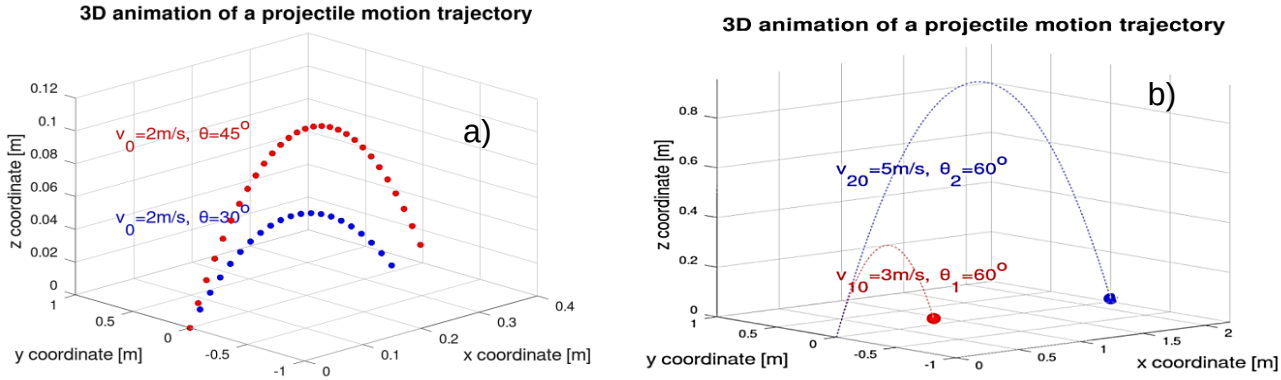

Figure 5. *Presentation of two approaches (a and b) to 3D animation of projectile motion trajectory. The left graph (a) results from the two subsequent runns of the same code. The right graph results from the one single running of the more complex code. On both graphs different colors correspond to different sets of initial arguments (v_0 and θ).*

```
UserC1=input ('Enter a mark for the color of the first projectile on the graph:   ')
UserC2=input ('Enter a mark for the color of the second projectile on the graph:   ')
n1=min([length(t1); length(t2)]);    n2=max([length(t1); length(t2)]);
x_low=min([x1(:); x2(:)]);       x_high=max([x1(:); x2(:)]);
z_low=min([z1(:); z2(:)]);        z_high=max([z1(:); z2(:)]);
figure
h=plot3(x1(1),y1(1),z1(1),UserC1,x1(1),y1(1),z1(1),'o',x2(1),y2(1),z2(1),UserC2,x2(1),y2(1),z2(1),'o');
set (gca,'fontsize',12),     xabel('x coordinate [m]','fontsize',14),      ylabel('y coordinate [m]','fontsize',14),
zlabel ('z coordinate [m]','fontsize',14),  title ('3D animation of a projectile motion trajectory','fontsize',16),   grid
on,    axis([x_low x_high -1 1 z_low z_high]);      hold on
for i=1:n1;
set(h(1), 'xdata',x1(1:i), 'ydata',y1(1:i), 'zdata',z1(1:i),'linestyle','--')
set(h(2), 'xdata',x1(i), 'ydata',y1(i), 'zdata',z1(i),'color', UserC1,'MarkerFaceColor',UserC1,'markersize',12)
set(h(3),'xdata',x2(1:i),'ydata',y2(1:i),'zdata',z2(1:i),'linestyle','--')
set(h(4), 'xdata',x2(i), 'ydata',y2(i), 'zdata',z2(i),'color', UserC2,'MarkerFaceColor',UserC2,'markersize',12)
pause (0.01),    end
for i=n1+1:n2;
set(h(3),'xdata',x2(1:i),'ydata',y2(1:i),'zdata',z2(1:i),'linestyle','--')
set(h(4),'xdata',x2(i),'ydata',y2(i),'zdata',z2(i),'color',UserC2,'MarkerFaceColor',UserC2,'markersize',12)
pause (0.01),    end
```

Figure 6. *Part of the script file for example* 2b

commands, which is not presented here) or within the two separated *for* loops (Fig. 6), can be a good solution for the achievement of the required animation on the 3D graph. After the last command in Fig. 6, commands for writing text on a graph (instead of a legend) would follow, accompanied with commands for manual rotation of a graph, for saving a graph as an image, etc.

In the commands related to animation of a graph in example 2b (Fig. 5b), it is especially important to pay attention to:

- the fact that writing a function handle for a plot function, as well as the adjusting of graph axes and title out of the *for* loop (in front of the loop), enables higher speed of the animation;

- the way of achieving fixed scaling on the axes during the animation, because this must provide visibility of simultaneous drawing of two trajectories on the same graph, where the range and maximum height of the projectile depend on the value of the initial velocity and launch angle at each new running the script;

for loop, and the way of adjusting this command through the loops.

Such a combination of commands enables that during the flight of the first projectile simultaneous drawing of the animated trajectories of both projectiles could be seen, while further animation implies continued drawing of the second projectile trajectory with the retained appearance of the trajectory of the first projectile.

4.3. Example 3

Example 3 refers to the creation and application (calling) of a function file, in tasks where projectile motion is considered. An example of a functional m-file that should enable calculation of the projectile horizontal range in an arbitrary task (for the launch from the origin of the coordinate system) is presented in Fig. 7. The chosen function name and the function file name is: f_Range_ProjectileMotion. The input variables in this function are the initial velocity, the angle of ejection in degrees and the gravitational acceleration. After calling this function in the

arbitrary script file (via the command: xR=f_Range_ProjectileMotion(v0,theta,g)), the function accepts specific numerical values related to its input variables (given in the form of scalars or vectors), processes them and generates numeric values of the projectile range.

```
function
xR=f_Range_ProjectileMotion(v0,theta,g)
xR=(sind(2*theta).*v0.^2)/g;
end
```

Figure 7. *Part of the script*

Thus, if in an arbitrary task the launch angle is given as a row vector, while the value of the initial velocity is defined via the *input* function, the commands shown in Fig. 8 could be used to determine the launch angle at which the projectile reaches the maximum range.

```
xRmax=max(xR);   for i=1:length(xR),
if  xR(i)==max(xR)
theta_xRmax=theta(i);   end,   end
```

Figure 8. *Part of the script*

The function analogue to the one presented in Fig. 7 (with the same input variables) can be written for the time of flight as well, where the body of the function would be defined via the time of flight equation.

```
tf=input('Enter an integer value of the upper limit of the time interval, in the range 7 - 10 s: tf=  ')
t=0:0.1:tf;
tB=tf/2    % the same as: tB=max(t)/2
th=0:0.1:tB;    n=length(th)
a=input('Enter an acceleration value in the range from 0.4 to 2 m/s^2: a=  ')
% The following equations can be applied to the motion in the first half of total time
 v=a*t;       x=a*(t.^2)/2;       y=zeros(1,length(t));
 xB=a*(tB.^2)/2;     vB=a*tB;
 a1=a*ones(1,length(th));   a2=-1*a*ones(length(th),length(t));
      figure
      subplot(211)
      h1=plot(t(1),v(1),'b-',t(1),v(1),'c-');
      set(gca,'fontsize',14),        xlabel('time (s)','fontsize',18),      ylabel('velocity (m/s)','fontsize',18)
      xlim([0  tf])   % or xlim([0 max(t)])
      ylim([0  1.5*vB])
      line('xdata',[tB,tB],'ydata',[0,1.5*vB],'linestyle','--','linewidth',1)
      grid on,      hold on

      subplot(212)
      h2=plot(t(1),a1(1),'b-', t(1),a2(1),'c-');
      set(gca,'fontsize',14),                                xlabel('time (s)','fontsize',18),
      ylabel('acceleration (m/s^2)','fontsize',18),          xlim([0   tf]),    ylim([-2*a  2*a])
      line('xdata',[0,tf],'ydata',[0,0],'linewidth',1)
      line('xdata',[tB,tB],'ydata',[ -2*a,2*a],'linestyle','--','linewidth',1)
      grid on,      hold on
disp 'Select a point for the tB label on the first subplot, using a keyboard'
for i=1:n
set(h1(1),'xdata',t(1:i),'ydata',v(1:i),'linewidth',3)
set(h2(1),'xdata',t(1:i),'ydata',a1(1:i),'linewidth',3)
pause(0.01),    end
% The following equations can be applied to the motion in the second half of total time
v=vB-a*(t-tB);       x=xB+vB*(t-tB)-a*((t-tB).^2)/2;  y=zeros(1,length(t));
for i=n:length(t)
   set(h1(2),'xdata', t(n:i),'ydata', v(n:i),'linewidth',3)
   set(h2(2),'xdata',t(n:i),'ydata',a2(n:i),'linewidth',3)
pause(0.01),     end
gtext(['t_B'] 'fontsize' 14)
```

Figure 9. *Part of the script file for example* 4

4.4. Example 4

The fourth example deals with the way of creating an animation in which:

- in the upper subgraph, an animation effect of the time dependence of the velocity is synchronized with the motion of particle allong x axis, where the motion is at first uniformly accelerated and then slowed down (with the same absolute value of acceleration);

- in the lower subgraph an animation effect of the time dependence of the acceleration can be seen.

The script file includes the *input* function, to prompt the user to enter the acceleration value and the upper limit (t_f) of the row vector assigned to time values in a certain range. The additional commands for auxiliary lines on both subgraphs are also included. The graph that is presented in Fig. 10 is

the snapshot made at the end of the animation, in the case when the values a=1 m/s^2 and t_f=10 s were entered after running the script.

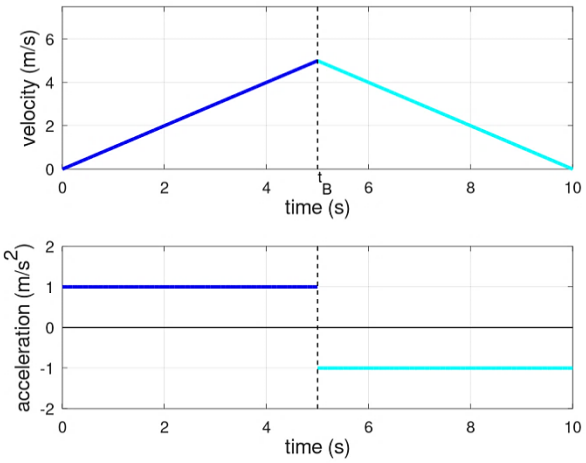

Figure 10. *Final snapshot of the animated graph related to accelerated/decelerated motion of the particle*

Fig. 9 shows the most important parts of the script used to create this animation. All commands, except of the couple of the so-called *se*t functions that define more specified way of performing plot function, are placed out of the loops, in order to speed up the animation. If the ordinate axis range is not limited for the lower subgraph, usage of the *gtext* command that should replace the legend on the graph, could be more convenient than text command. Utilization of the *gtext* command is also particularly convenient in examples such as 2a, because due to different values obtained on the ordinate (with different input values) it is not easy to predict the coordinates required for an appropriate text position.

5. CONCLUSION

The paper presents some examples of the application of an open-source GNU Octave software within the general physics course in undergraduate studies. GNU Octave is a multifunctional computer tool designed to process data in the form of matrices and is a major alternative to commercial software packages such as MATLAB. To demonstrate some of the possibilities of applying programming via Octave software within the undergraduate course of general physics, the creation of script files in the examples from the field of mechanical motion has been chosen in this paper. The examples have included: finding the general form of solutions for a system of equations (symbolic solutions), tabular formatting of results for a specific set of values of input variables, saving formatted results in the form of ASCII files, as well as 2D and 3D graphical display of results with animation effects for certain physical phenomena and processes. A brief glance at the creation and application of function files is also given. The importance to create script files that prompt the user to enter new values of various input parameters after each starting of the execution of a given script, in order to compare the changes on the graphs, and to reach a better understanding of certain physical relations and laws, was emphasized as well. Special attention has been paid to set various types of conditions that enable showing only results that have a physical meaning for the considered physical problem in the table and/or graph. Additionally, application of a decision making structure had been also used, for achieving targeted occurrence of warning notes in a case of obtaining physically illogical solutions of certain equations, as well as for performing animation according to different kinematic equations during the different time intervals. The animations and emphasized observations presented in this paper are methodologically important examples of developing and correlating knowledge in the field of informatics and general physics. The considered examples also represent a good educational basis for creating applets in general physics and related teaching areas.

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Session 3: *Engineering Education and Practice*

Professional paper
UDC: 621.317:004.42LabVIEW

Educational Setup for Power Cable Loading and Temperature Measurement

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Abstract: *This paper presents the equipment and procedure for temperature and current measurement on the low-voltage cables. Presented setup can be applied in teaching courses in the field of electrical installations, electrical heating or thermodynamics as a practical laboratory exercise. Two PVC insulated cables with different cross-sections were used as samples. A procedure for determining the heat transfer parameters of a cable modelled by a horizontal cylinder is also described. The values of the current obtained by the measurements were compared with the calculated values.*

Keywords: *power cable; heat transfer; temperature measurement; LabVIEW*

1. INTRODUCTION

As with most components in the electrical power systems, heating of power cables is mainly caused by internal losses, i.e. losses generated in conductors. The steady-state temperature of power cables is one of the most important parameters, which is 70 °C for PVC insulation, and 90 °C for cross-linked polyethylene. Current-carrying capacity (or ampacity) of the cable is determined by the characteristics of the cable: conductor material, number of loaded conductors and insulation material, as well as external conditions such as: installation type, ambient temperature (air or ground), number of cables laid in groups, thermal resistance of soil, intensity of solar radiation and wind speed. The current load of power cables and their losses are defined by the IEC 60287 and can be modelled with thermal-electric circuit [1, 2].

The cable in which heat is generated due to losses is cylindrical in shape and can be considered as long isothermal cylinder. Therefore, heat transfer equations for the cylinder can be applied and then current value can be calculated. Temperature and current measurement can be performed under controlled conditions in the laboratory. The values of current obtained by measurements can be compared with the values obtained by calculation.

The experimental setup presented in this paper was realized in the Laboratory for Electrical Installations at the Faculty of Technical Sciences in Čačak. This experiment can be applied as a practical exercise for students in subjects such as: Electrical installations, Electrical heating or Thermodynamics.

2. HEAT TRANSFER FROM HORIZONTAL CABLE

The single-core power cable, placed horizontally in the air, can be modelled with a thin horizontal cylinder. Also, cable insulation and sheath can be modelled with a hollow cylinder. Known temperatures of ambient and cable surfaces are used for determining the intensity of current through a conductor in the calculation procedure shown below.

Measurements are performed in the closed environment, simulating a case in which the only heat source is caused by losses in the cable conductor due to the current, i.e. excluding heat sources due to solar radiation.

Heat dissipation through the connecting ends of the conductors was neglected during the described calculation. The influence of the skin effect on the additional increase of the electrical resistance of the conductor, which can be calculated using the expressions given in [3] is also neglected.

The specific heat per unit length that is transferred from the surface of the cable to the environment (air) by convection and radiation can be determined by the following equation

$$\begin{aligned} q_{\text{tot}} &= q_{\text{conv}} + q_{\text{rad}} = \\ &= h\pi D\left(T_s - T_a\right) + \varepsilon\pi D\sigma\left(T_s^4 - T_{sur}^4\right), \end{aligned} \tag{1}$$

where h – convection coefficient; D – cable diameter; T_s – cable surface temperature; T_a – ambient air temperature; ε – cable surface emissivity; σ – Stefan-Boltzmann constant which is $5.67\cdot10^{-8}$ W/m^{2}K^4; T_{sur} – ambient surface

temperature. The convection coefficient is determined based on the equation

$$h = \frac{k}{D} Nu, \tag{2}$$

where Nu – Nusselt's number; k –air thermal conductivity under certain conditions. The Nusselt number for the case of a horizontal cylinder can be determined based on a correlation formula [4]

$$Nu = \left\{ 0.6 + \frac{0.387 \cdot Ra^{1/6}}{\left[1 + \left(\frac{0.559}{Pr} \right)^{9/16} \right]^{8/27}} \right\}^2 . \tag{3}$$

That applies to $Ra \leq 10^{12}$, Ra – Rayleigh number calculated using a following equation

$$Ra = \frac{g\beta (T_s - T_a) D^3}{\upsilon\alpha}, \tag{4}$$

where g – acceleration of gravity; β – volumetric thermal expansion coefficient; ν – momentum diffusivity; α – thermal diffusivity; and Pr – Prandtl number. All parameters for air were taken from appendix in [4]. In the steady-state conditions, the specific heat flux that is transferred from the surface of the cable by convection and radiation is equal to heat generated in the conductor. The heat that is transferred by conduction to the surface of the cable through insulation and sheath is

$$q_{tot} = \frac{T_c - T_s}{\frac{\rho_{th}}{2\pi} \ln \frac{d_2}{d_1}}, \tag{5}$$

where T_c and T_s – are conductor and (sheath) surface temperatures, respectively; ρ_{th} – thermal resistance of insulation and sheath which is 6 Km/W for PVC; d_1 and d_2 – inner and outer radius of insulation with sheath, respectively.

If the temperature of the cable and the total specific heat flux values are known, the temperature on the surface of the conductor can be determined by the following equation:

$$T_c = T_s + q_{tot} \left(\frac{\rho_{th}}{2\pi} \ln \frac{d_2}{d_1} \right). \tag{6}$$

The electrical resistance of the conductor at temperature T_c is

$$R_{T_c} = R_{20} \left[1 + \alpha (T_c - 20) \right], \tag{7}$$

where R_{20} – electrical resistance at 20 °C; α – the temperature coefficient which is $\alpha_{Cu} = 0.00393$ K^{-1} for copper. Based on the steady-state temperatures and specific heat flux, the current can be calculated using the equation

$$I = \sqrt{\frac{Q}{R_{T_c}}} = \sqrt{\frac{q_{tot} \cdot \ell}{R_{T_c}}}, \tag{8}$$

where Q – total heat flux; ℓ - cable length.

3. USED EQUIPMENT AND MEASUREMENT PROCEDURE

Two samples of single-core low-voltage power cables type were used for the purposes of the experiment: PP00 1 × 25 mm^2 and PP00 1 × 35 mm^2. The length of both cables was 2.1 m. Figure 1 represents the used laboratory equipment, and Figure 2 represents the scheme of the experimental setup. The power cable that is being tested (1) was connected to the secondary of step-down transformer (2) with a transmission ratio of 350:4. The current of the cable directly depends on the primary voltage of the step-down transformer, so current value was adjusted using the autotransformer (3). The tested cables were placed on a thin vertical wooden support (4). This created the condition of natural air flow around the horizontally placed cable.

The current of the cable was measured using current clamps *Benning* CM 3 (5). The current was adjusted by reading the current value from the current clamps and regulating the voltage on autotransformer. Four J type thermocouples (6) and acquisition equipment (7): NI 9219 card with NI cDAQ-9174 chassis were used for temperature measurement. A total of four thermocouples were used: three for measuring the cable surface temperature and one for measuring the ambient temperature, i.e. ambient air. The cable surface temperature T_s was determined as the mean value of measured temperatures of all three thermocouples.

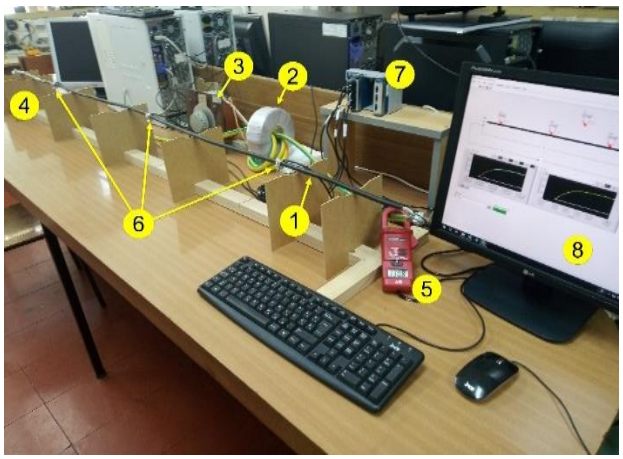

Figure 1. *Laboratory measuring equipment*

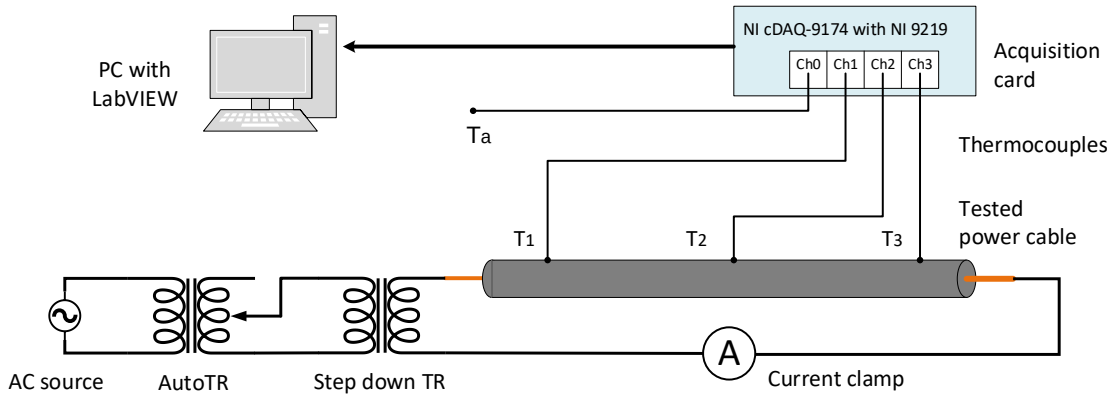

Figure 2. *Diagram of experimental setup*

The measured temperatures are downloaded and processed on a computer (8) i.e. created program in *LabVIEW* software. A user front panel shown in Fig. 3 was created in the *LabVIEW* software. This front panel shows the values of temperature on the surface of the cable at three measuring points, their mean value, and the ambient air temperature at one point. In addition to the temperature values, the program provides diagram of temperatures change over time. All measured temperature values can be recorded simultaneously in a *.xls* file.

Before the start of the measurement, the required natural air flow around the cable is achieved. Also, all windows and doors in the room were closed before and during the measurement and the air conditioner was turned off, which reduced the forced air flow in the room to a minimum. Before connecting autotransformer to the AC source (230 V, 50 Hz), the program was started and data recording was enabled. After that, the current of the cable is set to the desired value using an autotransformer. At the beginning of the measurement, a sudden increase in temperature is expressed, which leads to an increase in electrical resistance and a decrease in current, so a decrease in current is prevented by increasing the voltage.

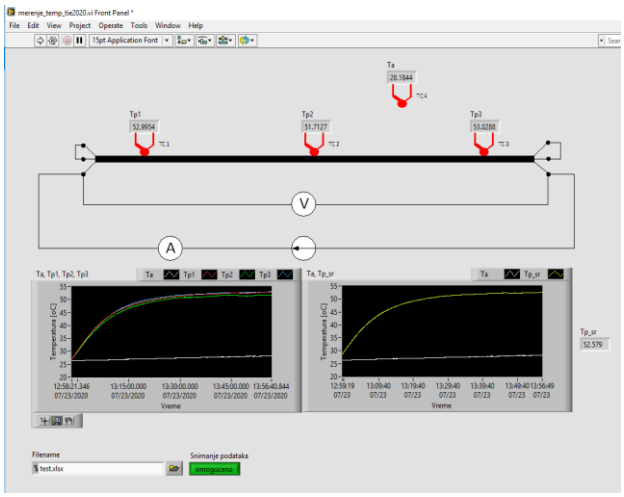

Figure 3. *Front panel in LabVIEW software*

Since it was necessary to maintain the value of the current load through a tested power cable, a continuous voltage adjustment using autotransformer was necessary. Measurement was ended when a steady state occurs.

4. MEASUREMENT RESULTS

The data processing and graphical display of the measured temperatures for two cables of different cross-sections were performed after the measurement. Figure 4 shows measured values of temperatures at the surface and ambient air for the PP00 1×35 mm^2 power cable. This cable was tested with two different load currents: 150 A and 180 A. In both cases, it is noticeable that the increase in cable temperature is exponential. Also, the increase in ambient temperature slightly contributes to the increase in cable temperature. The increase in ambient temperature was inevitable due to the existence of a heat source in the room. When the steady state occurred, the ambient and cable temperatures were 28 °C and 52 °C at a current value of 150 A, while temperatures were 28 °C and 62 °C at a current value of 180 A.

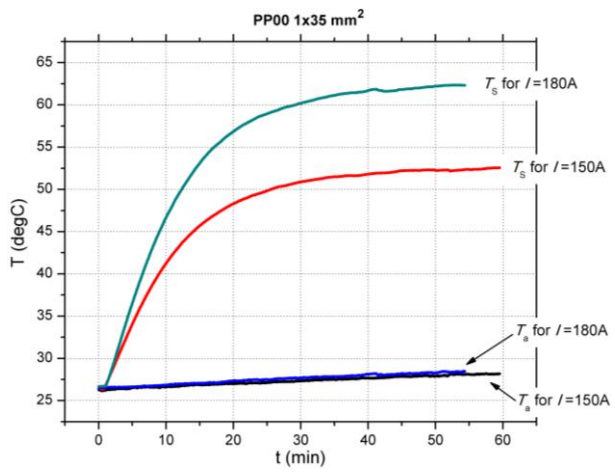

Figure 4. *The ambient and cable temperatures of 35 mm^2 power cable (150 A and 180 A)*

Figure 5 shows measured values of temperatures at the surface and ambient air for the PP00 1×25

mm^2 power cable. As in the previous case, this cable was also tested with two different load currents: 130 A and 150 A. These two measurements were made under different ambient conditions, so the temperature of the ambient is also different. At a current of 130 A in the steady state, the ambient and cable temperatures were 27 °C and 51 °C, respectively. At a current of 150 A, these temperatures were 29 °C and 60 °C, respectively.

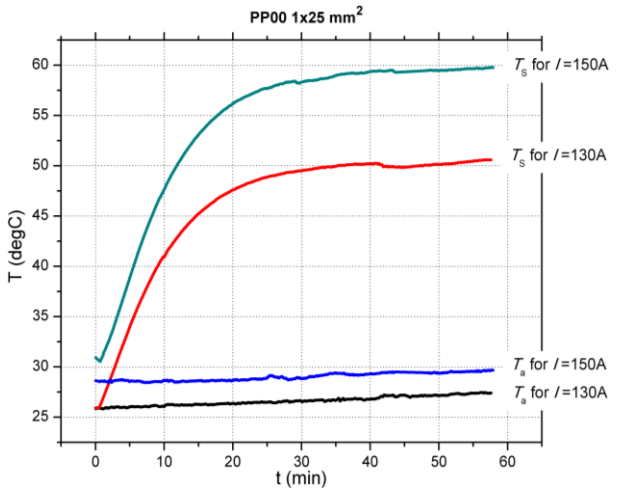

Figure 5. *The ambient and cable temperatures of 25 mm^2 power cable (130 A and 150 A)*

After the experiments, the values of the currents obtained by measurements and calculations were compared using equations (1)-(8):

(i) For the 35 mm^2 power cable with a current of 180 A: ambient and surface temperature are 29 °C and 62 °C, respectively which corresponds to the value of specific heat 18.61 W/m and current value of 179.8 A. The relative deviation in relation to the measured value of 180 A is **–0.11%**.

(ii) For the 35 mm^2 power cable with a current of 150 A: ambient and surface temperature are 28 °C and 52 °C, respectively which corresponds to the value of specific heat 12.74 W/m and current value of 149 A. The relative deviation in relation to the measured value of 150 A is **–0.67%**.

(iii) For the 25 mm^2 power cable with a current of 130 A: ambient and surface temperature are 27 °C and 51 °C, respectively which corresponds to the value of specific heat 12.26 W/m and current value of 124.1 A. The relative deviation in relation to the measured value of 130 A is **–4.54%**.

(iv) For the 25 mm^2 power cable with a current of 150 A: ambient and surface temperature are 29 °C and 60 °C, respectively which corresponds to the value of specific heat 16.71 W/m and current value of 142.2 A. The relative deviation in relation to the measured value of 150 A is **–5.32 %**.

Based on the results of temperature and current measurements and comparison with the calculated values, a satisfactory deviation in values was noticed, with a low percentage difference in current values. As pointed out in the second section, the part of the heat was dissipated through the conductor connections to the power cable. Neglecting that part of the heat affects the total value of the calculated specific heat *q* in reality has a higher value, and therefore the calculated current has a higher value.

5. CONCLUSION

The expected correlation between the cable temperature, the ambient temperature and the load current is proved through the examples presented in this paper. Also, the measured values were compared with the calculated values in heat transfer at the horizontal cable which gave small percentage difference.

Presented experimental setup for current load and temperature measurement of power cables can be helpful to students as a practical exercise in subjects such as: Electrical installations, Electrical heating or Thermodynamics (heat transfer). By implementing this setup in the mentioned subjects, student can confirm the results of calculations in all three methods of heat transfer and current load of cables. Also, by working on this setup, they can get familiar with the one of the methods for temperature measurement and the conditions for obtaining and controlling currents in laboratory conditions.

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Professional paper
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System for Automatic License Plate Recognition in Digital Image

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Abstract: *In this paper, one of the realizations of an automatic number plate recognition (ANPR) systems is presented. The system is developed for the recognition of license plates issued in the Republic of Serbia. The system consists of several separate algorithms which overcome individual problems in ANPR. The problems discussed in this paper are license plate detection in the vehicle digital image, license plate skew correction, license plate segmentation and character recognition.*

Keywords: *license plate detection; binarization; radon transform; license plate segmentation; character recognition; skew.*

1. INTRODUCTION

Automatic number plate recognition (ANPR) is an important computer vision technique which encompasses recognition and identification of the objects in a digital image [1]. ANPR identifies characters in the digital image of the license plate in real time.

The system consists of four separate algorithms:

1. License plate localization and detection;
2. Skew license plate correction;
3. License plate segmentation;
4. Character recognition.

The input of the system is the digital image of the vehicle, whereas the output is an array of recognized characters. In the Fig. 1 the generalized block scheme of the ANPR is shown.

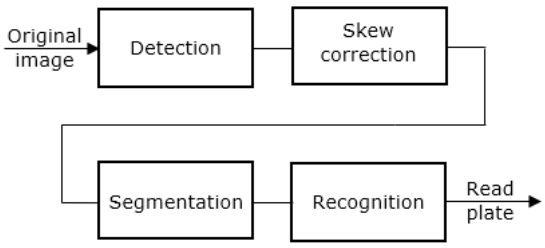

Figure 1. Simplified block scheme of the ANPR

The majority of papers, which consider ANPR, use digital images obtained using specialized high-quality cameras [2]. These cameras use specialized optics, infrared sensors, embedded systems as well as a preprocessing software, which significantly enhances the quality of the digital image. The obtained images have an optimal resolution and allow for an easy license plate recognition even when the targeted vehicles are moving at high speeds. In the contrast, the purpose of this paper is to develop an algorithm which successfully recognizes license plates in digital images of lower quality, obtained using commercial cameras and mobile phones.

In this paper, license plates issued in the Republic of Serbia, are considered. The system is developed using MATLAB and the Image processing toolbox.

For the purpose of testing the algorithm, the digital image database, consisting of 423 vehicle images, was created. The images were captured from different angles and distances from the vehicles, where the vehicles were stationary.

2. LICENSE PLATE DETECTION

License plate detection is the most important step in the process of ANPR. Success of the license plate detection directly determines the success of all following algorithms. If the plate is not detected successfully, the execution of the other algorithms is not possible.

During the development of the license plate detection algorithm, certain assumptions were made. The entire license plate must be visible and illuminated enough, without too many light distortions and any objects that cover any part of the license plate.

2.1. PREPROCESSING OF THE VEHICLE DIGITAL IMAGE

The goal of image preprocessing is to enhance the quality of the image and enable easier further analysis and processing. The quality of the used images varies and depends on the camera characteristics. Using a conventional camera,

obtained images have certain defects, such as noise. Scene illumination also has a great influence on the quality of the digital image. Different photometric defects, such as shadow and reflection, may deteriorate the quality of the image and even make ANPR impossible. Digital image preprocessing consists of several steps: rescaling, converting RGB image into greyscale image, contrast enhancement and image filtering.

Dimensions of the input images varies in the range from 1875×2500 pixels to 3096×4128 pixels. Because license plate detection on higher resolution images has not shown better results, all images that are larger than the certain threshold are rescaled.

Because the processing of colored images demands higher computational power as well as being more complex, most of the license plate detection algorithms are developed to work on greyscale and binary images [3]. The original input vehicle digital image is converted into a greyscale image.

For the purpose of exposing finer details in the digital image, contrast is enhanced using the linear operation of contrast stretching, which increases the probability of success of the ANPR [4].

Finally, the digital image is filtered using the median filter with the goal to reduce noise. In the Fig. 2 an original vehicle image as well as the preprocessed image are shown.

Figure 2. Original vehicle image (left) and the result of the preprocessing algorithm (right)

By preprocessing the digital image, an image with smaller dimensions is obtained, which significantly reduces the time needed for execution of further steps of ANPR. Also, the quality of the image is enhanced which results in the increase of the probability of successful license plate detection.

2.2. BINARIZATION OF THE VEHICLE DIGITAL IMAGE

The image binarization is the most important step of the localization and detection of the license plate. Binarization reduces the complexity of data in the digital image and simplifies recognition and classification of objects in the image. Binarization method and threshold are very important for the license plate detection. In this paper, two different types of binarization methods are used. First type of binarization is the global binarization which uses the same threshold for the entire image. Global binarization is best suited for evenly illuminated images. One of the best known global binarization method is the Otsu method [3, 5], which is used in this paper.

In the case of uneven image illumination (reflection, shadow…), because the global binarization methods give unsatisfactory results, adaptive binarization methods must be used [6]. Unlike the global binarization, the adaptive binarization has a unique threshold for each pixel.

On the other hand, in the case of evenly illuminated images, adaptive binarization often gives worse results. The main problem of adaptive binarization lies in the fact that the license plate can be merged with other objects in the image. Because the system has to work with both evenly and unevenly illuminated images, no single binarization method can be used on its own, but rather a combination of both.

2.3. DIGITAL IMAGE REGION LOCALIZATION

The region in the digital image represents a set of connected pixels [3]. For the purpose of eliminating a certain number of objects, which are too small to represent a license plate, all regions of the binary image which have less connected pixels than the predetermined number, are discarded.

Because the license plate in the binarized image represents a connected region, all connected regions are potential candidates for the license plate. Firstly, all connected components (regions) in the digital image are labeled using a method in the MATLAB Image Processing Toolbox called Connected-Component Labeling. The labeled image enables separation of individual objects using their unique label. In the Fig. 3 all connected components are displayed on both original vehicle image and on the binarized image.

Figure 3. All found regions in the digital image on the original RGB image (left) and on the binarized image (right)

After labeling the image, specific characteristics of each connected component are determined (dimensions, position of the rectangle which encompasses the region, the center of the region, orientation, surface area, Euler number…).

As seen in Fig. 3, there are many regions that are potential candidates for the license plate. Each candidate must fulfill certain conditions concerning region characteristics.

Euler number represents an important feature of the digital image because it describes the topological structure of the image [7]. Euler number is invariant to different geometrical

transformations such as scaling, translation, rotation and even certain nonlinear transformations which change the shape of the object. Because the license plate is a region on the binarized image which has a higher number of cavities (representing characters), the Euler number of the license plate is negative. Using the assumption that the region that is a candidate for the license must have an Euler number which is negative, many of the regions shown in Fig. 3 can be discarded. After discarding all regions with non-negative Euler number, the remaining regions are shown in Fig. 4.

Figure 4. Remaining regions after discarding regions with non-negative Euler number, original RGB image (left) and the binarized image (right)

The license plates have a standardized ratio between width and height, so this criterion is used in discarding all regions whose ratio is outside of the certain bounds. Because the license plate in the digital image can be at an angle, the bounds for the ratio must be chosen carefully. In this paper, it is adopted that the ratio must be between 1.4 and 6.

After discarding all regions with unsatisfactory ratio, the remaining three regions are shown in Fig. 5.

Figure 5. Candidates for the license plate shown in the RGB image (left) and the binarized image (right)

The result of the algorithm for region localization is a number of candidates for the license plate which satisfy the adopted criterions.

2.4. CANDIDATE SELECTION

For the purpose of selecting the right candidate for the license plate, further processing of all candidates must be done. The license plate has distinct edges which are a result of existence of dark characters on a white background. Based on the assumption that the license plate has the most vertical edges, compared to all potential candidates, vertical edge detection and its statistical analysis were used. To detect vertical edges in the digital image specialized filters were used.

Vertical edge detection was done using the Sobel filter [3]. In Fig. 6-8 the results of applying the Sobel filter on all three candidates is shown.

Figure 6. First candidate for the license plate (left) and detected vertical edges (right)

Figure 7. Second candidate for the license plate (left) and detected vertical edges (right)

Figure 8. Third candidate for the license plate (left) and detected vertical edges (right)

After acquiring the images with detected vertical edges, vertical image projection is done [8]. The results of the vertical image projection for all three candidates are given in Fig. 9-11.

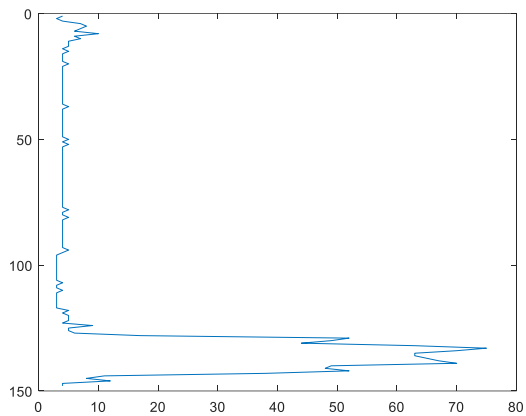

Figure 9. Vertical projection – first candidate

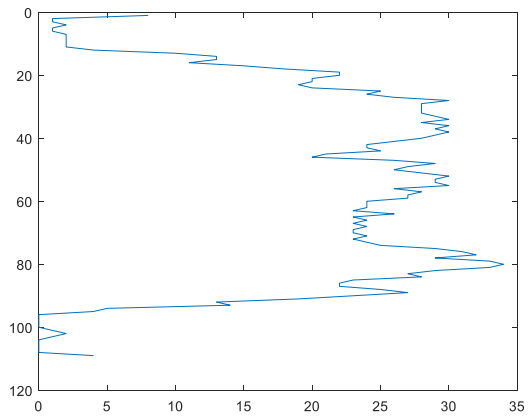

Figure 10. Vertical projection – second candidate

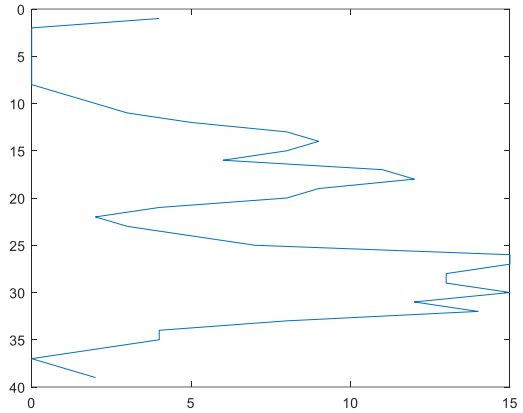

Figure 11. Vertical projection – third candidate

Analyzing Fig. 9-11, a specific shape of the vertical projection of the license plate can be observed. The vertical projection of the license plate has the maximum value in the middle of the projection while the values on both ends are much smaller. The reason for this shape of the vertical projection lies in the fact that the characters are in the center part of the license plate. The remaining two candidates have the vertical projection which is much different, and no specificity can be noticed.

The candidate for the license plate is chosen by calculating the mean of the vertical projection but discarding the starting and ending 25%. The candidate with the maximum mean value is declared the license plate.

Because of the previously determined dimensions and the position of the rectangle that surrounds the candidate, it is possible to segment the part of the original RGB image which represents the candidate. The result of the segmentation is shown in Fig. 12. The input of the algorithm for the license plate segmentation is an RGB image and not the binarized image for the reason that the quality of the candidate deteriorated during the process of license plate localization.

Figure 12. Detected license plate

3. CORRECTION OF THE SKEW OF THE LICENSE PLATE

Due to the fact that the vehicle digital image can be obtained from different angles, various distortions can occur. Depending on the position of the camera relative to the license plate, there are three types of tilt angles [9]:

1. Horizontal tilt (Fig. 13);
2. Vertical tilt (Fig. 14);
3. Combined tilt (Fig. 15).

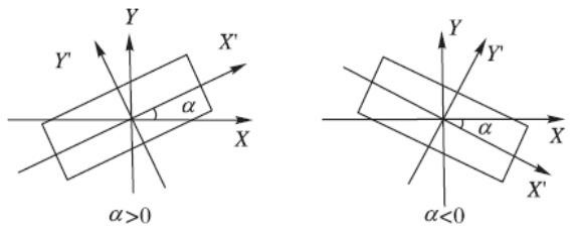

Figure 13. Horizontal license plate tilt [9]

In the Fig. 13 it can be seen that the horizontal tilt corresponds to the rotation of the license plate.

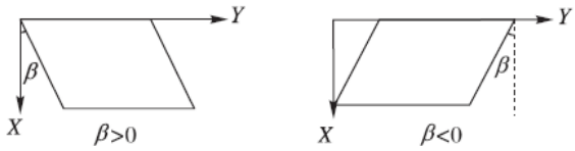

Figure 14. Vertical license plate tilt [9]

In the Fig. 14, it can be seen that the vertical tit corresponds to the shear of the license plate. Vertical tilt can be corrected by using the inverse affine transform [10].

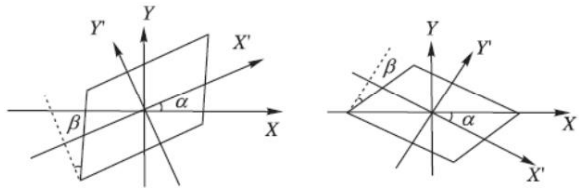

Figure 15. Combined license plate tilt [9]

In the Fig. 15, a combination of horizontal and vertical tilt is shown. Combined tilt is the most common type of license plate tilt.

In many cases, if tilt correction is not performed, problems in the succeeding algorithms may occur. One of the main problems is that the segmentation algorithm may not segment all characters in the license plate. If the license plate has either horizontal or vertical tilt, it is necessary to process the digital image of the license plate to eliminate the tilt. The skew correction can be divided into two steps.

The first step is the correction of the horizontal tilt, while the second step is the correction of the vertical tilt. For determining the angle of the horizontal tilt, Radon transform is used [11]. Before applying the Radon transform, all edges in the image must be detected. For the purpose of detecting the edges in the image, Canny filter is used [3]. The maximum of the Radon transform corresponds with the angle of the horizontal tilt. Block scheme of the horizontal tilt elimination is shown in Fig. 16.

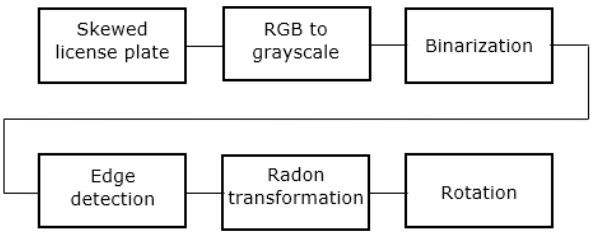

Figure 16. Horizontal tilt elimination block scheme

Because the orientation of individual characters is the same as the orientation of the entire license plate, the vertical tilt angle can be determined by determining the vertical tilt angle of individual characters. Most of the characters have the smallest width when there is no vertical tilt, as shown in the Fig. 17.

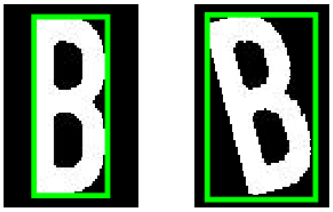

Figure 17. An example of width-tilt relation

For the purpose of correcting the vertical tilt angle, individual characters must first be segmented. After acquiring individual characters, each character is rotated in the range $[-30°, 30°]$, and its width is determined [12]. The angle for which the character has the minimum width is adopted for the angle of vertical tilt of the character. Based on the vertical tilt angles of individual characters, vertical tilt angle of the license plate is determined.

After acquiring the vertical tilt angle, the correction is done using the inverse affine transform.

4. License plate segmentation

After license plate detection, characters of the license plate must be segmented. Before the segmentation of individual characters, the license plate digital image must first be preprocessed. The preprocessing of the license plate image is rather similar to the preprocessing of the vehicle digital image and consists of the same steps plus determining the complement of the image. The result of the preprocessing of the license plate digital image is shown in Fig. 18.

Figure 18. Original license plate image (top) and the result of the preprocessing (bottom)

After preprocessing the license plate image, all connected components of the image are determined. The result of the algorithm is given in Fig. 19.

Figure 19. Connected region on the license plate

In Fig. 19 it can be seen that, aside from the regions that match the characters, additional regions were extracted. For the purpose of eliminating the additional regions, a criterion of expected height and width of the characters is used. Given the fact the character "0" is made out of two separate regions, the width of the expected region must be adopted small enough. On the other hand, the letter "I" has a much smaller width, so the criterion for width must be adopted small enough. If both height and width criterions are adopted small enough, other regions aside from the regions of characters would pass the criterion. In the end all regions whose width is not between 15 and 80 pixels and height not between 30 and 100 pixels, as well as those whose width is not between 5 and 50 pixels and height not between 50 and 100 pixels, are eliminated. After elimination of regions, the remaining regions are given in Fig. 20.

Figure 20. After elimination of the non-character regions

It can be seen that the character "0" consist of two separate regions, so the overlapping regions are merged. The result of merging the overlapping regions is shown in Fig. 21.

Figure 21. After merging overlapping regions

5. CHARACTER RECOGNITION

The last step in the ANPR algorithm is the character recognition. There are many different techniques when it comes to object recognition: statistical techniques, syntax techniques and soft-computing techniques. In this paper a statistical technique for object recognition is used.

In this paper, for the purpose of recognizing individual characters, template matching is used [13]. All characters that are supposed to be recognized are rescaled into the dimensions of the templates (57×28 pixels). For each character, the correlation coefficient with every template is calculated and the character is classified as the character on the template which has the highest correlation coefficient.

Because the license plates in Serbia have the starting two characters which are letters, as well as the last two, while in the middle there are ciphers, the first and last two characters are matched only with templates of letters while the characters in the middle are matched only with templates of ciphers.

6. THE PERFORMANCE OF THE SYSTEM

The success of each individual step of the ANPR affects the performance of the entire system. The success of the algorithms is determined using different criterions, such as a non-existent region (no region fulfills preset conditions), number of characters in the segmented license plate image (the number outside of the preset boundaries), etc. These criterions reduce the number of false positives in ANPR.

The greatest effect on the success of individual steps of the ANPR, has binarization. As it has been discussed in chapter 2.2, there are two types of binarization that can be used, whereas no single type of binarization can be used for all digital images. Because, in most cases, global binarization gives satisfactory results, as well as being less complex, each algorithm firstly uses global binarization. If the global binarization gives unsatisfactory results, then individual algorithms use adaptive binarization. The combination of global and adaptive binarization leads to longer duration of algorithm execution, while on the other hand, the performance of the ANPR increases.

The system was tested on a database with 423 vehicle digital images with different photometric characteristics and different license plate tilts. The performance of individual algorithms is given in Table 1, where performance is defined by the number of successful realizations of the algorithm compared to the total number of input digital images of the algorithm. The performance of the entire system is 93.14%.

Table 1. Performance of individual algorithms

	Performance [%]
Detection	95,50
Segmentation	98,51
Recognition	98,99

Mean execution time for the used database, when only global binarization is used, is 3.46 s. If only adaptive binarization is used, mean execution time is 11.87 s. The proposed system uses a combination of both global and adaptive binarization, resulting in the mean time of 6.74 s.

7. CONCLUSION

In this paper an ANPR algorithm, consisting of four separate algorithms, is implemented. The system enables for an automatic license plate detection and localization in the digital image, skew correction, license plate character segmentation as well as character recognition.

Special attention was paid to binarization step in detection and segmentation algorithm. Pros and cons of both global and adaptive binarization were presented. It has been determined that for the success of the ANPR, a combination of both types of binarization must be used.

The skew correction improves the performance of the entire ANPR algorithm by enabling character segmentation in the case of the license plate tilt.

The system was tested on a database of 423 different vehicle digital images. The performance of the entire system is 93.14%. Because of its high performance, the system can be utilized as a subsystem in electronic toll collection systems.

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Induction Machine Control Algorithm Implementation with MSK28335 Digital Platform

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Abstract: This paper presents possibilities of a Technosoft digital platform MSK28335 in control algorithm implementation of an induction machine. The educational aspect of a MSK28335 digital platform is emphasised and how it can gain students' knowledge and understanding of induction machine control principles through course of control of electric drives. Several control algorithms are presented and explained as well as MATLAB integration possibility which allows Rapid Control Prototyping option. This feature gives users to develop, implement and test new control algorithms in a simple and effective manner without having any advanced programming skills. The graphical results of each presented control algorithm are presented, followed by proper discussion.

Keywords: *MSK28335; IM control algorithms; Field oriented control; Rapid control prototyping; lab. setup.*

1. INTRODUCTION

The rapid development of electronics in the end of 80's years last century enabled to use the AC motors in applications where it required a high dynamics response. AC motors whose greatest advantages are robustness and reliability with the help of modern power converters have approached the great control capabilities of DC motors. Behind of using modern electronic components for the development of better control capabilities AC motors it's worthy to mention use of modern digital technologies. It refers to usage of fast digital signal processors (DSP) which allow implementation different algorithms for controlling AC motors [1]. Some more complex principles of control AC motors in relation to DC motors require more effort in understanding their operating principles. Different types of mathematical transformations, controller, types of power converters, microprocessor systems represent a complex system for understanding and mastering advanced control algorithms of control AC machines. For this reason, this paper presents Technosoft 's solution for testing induction motor control structures based on the use of the MSK28335 digital platform [2]. The MSK28335 digital platform basically consists of two main parts: the APCM750 v3.4 power module and the TMS320F28335 DSP control module. The MSK28335 platform comes with 5 implemented control algorithms where you can easily modify existing or implement new types of control AC motors. This makes it much easier for students to understand the principles of operation of modern algorithmic drive structures with AC machines. Also, the connection with the MATLAB software enables the avoidance of traditional programming in C language and easy and fast testing of new algorithms by applying Rapid Control Prototyping (RCP) principles. Lately, Rapid Control Prototyping has become quite popular and attractive in electric drive control algorithms development [3]. Quick and easy design of control algorithms allows engineers to test and enhance control methods and develop final prototypes in a simple and effective manner without advanced programming knowledge [4, 5].

2. Experimental setup description

Experimental laboratory setup with MSK28335 digital platform is shown in Fig. 1.

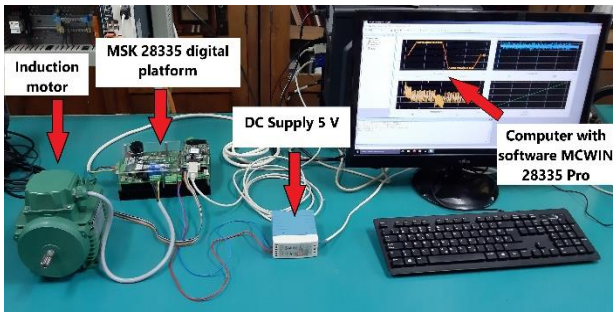

Figure 1. *MSK28335 experimental digital setup*

Induction machine – SIEBER L71 three phase induction machine, 750 W, with embedded encoder (500 ppr) on the rotor shaft and parameters given in appendix.

DC power supply – 5V DC logic power supply.

PC – computer with installed Technosoft software *MCWIN2833x PRO* and *DCM Developer Pro*.

MSK28335 – digital platform with Texas Instruments floating point processor F28335, 150MHz.

Fig. 2 shows main connectors and how the MSK28335 platform is connected to the rest of the experimental setup.

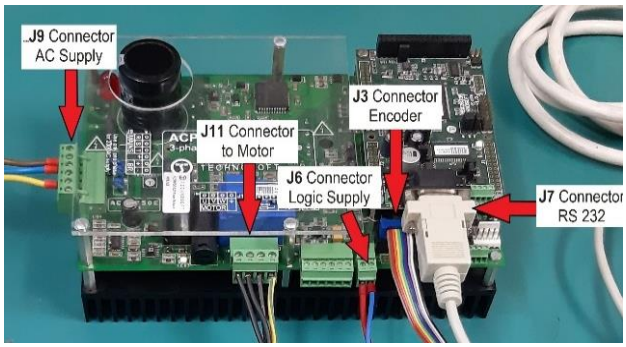

Figure 2. *MSK28335 main connectors*

J9 AC supply – power converter supply, AC 3ph - 110V or AC 1ph - 230V.

J6 logic supply – 5V DC logic power supply

J11 – 3ph induction motor connector

J3 – incremental encoder connector.

J7 – RS 232 serial communication with PC [9].

Technosoft's software package for control induction motor installs on windows environment and consists of:

- MCWIN28335 Pro. Contains: serial monitor for real-time communication, PROCEV2833xx processor evaluation software, DMCD28x-Pro Digital Motion Control Developer software for application development, compilation, code downloading and testing of digital management algorithms.
- DMCode-MS (IM) which contains a complete MATLAB library for digital control of an induction motor (measuring blocks, transformations, controllers for position, speed, torque, voltage control, etc.).
- DMCode-S (IM), ready applications of current, speed, position regulation and voltage control of inverters based on Field Oriented Control
- TI software tools - software tools from Texas Instruments. Contains: assembler, linker and C - compiler [10].

3. THEORETICAL BACKGROUND OF THE IMPLEMENTED ALGORITHMS

Each implemented control algorithm has an identical kernel structure according to which machine control algorithm executes and it is presented in Fig. 3.

Main algorithm steps for all control algorithm implemented in MSK28335 are as follows: First, the ACPM750 power module errors is reset if it exists → hardware is initialized → interrupt aspects for time base are initialized → current and speed controllers are initialized → PWM generation is started → current measurements are obtained → measurement is started from encoder → after all calculations based on the obtained measurements, the interruptions related to the transistors are activated.

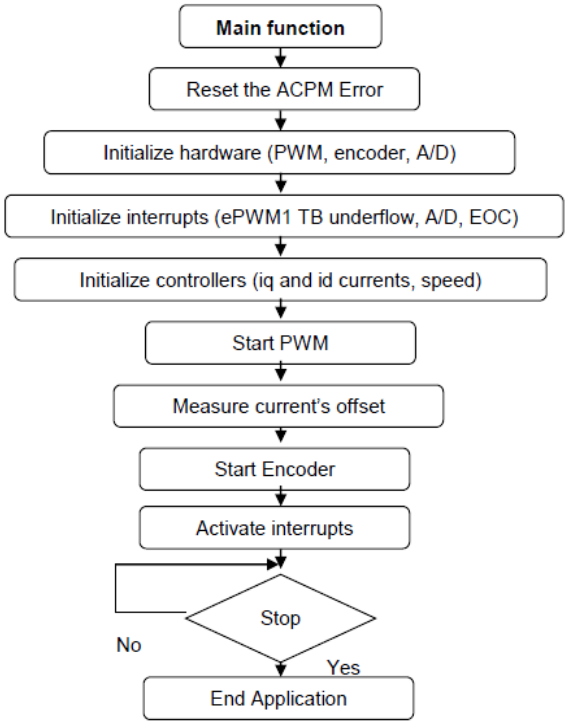

Figure 3. *Kernel structure*

The main function essentially calls blocks that represent structures/functions written in the C - programming language necessary for proper algorithm execution. By opening and studying these blocks, the student can understand how to perform: analog-to-digital conversion (ADC.c), a transformation of the three-phase *abc* in the two-phase *dq* system (Tabcdq.c), obtaining the speed and position from the encoder (Encoder.c), position estimation rotor field (EFP.c), the inverse transformation of the dq in the abc system (Tdqabc.c), PWM generation (PWM.c), etc.

2.1. Three phase motor voltage generation

This laboratory exercise should enable students to understand the principles of voltage generation by Pulse Width Modulation (PWM) technique. Realization of the given voltage reference at the inverter output is done in the transformed *dq* coordinate system. The idea is to set the voltage in the *d* - axis to a constant value and the voltage in the *q* - axis to follow a given reference, then performed coordinate transformations and PWM voltage generation.

When performing this exercise, the student can understand the principle and necessity of

coordinate transformations in a three-phase induction machine as well as the principles of PWM voltage generation. This is the simplest way to control the machine speed in an open loop system.

The results obtained after testing this control method (voltage reference and the resulting voltage on inverter outputs) are shown in Fig. 4.

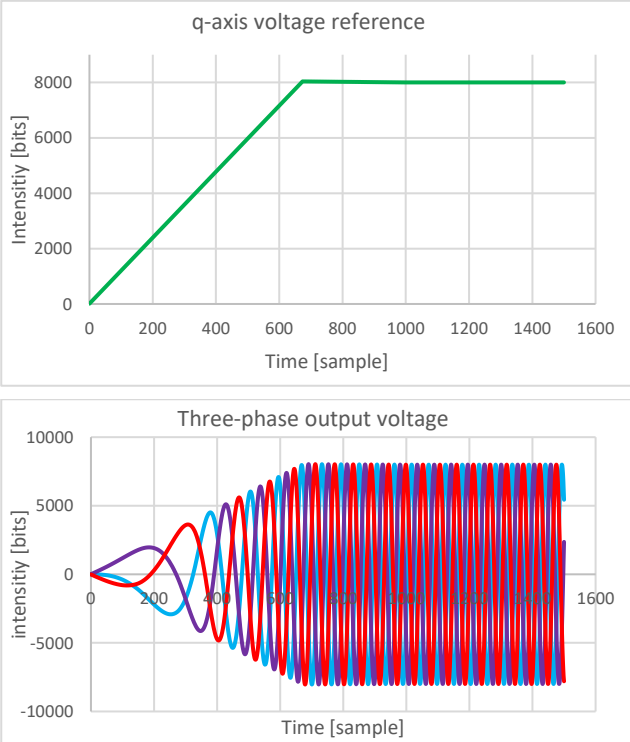

Figure 4. *q-axis component of voltage reference (top) and three-phase output voltage (bottom)*

2.2. U/f control

U/f control belongs to the group of scalar control methods. Unlike the vector control, U/f method involves changing the voltage and frequency of the power supply of an AC machine without affecting their current phase position. In order to make the speed change below synchronous speed possible and avoid the saturation of the machine it is necessary to change the voltage proportionally to the stator frequency. For higher speeds, above the synchronous, it is necessary to increase the frequency while the voltage is limited to its nominal value in order to prevent possible endangerment of the machine insulation. The relation between stator voltage and frequency is given by well-known equation (1) and shown graphically in Fig. 5 (red line).

$$u_s = \begin{cases} \dfrac{U_{sn}}{f_{sn}} f_s & , \text{ for } f_s < f_{sn} \\ U_{sn} & , \text{ for } f_s \geq f_{sn} \end{cases} \qquad (1)$$

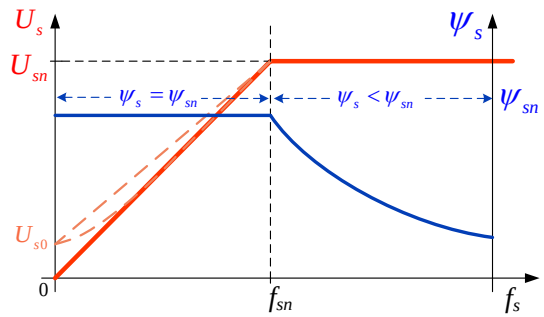

Figure 5. *U/f control principle*

This theoretical U/f control background is implemented as a C code application with block structure showed in Fig. 6.

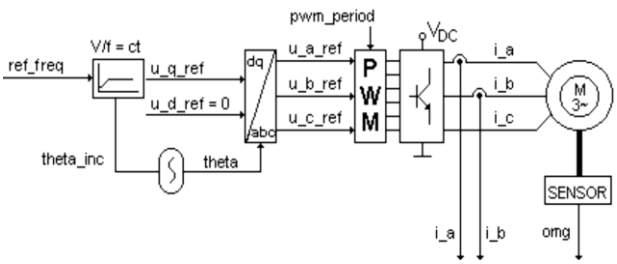

Figure 6. *U/f control block structure*

During this exercise, the student can expand his knowledge by understanding digital implementation of scalar control with transformed model of an induction machine. According to Fig. 6 scalar control can be realized by controlling the voltage in the *d* axes and *q* axes and determining the angle (theta) of the transformed *dq* coordinate system. When performing this exercise, the student can understand why a constant ratio U/f is necessary in subsynchronous speed region and what the relation between the voltage in the *q* - axis and the resulting angle theta should be.

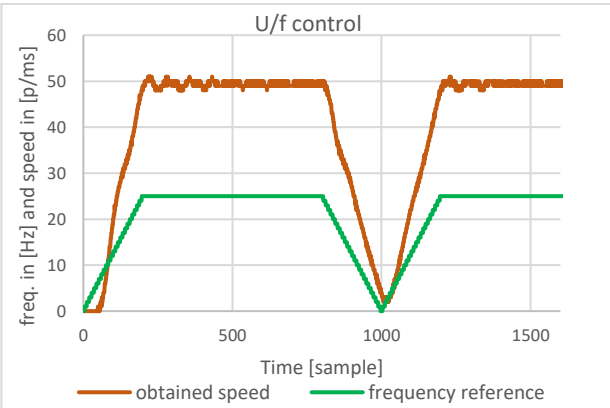

Figure 7. *Experimental results for reference frequency and obtained motor speed.*

In Fig. 7 reference frequency is set in Hz (25 Hz) while the speed is presented in encoder pulses per one speed control loop (1 ms). That means 25 Hz corresponds to motor speed closed to 1500 rpm.

2.3. Decoupled stator current control

This laboratory exercise focus is on control of the stator currents based on the principles of Field-Oriented Control (FOC). During this exercise, the student is introduced to the principle of decoupled rotor field-oriented control, its main requirements and characteristics.

The block structure shown in Fig. 8 represent a closed loop control. In order to realize field-oriented control, it is necessary to provide independent control of motor torque and motor flux. This is achieved by using a decoupled machine model and controlling the stator currents in the *d* - axes and *q* - axes, and it is necessary to determine precise orientation of the rotor field.

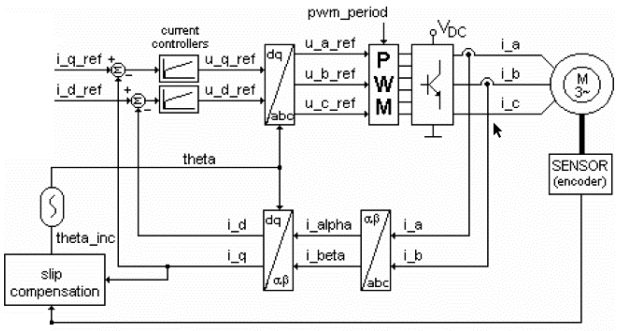

Figure 8. Decoupled stator current control block *structure*

Digital platform allows decoupled control of an induction machine. MSK28335 platform provides motor current measurement in two phases (current in the third phase is obtained by calculation of previously measured two currents), the mathematical transformation coordinate system of three-phase into two-phase system is performed, and the orientation of the rotor field is obtained by estimation, knowing mechanical position of the rotor and rotor frequency. By having an insight in C - programming language code, the student is able to understand the whole control algorithm and how it is executed in detail.

In this control algorithm the stator current in the *d*-axis is maintained at a constant value because it represents the flux of the machine, and the current in the *q*-axis, which represents the torque, follows the given reference. Finally, stator currents responses in *d*-axes and *q*-axes, shown in Fig. 9, reflects the principle of this type of control.

The motor field position is determined based on the "theta" angle increment. The theta increment is calculated as the sum of the mechanical angle of the rotor and the rotor frequency resulting with final "theta" angle of the *dq* coordinate system. Theta increment is computed as follows:

$$\omega_r = \frac{1}{T_r}\frac{i_{qs}}{i_{ds}} \tag{1}$$

$$theta\_inc = \omega + \omega_r \tag{2}$$

Where:

ω - mechanical angle of the rotor shaft

ω_r – rotor circuit frequency

T_r – rotor time constant

theta_inc – increment of "theta" angle

Consequently, the resulting "theta" angle is further used for the sine and cosine calculation needed for the implementation of coordinate (abc2dq) transformations [9].

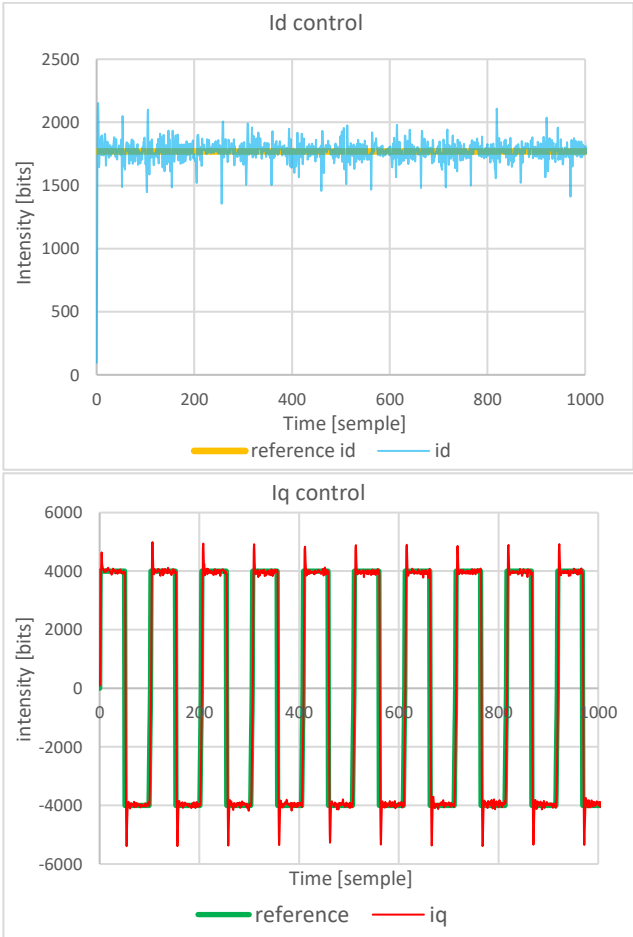

Figure 9. *Reference and obtain current in d-axes and q-axes*

PI controllers are used for current control loops in the *d* and *q* axes. Rise and settling time of the current responses can also be analysed from the obtained results. PI controller parameters influence on current responses can also be observed and appropriate conclusion can be drawn.

2.4. Speed control

This control principle is also based on FOC, and is practically an upgrade to the previously explained current control. It is realized by adding a speed controller (PI) in front of the current regulators making a cascade control which can be seen in the following block diagram. The block structure of the speed control algorithm is shown in Fig. 10.

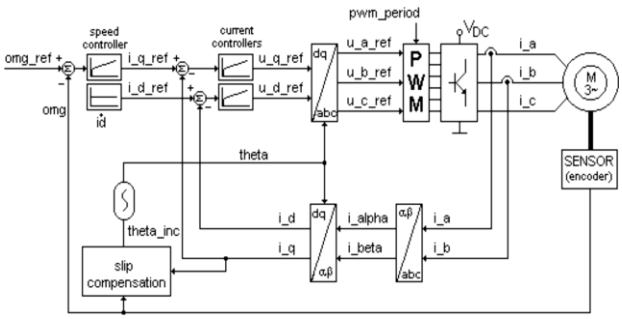

Figure *10*. *Block diagram of speed control*

When performing this exercise, the student has the opportunity to get familiar with the cascade operation of two controllers in two loops. The speed control calculations are done in a slow loop that is executed every 1ms and the current controller operates in a fast loop that is executed every 100μs. It can be seen (as in current control) that the flux or current in the *d* - axis is maintained at a constant level and the current in the *q* - axis controls the motor speed. Current reference *q* - axis value is obtained from the speed controller output. Fig. 11 (top) shows the speed response with its reference value. Stator currents in *dq* coordinate system with its references are shown in Fig. 11 (bottom).

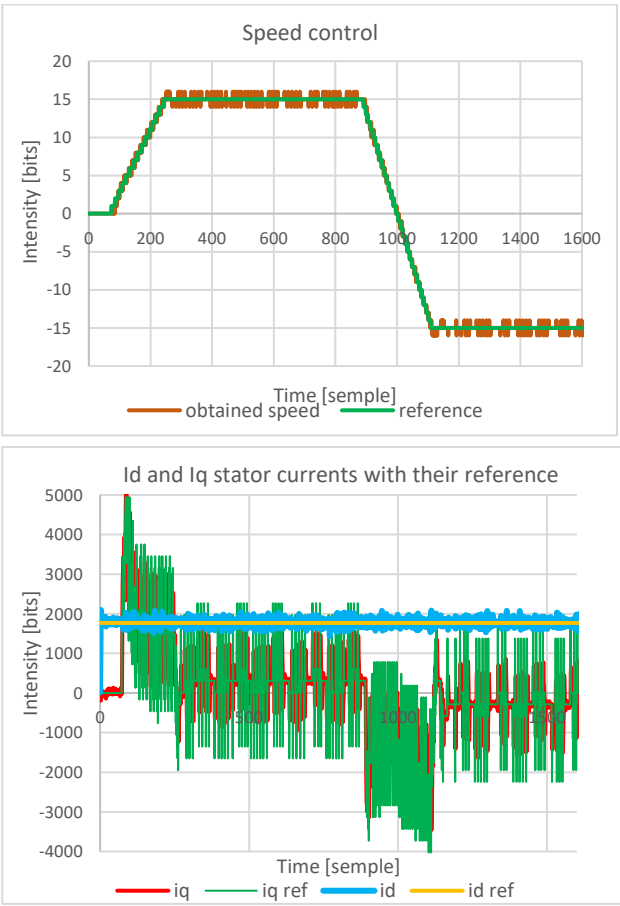

Figure 11. Speed response (top) and stator currents in *qd* reference frame (bottom)

2.5. Position control

This control type aims to control the position of machine rotor shaft according to the set reference. In this exercise, instead of a speed (PI) controller, there is a position (PID type) controller. Here, the student can get familiar with the principle of achieving the given position of the induction motor rotor shaft. Compared to the speed control, position controller has additional derivate (D) gain. Position control is a very common demand in industrial processes and appropriate PID controller tuning is of great importance in order to achieve a quick motor position response. Fig. 12 shows a block diagram of positional control.

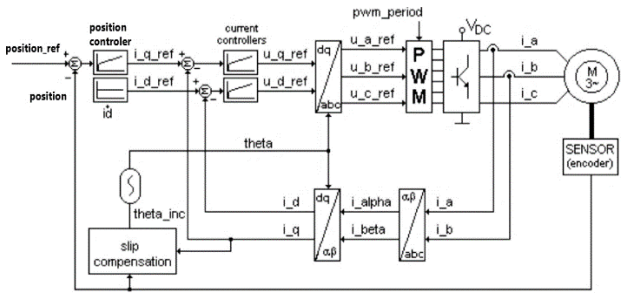

Figure *12*. *Block diagram of position control*

As in the previous case, there are two loops, in the slow loop (1ms) the position control is performed and in the fast loop (100μs) the current control is performed. Fig. 13 shows the given references and the obtained response motor position and currents in *d* and *q* axes.

The student can calculate the jumps and settling times for the used controller from the obtained results.

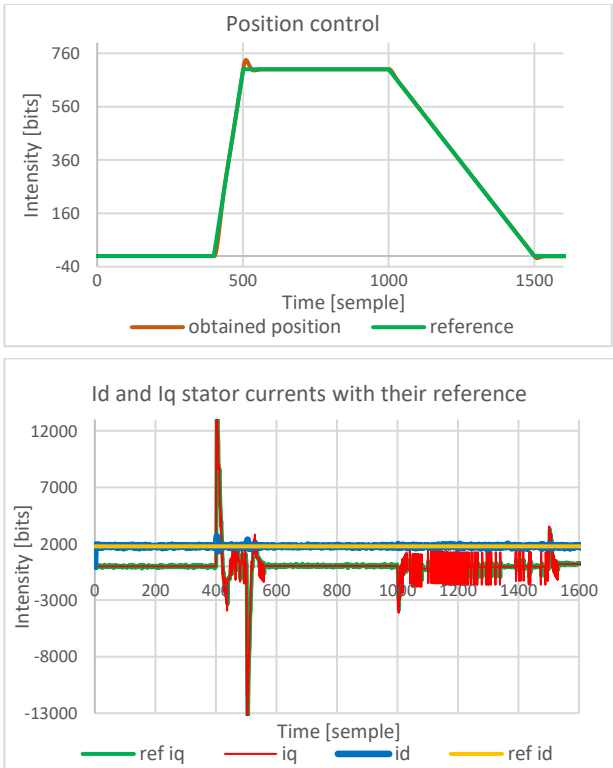

Figure *13*. Position response (top) and stator currents in *qd* reference frame (bottom)

2.6. MATLAB simulation and code generation

One of the main possibilities of MSK28335 digital platform is a MATLAB library integration option. With MATLAB/Simulink it is possible to in sample manner model appropriate control algorithms with already prepared blocks for coordinate transformation, PI control, PWM, AD conversion, encoder readout etc. from F28335 existing library. Then algorithm can be tested and tuned until satisfactory results are obtained. This option allows users to compile the Simulink model to C code and directly download it to the digital platform processor with one click.

In that way students can develop and test their control algorithms by Rapid Control Prototyping principle which makes the development process much faster and easier. The Simulink code generation principle is shown in Fig. 14.

Control algorithm development in this way doesn't require advanced programming skills of the user which drastically reduce implementation and testing time of new algorithms. After successful simulation in MATLAB by choosing the option "Build project" user generate and compile appropriate C code which is automatically downloaded to the MSK28335 digital platform. The example of MATLAB/Simulink project was shown in Fig. 15.

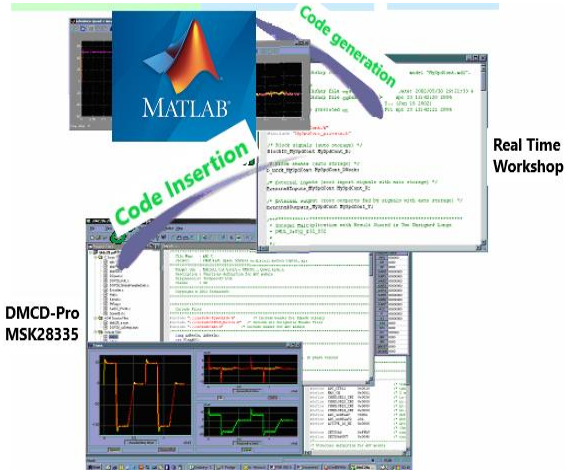

Figure *14.* *Automatic code generation from Simulink model*

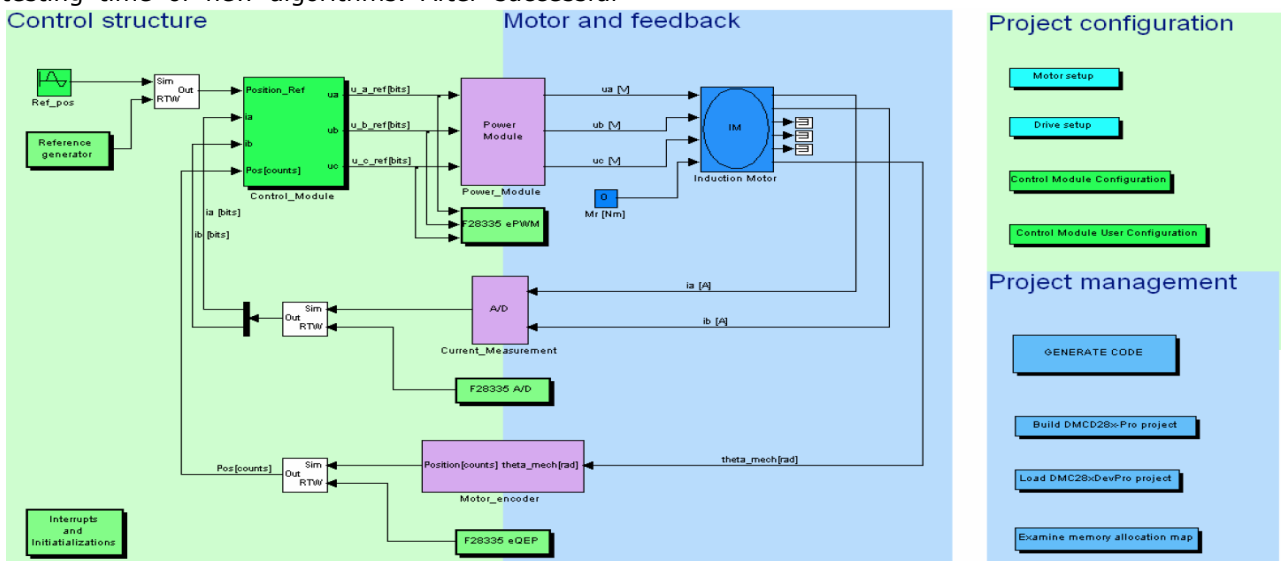

Figure *15.* *MATLAB/Simulink simulation control structure of induction machine speed control*

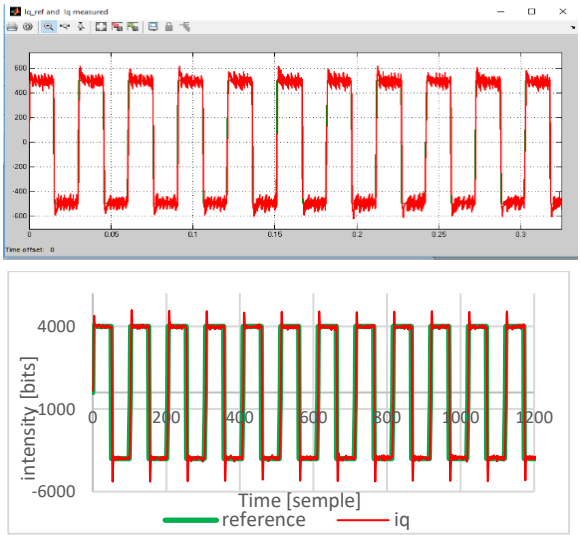

Figure *16.* Comparison of simulation and experimental results for current control method

Afterwards, the implemented algorithm is ready to be tested in real-time experimental setup after which the results obtained by simulation and experiment can be compared (Fig. 16).

ACKNOWLEDGEMENTS

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APPENDIX

Table 1. *Induction motor SIEBER L71 parameters*

U_n [V]	400	R_s [Ω]	24.6	L_s [H]	1.48
I_n [A]	0.95	R_r [Ω]	16.1	L_r [H]	1.48
P_n [W]	370	n_n [min^{-1}]	2860	L_m [H]	1.46

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Laboratory DC Machine Test Bench with Siemens DCM Drive

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Abstract: *This paper gives educational aspect of a laboratory setup with DC machine dedicated to students who follow the courses of electric machines and drives. The main idea is to present possibilities of new Siemens DCM drive in different operation modes with DC machine in laboratory environment. Laboratory test bench allows students to load DC machine and observes characteristic parameters, tune the motor current and speed control loops, implement different braking and regenerative operation regimes of DC machine. Basic setup of DCM drive and laboratory exercises are described as well as some experimental results. Proper discussion of the obtained results is given at the end of a paper.*

Keywords: *DCM drive; laboratory setup; DC machine; Starter.*

1. INTRODUCTION

Electric motor drives are unavoidable part in modern industrial processes. Nowadays, in the industry, the majority of all drives makes drives with AC machines. Substantial increase in urbanization along with growing rate of industrialization are the major factors driving the AC drives market trends. Urbanization would increase consumer demand, which results in to increase in the manufacturing sector, propelling the demand for AC drives during the forecast period [1]. Installation of new electrical drives in solving industry operation demands and retrofit or repairing existing industrial drive usually imply installation of (or replacement) with the AC drive. This is mainly justified after a simple economic analysis as well as the extraordinary control capabilities of the AC drives and induction machine characteristic.

However, the installation of drives with AC machines is not always justified in economic and technical terms. Depending on the power of the drive, the existing technical conditions and the operational range of the drive, there are situations where the installation of a drive with DC machines has an economic advantage over an AC drive with the same power [2]. From this reason, the principles of operation and control of DC drives are still studied in courses of electrical machines and drives at universities.

Modern power converters for DC drives used in industry rely on very simple operational principle that students are get familiar during the course of electric drives and laboratory exercises. However, the software capabilities of modern converters and drives with the development of IT are becoming advances and more complex, so students, although knowing the principle of operation of the drive, are not able to quickly and easily perform commissioning the DC drive. Modern industrial communications, higher control levels, the Industrial Internet of Things (IIoT), etc. represent a special aspect of drives nowadays that further enhance their possibilities.

For this reason, in the EMPA laboratory [3] of Faculty of Technical Sciences Čačak, a laboratory setup for 4-quadrant (4Q) operation of DC and AC drive is developed where students can get familiar with different operation principles of modern electrical drives. This is particularly important nowadays where the use and exploitation of DC drives is almost neglected and rarely applied. In this paper modern Siemens DCM converter is described and its educational and operational possibilities are presented through experimental setup.

2. LABORATORY SETUP AND THEORETICAL BACKGROUND OF DC DRIVE CONTROL

DC machine is an unavoidable part of the industry, and it is used in electric drives that require a wide range of power and speed as well as high accuracy in terms of torque, speed and position control [4].

Laboratory setup with AC and DC machine drives and with a control joystick is developed and shown in Fig. 1. In this laboratory setup students can perform different operation regimes of DC machine where AC machine can be used for emulation of different load characteristics. Parameters of DC machine are given in the Appendix. The theoretical

principles of DC drive control are much simpler compared to the AC drive. DC drive control is based on armature and field circuit voltage / current control as it is shown in Fig. 2.

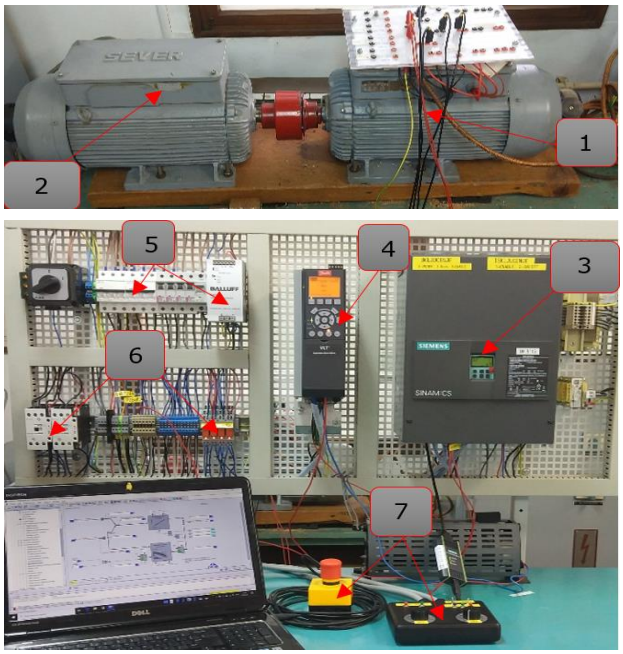

Figure 1. *4Q laboratory setup with DCM drive*

Where:

1. DC machine
2. AC (induction) machine
3. DCM converter – Siemens DCM
4. AC converter – Danfoss
5. Logic power supply and safety
6. Relays and contactors
7. Control joystick and emergency stop

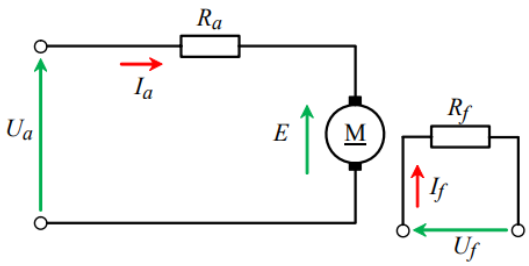

Figure 2. *DC machine armature and field circuits*

By controlling the parameters of the motor armature and field circuits, it is possible to achieve different mechanical (torque vs. speed) characteristics of the DC drive in order to adapt it to the load system. With the additional load system control, it is possible to realize and record characteristics for different operating regimes of the 4Q DC drive such as:

- Recording of mechanical characteristics at different values of armature voltage, Fig. 3
- Recording of mechanical characteristics at different values of field current, Fig. 4
- Recording of mechanical characteristics with added resistance in armature circuit
- Generator (recuperative) braking
- Reverse current braking (plugging)
- Electrodynamic braking
- Characteristics of DC machine as a generator, etc.

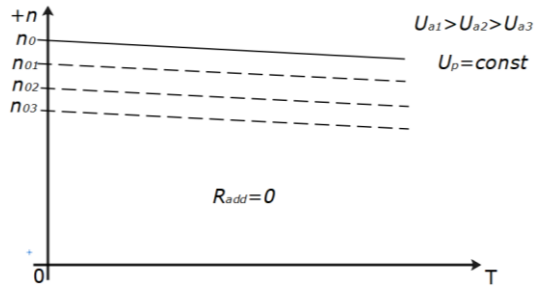

Figure 3. *Mechanical (torque vs. speed) characteristics of DC machine obtained by changing the armature voltage*

The principles of DC drive control, although very simple, require different control loops implemented and tuned in order to achieve satisfactory drive characteristics [5-6]. The control loops of the current, speed and position of the DC drive require careful tuning so the drive can keep higher possible bandwidth characteristics.

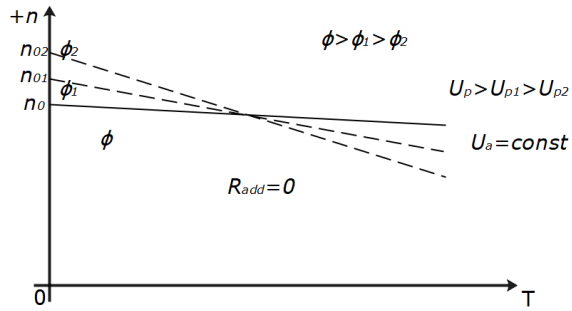

Figure 4. *Mechanical (torque vs. speed) characteristics of DC machine obtained by changing the field voltage (field weakening)*

The realized laboratory setup enables 4Q drive operation with DC motor and closed speed loop control where the speed is measured with tachogenerator located on the motor shaft. The control structure loops of the armature current, field current as well as speed/position is realized within the DCM converter. Parameterization of entire drive is performed via the software package STARTER. Commissioning and reference control are performed by using the joystick shown in Fig. 5.

Figure 5. *Control joystick*

3. SIEMENS DCM DRIVE AND STARTER SOFTWARE

SINAMICS DC MASTER converter units are compact units containing both the power unit for the armature supply and the power unit for the field supply, as well as the control electronics and possible additional modules, Fig. 6. SINAMICS DCM converter can operate in all four quadrants (4Q), can control the speed of the motor in both directions and return the energy directly to the power network during the generator regime. The armature is supplied via two fully-controlled three-phase bridges connected in a circulating-current-free inverse-parallel configuration.

Figure 6. *Sinamics DCM drive*

Applications where a logic operation connecting several states (e.g. access control, system status) to a control signal (e.g. ON command) is required to control the drive system also can be implemented in DCM drive with Free Function Blocks (FFB) where vast of logic and mathematics operation and latching elements can be implemented. Moreover, for applications requiring a more complex method of controlling the drive system which cannot be accomplished using the FFB option of Drive Control Charts (DCC) can be used. DCC makes it possible for one of the interconnected elementary function blocks to generate a graphical depiction of an existing function diagram and load it to the converter [7].

The drive can be parametrised and controlled via board operator panel (BOP – in this case) or advanced operator panel (AOP). However, easiest way of parametrisation of the drive is through STARTER software where with graphical representation of drive control structures user can easily access to all parameters (form digital and analogue IO to the output gating unit of the armature and field voltage control structures).

After properly wired the converter and motor and established profibuss industrial communication with the PC (Starter), it is necessary to configure the drive and enter the basic information about the drive. This means entering the motor rated values, definition of the motor current and speed limits as well as additional drive elements such as encoder / tachogenerator, motor brake, etc. (Fig. 7).

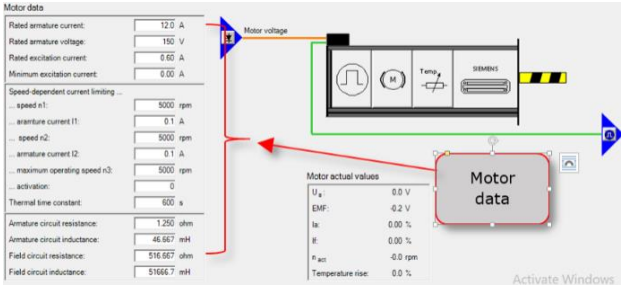

Figure 7. *Motor data*

Before commissioning, it is necessary to assign the main digital IO functions and connect them to the buttons, switches and potentiometer on the control joystick shown at Fig. 5. Then the user can define the drive control type – torque or speed control.

Definition of digital and analogue IO drive functions can be done by connecting them to wide range of other drive variables, as it is shown in Fig. 8. In this way, the necessary requirements and procedures for switching on, switching off the drive, emergency stop function, alarms and other faults acknowledgements and reset can be defined and set.

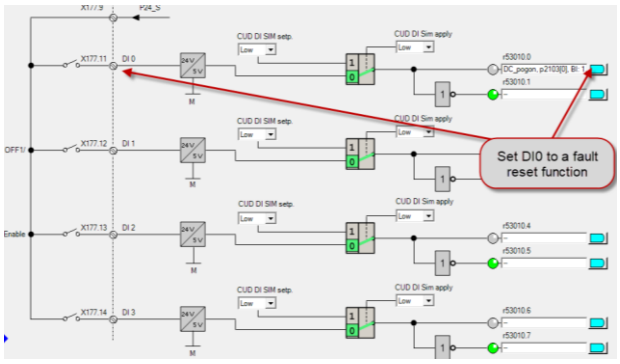

Figure 8. *Definition of D/A inputs and outputs*

In order to have a drive with fast and quality response, the motor data (resistances and inductances of all motor windings) must be properly entered. Moreover, the optimisation procedure of the drive control structures must be performed. Optimisation procedures (self-tuning) include the start of the drive under certain conditions where the drive itself determines the necessary and optimal parameters of the current and speed control structures, friction coefficients, shaft torsion, etc. (Fig. 9.)

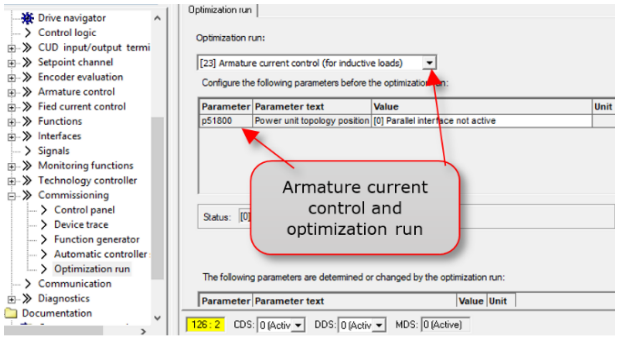

Figure 9. *Drive optimisation runs procedures*

In addition to the listed options, the DCM converter enables detailed adjustment of armature and field circuit parameters, definition of reference values, encoder evaluation, brake control function, motor monitoring, control panel, device trace, function generator, etc., as can be seen in Fig. 10.

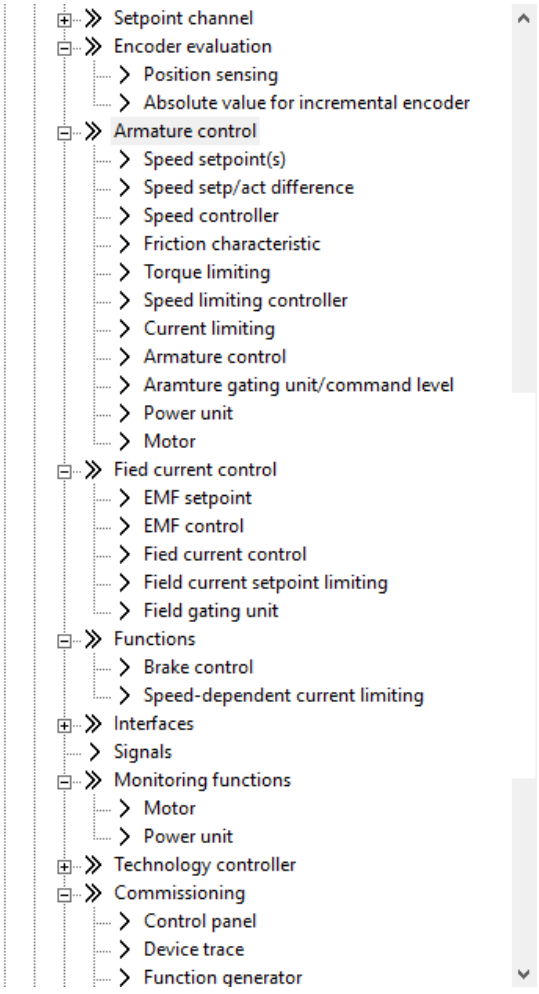

Figure 10. *Converter properties menu*

One of the blocks for the armature circuit control parameters setting is shown in Fig. 11. In addition to the parameters of the PI controller, it is possible to correct the influence of the motor back EMF on the current controller parameters (armature current pre-control - Fig. 11).

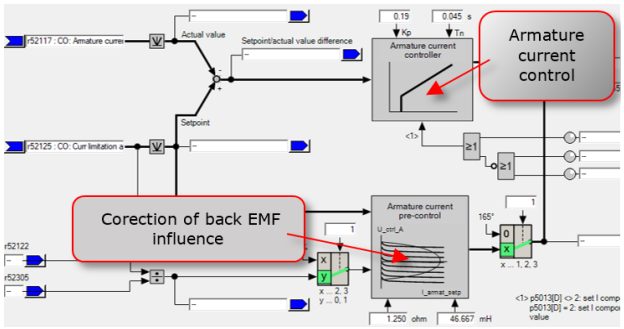

Figure 11. *Armature control block*

In the case of armature and field circuits, where the converter regulates the currents by changing the converter's output voltage, it is also possible to make an influence on the ignition angles of the corresponding thyristor switches as can be seen in Fig. 12.

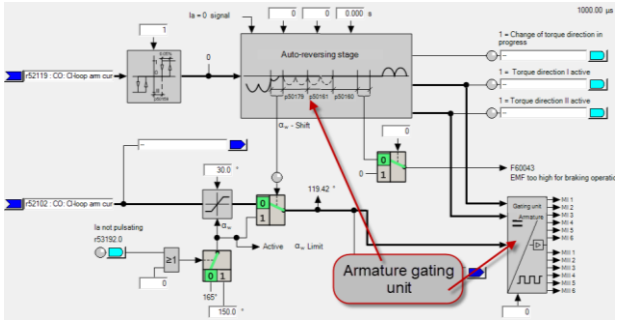

Figure 12. *Armature gating unit block*

Beside previously mentioned BOP and AOP the STARTER software allows the user to create an operator panel with all necessary control functions. Moreover, it is possible to create a repeating motor operation sequence with changing the control type during the sequence execution.

The user has the option to observe and modify all drive parameters in the *Expert list* section as it is shown in Fig. 13. The option of *field weakening* activation which allows the drive to reduce motor field and operate at speeds higher than rated speed is shown in Fig. 13. The *Expert list* enables the overview and modification of more than 52,000 drive parameters, which allows students great opportunities for learning and practicing with this laboratory setup.

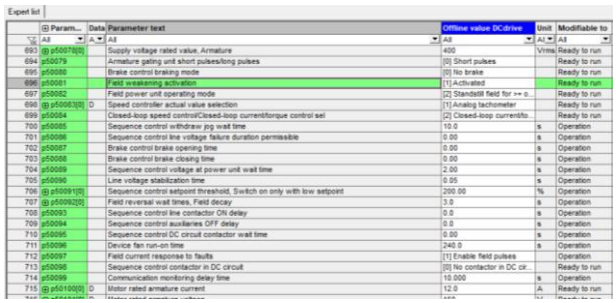

Figure 13. *Activation of Field weakening option in parameters Expert list*

4. LABORATORY EXERCISES AND OBTAINED RESULT

Working on this laboratory setup students can get familiar and perform:

- Proper identification and wiring of the drive elements;
- Establishing appropriate industrial communication protocol between the converter and the computer;
- Entering the basic parameters of the motor and defining the overall operating limits of the drive;
- Drive optimisation process and control structures tuning;
- Recording and graphical presentation and analysis of characteristic drive quantities obtained at different operating drive regimes;
- Control parameters modification of the motor current and speed loops and analysis of its influence on the obtained response quality.

The obtained results of the motor speed response to a set reference in the form of a step function are shown in this chapter. The following drive quantities were recorded using the *Device trace* option:

- *Speed actual value,*
- *Armature current actual value,*
- *Feld current controller actual value,*
- *Armature voltage actual value* – voltage measured on machine armature terminals
- *Fixed setpoint output after selection* – speed reference.

Selection of recorded quantities and definition of the recording parameters are shown in Fig. 14.

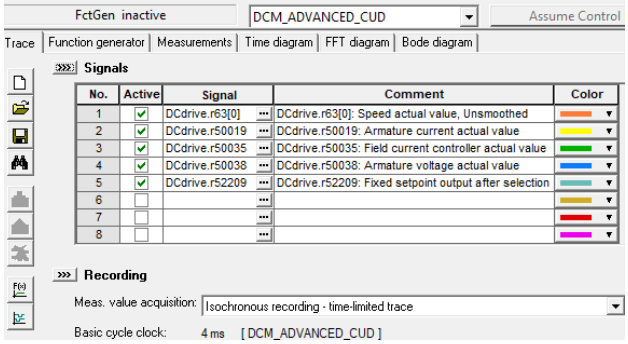

Figure 14. *Recording drive quantities*

The obtained results during the motor start with set speed reference change from zero to rated speed value are shown in Fig. 15. The acceleration and deceleration ramp parameters are set to a minimum value (0s) while the armature current limits are set to ± 100%. Current and speed loop parameters are set to optimal values determined during the optimisation runs (Fig. 9). In this way, the experiment of recording the motor speed response time (time necessary to motor reaches rated speed from zero speed) with armature current limits of 1 p.u. is performed. Having in mind the acceleration time, the speed change range and the motor rotor inertia the accelerating torque as well as motor torque constant can be calculated.

Fig. 15 shows that motor field is turned on approximately 2s before the motor speed reference is set. The filed current response exhibits a small overshoot (around 15%) at the rated reference value of 0.6A. Thanks to the armature current limits (±100%) motor reaches the reference speed in 850ms with 5% overshoot. Other information regarding the quality of the motor current and speed control loops can be seen in Fig. 16. Zoomed part of Fig. 15 during the acceleration and deacceleration (braking) are shown in Fig. 16.

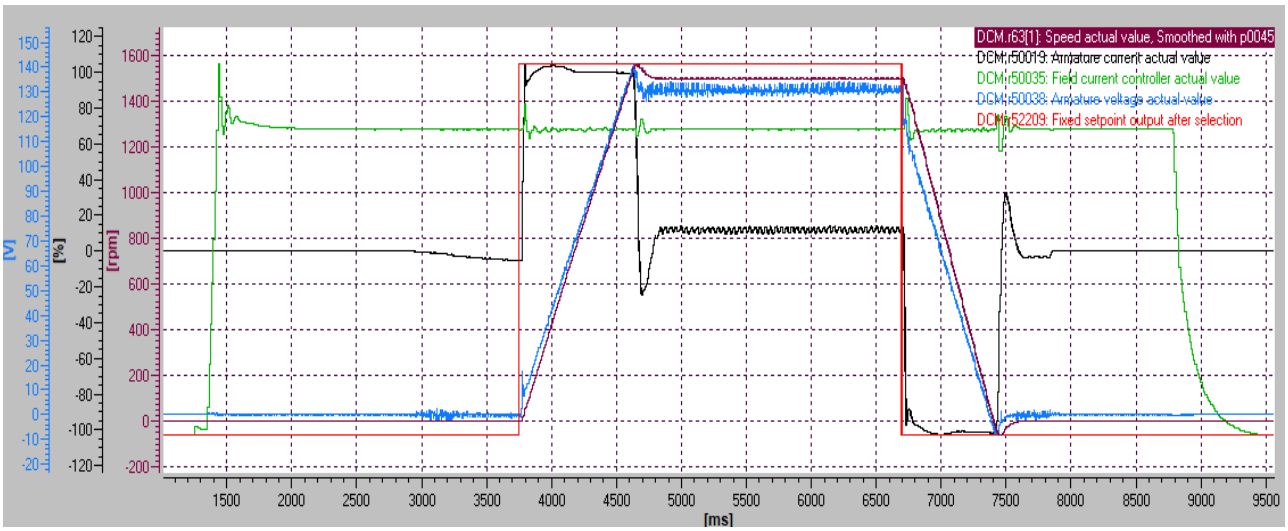

Figure 15. *Motor speed response: Speed reference (red), actual motor speed (purple), field current (green), armature current (black), armature actual voltage (blue).*

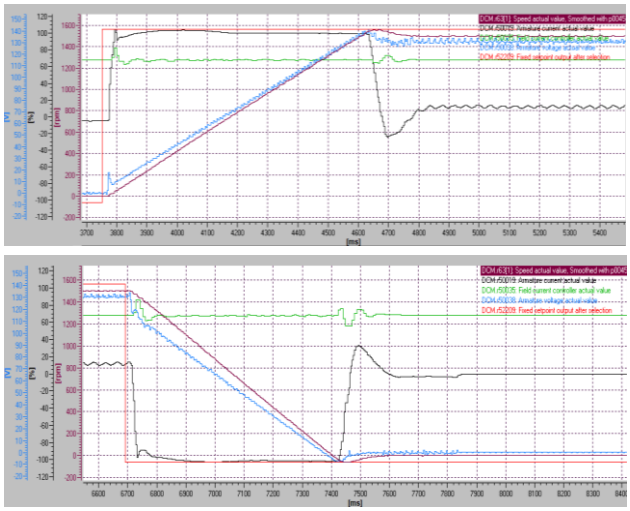

Figure 16. *Zoomed part of Fig. 15 – acceleration (top) and deacceleration (bottom)*

During the deacceleration motor operates in reverse current braking also known as plugging regime. In such case, *Armature voltage actual value* showed in Fig. 16. (bottom – blue line) represents back EMF of the machine, while armature voltage U_a has negative values in order to keep armature current at 1 p.u. The user can achieve desired acceleration and deacceleration time values by defining higher armature current limits or corresponding rump-up and rump-down time values for slower speed response.

By changing parameters in motor current and speed loop the user can observe and learn how each of the control parameters affects the current and speed response quality or compare it to the simulation results. This knowledge is very useful in situations where user have to tune controller manually on a base of experience.

5. CONCLUSION

The paper presents a laboratory setup with a DCM converter for DC drive. The setup allows students who follow the course of electric machines and drives to get familiar with the principles and possibilities of modern industrial controllers in DC drive. The commissioning of the DCM converter, parameters setting, drive optimisation and other laboratory activities that the student can perform with the described setup are presented throughout the work. The obtained results and responses of the DC drive at the optimally set current and speed control loop are presented and analysed at the end of the paper. Working on this setup, the student can try out and examine different operating regimes of the DC machine that exist in nowadays industrial exploitation.

ACKNOWLEDGEMENTS

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APPENDIX

Table 1. *DC machine SEVER ZIN.112N.S parameters*

I_{an} [A]	12	n_n [min^{-1}]	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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Cyber Security of Multi-vector Energy System with Demonstration of Tap Changer Position Estimation

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Abstract: *Multi-vector Energy System is shaped in the progress of optimizing different energy sectors' generation, distribution, transmission, conversion, storage and consumption and finally become an energy integration system. There are many valuable advantages of Multi-vector Energy Systems such as reducing carbon emissions, ensuring the security and reliability of energy supply, increasing renewable energy accommodation and improving the overall energy efficiency. Modern information and communication technology (ICT) and big data analytics are integrated in Multi-vector Energy Systems to satisfy the utilization of distributed energy sectors and the demand of multiple energy consumption. As massive sensors and complicated ICT network are widely applied, Multi-vector Energy System gradually become highly coupling Cyber Physical System (CPS). Therefore, Multi-vector Energy System is confronted with the threat of Cyber-attacks, which endanger the safe operation and information security of the system. In this paper, a typical cyber-attack, False Data Injection Attack (FDIA), is introduced and two cyber-attacks scenarios aimed at transformer tap position are analyzed. To avoid the FDIA from disturbing tap changer position measurement, a tap changer position estimation method is proposed and deployed in OPEN-3000 Energy Management System (EMS). Due to the limited resource, an improved tap changer position estimation method against FDIA is tested and the result is proved applicable.*

Keywords: *cyber-attack, false data injection, ICT, Multi-vector Energy System, state estimation.*

1. INTRODUCTION

Energy systems strongly support the development of society and economy. Energy systems rapidly promote innovation and living standard of modern life as a driving power. In industrial society, traditional fossil fuels including coal, oil, natural gas and others are the most common energy resources worldwide. Also, renewable energies are used more widely since energy industries revolution including wind power, tidal energy, biomass energy, solar energy, etc. Although the current global reserves of fossil fuels are adequate, the world may be faced with future risks such as severe environmental pollution and resource exhaustion since fossil fuels have been large-scale exploited and utilized over hundreds of years. Meanwhile, the categories and reserves of renewable energies are abundant, even more important they are clean and environmental-friendly. So, the prospect of renewable energy is bright.

1.1. Motivations

Existing energy infrastructures have been mostly installed for 20 to 50 years. Plenty of facilities are about to finish their designed lifetime also transmission systems are becoming congested as the energy demand increases. If these infrastructures fail to meet the future requirements, the upgrading is necessary. Besides, other problems push the revolution of the existing systems including restructuring power industry, accommodating more renewable energy, getting rid of the dependence on finite fossil fuels and becoming environmental-friendly.

At present, the research about Multi-vector Energy System are hot issue all over the world. Multi-vector Energy System contains multiple energy carriers including electricity, gas, heat and hydrogen, which are tightly coupled by distributed energy generation. Multi-vector Energy System brings many advantages such as increasing renewable energy accommodation, reducing carbon emissions, improving the overall energy efficiency and ensuring the security and reliability of energy supply.

As the rapid development of ICT technology and sensor technology, Multi-vector Energy System are made possible through high coupling of physical system and cyber systems, and gradually transform into a Cyber Physical System (CPS). This also means the combination of ICT and energy technologies. ICT system provides functions such

as monitoring and controlling meanwhile brings challenges to the cyber security of Multi-vector Energy Systems.

Because ICT infrastructures are situated in an open environment and the coupling mechanism between cyber system and physical system are very complicated, the cyber security gradually become a serious problem. Therefore, the cyber security concerns the safety and reliability of Multi-vector Energy Systems.

1.2. Literature review

Accompanying with the wide application of sensors and information communication technology (ICT) network, conventional energy system becomes a multi-dimensional diversified system, also known as Cyber-Physical System. Firstly, CPS provides various kinds of functions including information processing, real-time monitoring and dynamic controlling to the system operator. Secondly, more cyber security loopholes hidden in the vast information data flow in CPS have been exposed to cyber-attacks. Recently, Cyber-attacks aimed at CPS have resulted in some severe blackouts and cause the alert globally. However, only a few researches are studied on cyber-attacks aimed at CPS worldwide and extensive knowledge about cyber-attacks in concepts, means and scenarios is still in shortage.

Advanced metering infrastructure (AMI), demand response (DR), distribution automation (DA), transmission operation, and many other applications are supported by cyber system and these applications are the main attack targets in cyber-attacks. Cyber-attack scenarios typically exist in energy generation, transmission, distribution and consumption.

The cyber-attacks target at confidentiality, integrity and availability of data [1]. As a typical cyber-attack, false data injection attacks (FDIA) tamper with measurement data to break the integrity of data flow, which are accessible and concealed. These attacks can interfere analysis and decision-making of control center, thereby cause unexpected consequences. These attacks are great threats to system operation safety, for example, attackers injected false data into the Supervisory Control and Data Acquisition (SCADA) system of power grid in Ukraine in 2015. This attack also deleted and altered the data on hard disk, which make system operators lose the control of whole system and the fast recovery ability, therefore cascading failure are spread widely and difficult to recover [2-4].

FDIA frequently utilize the shortcomings of bad data identification in state estimation and maliciously tamper with the measured values of measuring instruments. Then the operator and control center misjudge system state, which could cause mal-operation or operation failure of power system automation devices, thus affecting the safety and stability of the system. As the increasing level of coupling between physical system and cyber system, the attack range of FDIA also expands. In general, attacks aimed at breaking the stability of system or obtain illegal profits by malicious tampering with measurement and control of information and communication equipment can be regarded as FDIA.

On-Load Tap Changing transformer (OLTC) are broadly utilized in electricity systems to control bus or node voltages [5-7]. Voltage control are carried out by changing reactive power flows due to the tight coupling between them [6]. The commands of changing tap changer position are transmitted as action signals through SCADA communication channels. However, cyber-attacks can compromise SCADA channels and inject malicious command of changing tap changer position [8-11].

Only a few researches are studies on the cyber-attacks aimed at voltage control [12-14]. Nevertheless, these incorrect control actions are caused by FDIA basically. The study focuses on the cyber-attacks aimed at 'centralized voltage control scheme' in distribution network [12]. In this study, the voltage measurements are vulnerable to malicious manipulation, leading to needless change of tap changer positions. Through the comparison between historical tap changer position behavior and current measurement, attacks can be detected. However, these attacks [12] cannot succeed in a system with state estimator. Because the bad data detection will filter out the false data injection as bad data based on redundant measurements. The attack model in [13] has the same restrictions with the attack model in [12]. In [13], it is assumed that the attackers have only gained the access of voltage measurements but not the power injection measurements. Hence, these cyber-attacks [12-13] cannot be carried out successfully in transmission networks due to the state estimation with bad data detection. It is discussed that cyber-attacks aimed at Automatic Voltage Control (AVC) software embedded in the Energy Management Systems (EMS) in transmission networks [14]. Given the voltage control system in [14], active and reactive power generation are solved by optimal power flow to be the control parameters. In [15], a false data injection aimed at malicious interfering the control process is detected by a reinforcement learning based approach.

The available literature about cyber-attacks concerning false command injection is lacking [16], [17]. In [16-18], it is reviewed that the attackers in 2015 Ukraine blackout event have gained the control of circuit breakers and disconnected some parts of the power grid. This is an example of cyber-attack caused by malicious commands in power grid.

1.3. Contributions

In this paper, a typical cyber-attack mode, False data injection attack (FDIA), is emphasized. Typical cyber-attack scenarios and some real cases are reviewed.

The original augmented state estimation for tap changer position estimation is improved. In addition, the effects of the improved method on the performances of state estimation and advanced analysis software are studied. The analysis shows that the improved tap changer position estimation method greatly enhances the accuracy and reliability of state estimation. Therefore, the reliability and practicability of power advanced analysis software are also improved.

The requirement for measurements configuration is more redundant and falsified tap changer position measurement is difficult to pass bad data identification module. The difficulty of breaking the reliability and security of power system is increased.

2. TRANSFORMER TAP CHANGER POSITION ATTACK SCENARIOS

The difference between cyber-attacks aimed at transformer tap changer control and FDIA lies in the attack targets. The control command is the main attack target in the former attacks but measurements in FDIA. Cyber-attacks aimed at tap changer control can be launched stealthily. In order to hide the malicious change in tap changer position, it is essential for the attacker to make the estimated and measured tap changer position consistent and its control parameters, that is, the bus voltage perform similar to the set values due to noise of measurements. This can be achieved by a selective injection of false data [19].

As the one line diagram shown in Figure 1, the tap ratio k can be varied by changing tap changer position, thereby control the voltage of bus i (Vi). Two cases of cyber-attacks aimed at transformer tap changer control are analyzed next.

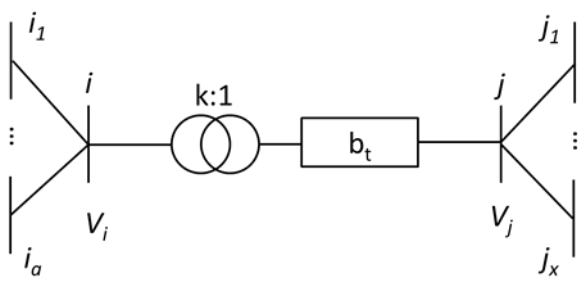

Figure 1. *An OLTC transformer simplified model with surrounding nodes.*

2.1. Case 1: Concealing Malicious change in tap changer position (tap ratio)

There are some steps to hide a malicious change in tap changer position (tap ratio). In the first place, attackers must tamper the measuring instruments relaying tap ratio messages. Secondly, only tampering with the tap ratio alone is not adequate to hide the attacks from bad data detection in EMS because adjacent measurements have quantitative relation with tap ratio k, which reveal true tap changer position. During bad data detection in state estimation, false tap changer position can be identified and submitted to notify system operator. Therefore, for the stealth of cyber-attacks, the listed measurements must be tampered synergistically:

- Active and reactive power injections of nodes i and j.
- Active and reactive power flows between nodes i and j.

2.2. Case 2: Concealing Malicious Change in Tap Changer Position and Related Bus Voltage

It is recognized that if attackers maliciously change the tap changer position, the bus voltage V_i will also change. If the bus voltage V_i is seriously deviated from its normal settings, detection procedure will be triggered. Hence, measurements having quantitative relation with both tap ratio k and bus voltage V_i must be tampered simultaneously to keep the cyber-attack fully concealed. In this situation, estimated and measured values of tap ratio k and bus voltage V_i can be kept consistent with the values derived from EMS. The following measurements must be altered in addition:

- The voltage measurement of bus i (V_i).
- Active and reactive power injections of nodes connected to node i.
- Active and reactive power flows between node i and adjacent nodes.

There are some common points between a concealed malicious attack aimed at tap changer position and an FDIA. The effects of attack in Case 1 are not obvious or even unobserved while tap changers coordinate with other parameters to fulfill certain goal such as minimizing reactive power loss. But when tap changers are regulated to maintain system voltages, the attack in Case 2 is qualified to stay concealed.

3. PROPOSED TAP CHANGER POSITION ESTIMATION

3.1. Original Estimation Method

The augmented state estimation method is commonly used to estimate transformer tap changer position. In augmented state estimation method, the parameters to be estimated are taken as parameter state variables, together with the original node state variables (node voltage vectors). Increasing the dimension of the state variables will decrease the redundancy of original measurements as well as the estimation accuracy. So, a more redundant measurement configuration is proposed to ensure the estimability of parameter

state variables. The measurement function of the power system can be written as

$$z = h(x) + v \tag{1}$$

z- m dimension measurement vector

x- n dimension state variable vector

v- m dimension measurement error vector

h(x)- m dimension nonlinear function vector, mathematical model of the system representing the relation between actual values of measurement and state variables.

In conventional state estimation, state variables are voltage (u_i) of all busbars and voltage phase angle (θ_i) of all nodes except slack bus node in the same electrical island. That is x=(u_1, θ_1, u_2, θ_2 … u_n) (n is slack bus, θ_n=0). Equation (1) can be rewritten as

$$z = \begin{bmatrix} h_1(u_{11}\theta_{11}u_{12}\theta_{12}\ldots u_{1n}) \\ h_2(u_{21}\theta_{21}u_{22}\theta_{22}\ldots u_{2n}) \\ \ldots \\ h_m(u_{m1}\theta_{m1}u_{m2}\theta_{m2}\ldots u_{mn}) \end{bmatrix} + v \tag{2}$$

In augmented state estimation, the unknown parameter P is considered as state variable (parameter state variable), equation (2) is reformed as below

$$z = \begin{bmatrix} h_1(u_{11}\theta_{11}u_{12}\theta_{12}\ldots u_{1n}P) \\ h_2(u_{21}\theta_{21}u_{22}\theta_{22}\ldots u_{2n}P) \\ \ldots \\ h_m(u_{m1}\theta_{m1}u_{m2}\theta_{m2}\ldots u_{mn}P) \end{bmatrix} + v \tag{3}$$

As long as the configuration of measurements satisfies the requirements of estimability, parameter state variables can be multiple. The optimal solution of the augmented state variables vector can be solved by weighted least square estimation method. The iteration equation of the weighted least square method is

$$H_a^T R^{-1} H_a \Delta x_a = H_a^T R^{-1} \Delta Z \tag{4}$$

H_a is augmented Jacobian matrix, its elements can be figured by equation below

$$H_{aij}(x_a) = \frac{\partial h_i(x_a)}{\partial x_{aj}} \tag{5}$$

The difference between augmented state estimation and conventional state estimation is the augmentation of dimensions of state variable vector, meaning the augmentation of row in Jacobian matrix. Given a start condition $x_a^{(k)}$, follow the equation below

$$\Delta Z^{(k)} = Z - h\left(x_a^{(k)}\right) \tag{6}$$

Substitute the value of $\Delta Z^{(k)}$ into (4). Corresponding $\Delta x_a^{(k)}$ can be resolved.

$$x_a^{(k+1)} = x_a^{(k)} + \Delta x_a^{(k)} \tag{7}$$

Follow the equations above, state variables can be iterated until convergence. k is the number of iterations.

3.2. Improved Tap Changer Position Estimation Method

OLTC transformer is modelled as Pi-equivalent circuit [20], similar to transmission lines. In Pi-equivalent circuit, the shunt and series admittances are functions of tap ratio k. The simplified model of OLTC transformer in Figure 1 can be represented by a Pi-equivalent model in Figure 2. In the Pi-equivalent model, the equivalent admittances are shown as below

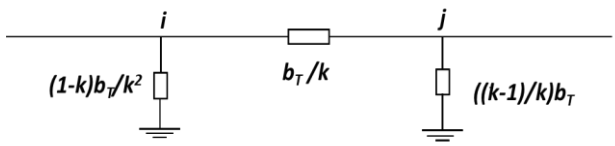

Figure 2. *Pi-equivalent model of OLTC transformer.*

$$P_i = \sum_{j=1}^{n} U_i U_j (G_{ij} \cos\theta_{ij} + B_{ij} \sin\theta_{ij}) \tag{8}$$

$$Q_i = \sum_{j=1}^{n} U_i U_j (G_{ij} \sin\theta_{ij} - B_{ij} \cos\theta_{ij}) \tag{9}$$

The power flow from node *i* to node *j* is

$$P_{ij} = -\frac{1}{k} U_i U_j b_T \sin\theta_{ij} \tag{10}$$

$$Q_{ij} = -\frac{1}{k^2} U_i^2 b_T + \frac{1}{k} U_i U_j b_T \cos\theta_{ij} \tag{11}$$

The power flow from node *j* to node *i* is

$$P_{ji} = \frac{1}{k} U_i U_j b_T \sin\theta_{ij} \tag{12}$$

$$Q_{ji} = -U_j^2 b_T + \frac{1}{k} U_i U_j b_T \cos\theta_{ij} \tag{13}$$

According to the principle of augmented state estimation, *K* is considered as parameter state variable. Also, elements in Jacobian matrix are shown as below due to the principle of fast decoupled state estimation.

$$\frac{\partial V_i}{\partial K} = 0 \tag{14}$$

$$\frac{\partial P_i}{\partial K} = 0 \tag{15}$$

$$\frac{\partial P_j}{\partial K} = 0 \tag{16}$$

$$\frac{\partial Q_i}{\partial K} = \frac{U_i}{k^2} b_T \left(\frac{2U_i}{k} - U_j\right) \tag{17}$$

$$\frac{\partial Q_j}{\partial K} = -\frac{1}{k^2} U_i U_j b_T \tag{18}$$

$$\frac{\partial P_{ij}}{\partial K} = 0 \tag{19}$$

$$\frac{\partial P_{ji}}{\partial K} = 0 \tag{20}$$

$$\frac{\partial Q_j}{\partial K} = \frac{1}{k^2} U_i b_T \left(\frac{2U_i}{k} - U_j\right) \tag{21}$$

$$\frac{\partial Q_i}{\partial K} = -\frac{U_i U_j}{k^2} b_T \tag{22}$$

The gain matrix in the weighted least square estimation is written as below.

$$H^T R^{-1} H = \begin{bmatrix} A & 0 \\ 0 & B \end{bmatrix} \tag{23}$$

$$A = U_0^4 \left[(-B_a)^T R_a^{-1} (-B_a) \right] \tag{24}$$

$$B = U_0^4 \left[(-B_r)^T R_r^{-1} (-B_r) \right] \tag{25}$$

$$\frac{\partial h_a}{\partial \theta} = -U_0^2 B_a \tag{26}$$

$$\frac{\partial h_r}{\partial U} = -U_0^2 B_r \tag{27}$$

From (14) to (22), parameter state variable K has no influence on P-θ type Jacobian matrix B_a, B_a is still a constant matrix. Therefore, only Q-V type Jacobian matrix B_r need to be reformed each iteration. Compared to augmented state estimation, the simplified method in fast decoupled state estimation is adopted with faster computing speed and less storage usage and higher convergence precision.

Due to the increase of state variables in matrix B_r, measurements configuration is required to be more redundant, that is, reactive power flows and voltage magnitudes must be measured on primary and secondary side of the estimated transformer.

After estimating the value of K, the estimated tap changer position can be examined by the range of transformer tap changer position, tap changer position of rated voltage and step of tap changer.

4. PERFORMANCE EVALUATION

4.1. Current Situation of Tap changer position Estimation

Table 1 shows the tap changer position estimation comparison between artificial pseudo tap changer positions and estimated tap changer positions before applying improved tap changer position estimation method. The tap changer positions in column 'Artificial Pseudo Tap changer position' are collected by verification of on-site operators and set pseudo measurement manually. The tap changer positions in column 'Estimated Tap changer position' are estimated by state estimation method before improvement. From the comparison, the accuracy of original tap changer position estimation is proved to be not ideal.

Table 1. *Comparison between artificial pseudo tap changer positions and estimated tap changer positions.*

Station ID	Voltage Type (High-Mid-Low winding)	Artificial Pseudo Tap Position	Estimated Tap Postion
TWA	13.8kV/4.16kV	2	3
TWA	13.8kV/4.16kV	2	3
DAS	34.5kV/1kV	3	4
DAS	34.5kV/1kV	3	4
BOT	230kV/69kV/13.8kV	9	11
BOT	230kV/69kV/13.8kV	9	11
BOT	230kV/69kV/13.8kV	9	11
BAY	69kV/13.8kV	2	3
BAY	69kV/13.8kV	2	3
BNG	69kV/13.8kV	2	3
BNG	69kV/13.8kV	3	2
MLL	69kV/13.8kV	3	2
MLL	69kV/13.8kV	3	2
ANG	115kV/13.8kV/13.8kV	5	6
ANG	115kV/13.8kV/13.8kV	5	6
ANG	115kV/13.8kV/13.8kV	5	6
BAN	115kV/69kV/13.8kV	8	9
BAN	115kV/69kV/13.8kV	8	9
BAN	115kV/69kV/13.8kV	8	9
CLR	115kV/13.8kV	2	3
CLR	115kV/13.8kV	2	3
CUR	115kV/69kV/13.8kV	2	3
CUR	115kV/69kV/13.8kV	11	9
CUR	115kV/69kV/13.8kV	11	9

4.2. Test Substation Details

YUCI substation, with one line diagram shown in Figure 3, is taken as an example.

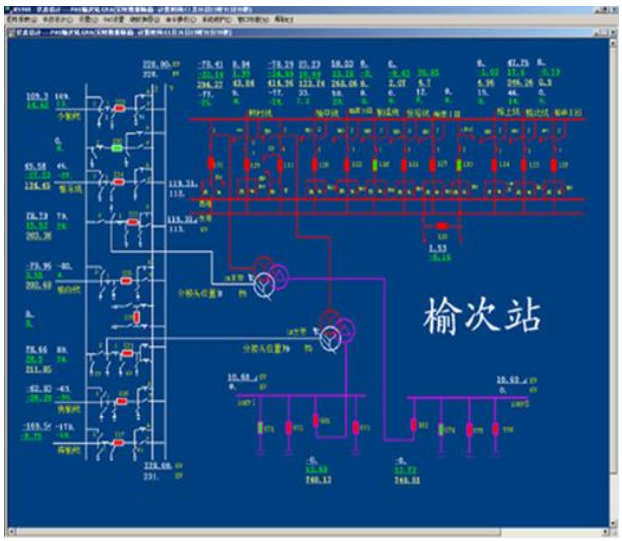

Figure 3. *One Line Diagram of YUCI substation.*

SE sections using original tap changer position estimation and the improved tap changer position estimation are both calculated and saved based on same SCADA section. The redistribution of SE power flow is used to verify which tap changer position estimation has more consistency with the actual tap changer position and higher state estimation eligible ratio at the same time. Thus, the rationality and practicability of the improved tap changer estimation method are verified.

At first, some basic topology and devices parameters in YUCI substation are introduced. The highest voltage level in YUCI substation is 220kV. The 220kV and 121kV busbar connection is double-busbar (DB). For 220kV side, 221 is the 220kV circuit breaker of 1# transformer, 222 is the 220kV circuit breaker of 2# transformer, 230 is the bypass circuit breaker and 220 is the bus-tie circuit breaker. For 121kV side, 131 is the 121kV circuit breaker of 1# transformer, 132 is the 121kV circuit breaker of 2# transformer, 130 is the bypass circuit breaker and 120 is the bus-tie circuit breaker.

The parameters of two transformers in YUCI substation are shown as below.

Table 2. *The parameters of two transformers in YUCI substation.*

	Rated Capacity (MW)			Rated Voltage (kV)		
	H	M	L	H	M	L
1# TR	150	150	150	220	121	10.5
2# TR	150	150	150	220	121	10.5
	Percentage of short-circuit voltage			Short-circuit loss		
	H-M	H-L	M-L	H-M	H-L	M-L
1# TR	13.4	23	7.53	628	783.6	535.6
2# TR	13.5	23.3	7.69	626	793.5	522.1
	OLTC	Min Tap	Max Tap	Nom Tap	Tap Step	Connnection
1# TR	Y	1	19	10	1.06	Y0-Y0-△
2# TR	Y	1	19	10	1.06	Y0-Y0-△

4.3. Comparison of SE Power Flow Sections

Two separated state estimation calculation are respectively conducted using original tap changer position estimation and the improved tap changer position estimation based on the same SCADA historical section. The diagram and data sheet of power flow in YUCI substation are saved and compared as it is given in Table 3.

Due to the wrong tap changer position estimation, state estimator gives the ineligible point statistics in YUCI station. As shown in Table 4, the active and reactive power flow distribution of state estimation is interfered by the wrong tap changer position estimation.

It can be concluded from Table 3 that two methods are adopted using the same SCADA section at the same time and the actual power flow remains unchanged. While the estimated value of tap changer position is different, power flows are redistributed. Comparison of estimated tap changer position using two methods is shown in Table 5. It can be seen that improved tap changer position estimation method is more consistent with actual tap changer position and substation measurement error is less. Therefore, the state estimation power flow section in YUCI substation is more consistent with the actual situation.

Table 3. *Comparison of power flows using two tap changer position estimation.*

	SCADA data	SE data	
		Original Tap Changer Position Estimation	Improved Tap Changer Position Estimation
1# TR Tap Position	4	8	4
2# TR Tap Position	4	8	4
223	76+j3	76.1+j3.5	74.5+j2.35
230	0+j0	0+j0	0+j0
224	-19-j18	-18.9-j17.5	-18.2-j18.5
222	64+j12	64.3+j8.42	65.9+j9.19
225	-79+j25	-78.5+j25.4	-78.5+j25.4
220	0+j0	0+j0	0+j0
221	66+j12	64.9+j5.32	65.4+j6.5
226	58-j50	58.04-j41.67	52.3-j41.34
227	-166+j14	-165.9+j16.4	-163.1+j16.5
132	-63-j15	-63.9-j15.6	-63.9-j15.6
125	9+j0	8.86+j1.03	8.82+j1.22
131	-63-j15	-64.6-j13.1	-65.1-j14.9
128	6+j0	6.02+j0.45	5.97+j0.94
122	52+j16	52.8+j15.8	52.4+j17
126	0+j0	0.01-j0.01	0.01-j0.01
121	0+j0	0.01-j0.38	0.01-j0.41
127	12+j0	11.2+j0.01	12.4+j0.26
130	0+j0	0+j0	0+j0
124	9+j2	0.01-j0.91	0.01-j0.98
123	49+j13	49.7+j12.9	50.3+j14.1
129	0+j0	0.01-j0.17	0.01-j0.18
220kV 1# Bus Voltage	231kV	231kV	231kV
220kV 2# Bus Voltage	233kV	231kV	231kV
110kV 1# Bus Voltage	111.97kV	116kV	115.84kV
110kV 2# Bus Voltage	112.22kV	115kV	116.09kV

Table 4. *Ineligible Data Statistics in YUCI Station.*

SE Ineligible Measurements	Measurement Points
Ineligible P measurement	Line: YUQIAN I, Error: -8.63, Standard Error: 7.57
Bad Data P measurement	Line: YUBEI, Error: 11.77, Standard Error: 10.33
Ineligible P measurement	Line: YUCI 124, Error: 9.00, Standard Error: 7.89
Ineligible Q measurement	Transformer 2# 121kV winding, Error: -6.1, Standard Error: 5.35
Ineligible V measurement	110kV 1# Busbar Voltage, Error: -3.85, Standard Error: 2.92
Ineligible Q measurement	Transformer 1# 121kV winding, Error: 5.46, Standard Error: 4.79

Table 5. *Comparison of Estimated Tap Changer Position Using Two Methods.*

	Actual Tap Position (1#/2#)	Estimated Tap Position (1#/2#)	Substation Measurement Error Statistics
Original Tap Changer Position Estimation Method	4/4	8/8	4.166%
Improved Tap Changer Position Estimation Method	4/4	4/4	2.012%

4.4. The Impacts on Performance of Power Advanced Software

Then, an important index of state estimation, System Eligible Ratio, is introduced to judge the influence of different tap position estimation methods on state estimation. System Eligible Ratio is calculated by equation as below.

$$\text{System Eligible Ratio} = \frac{Eligible\ Points}{Total\ Measurement\ Points} * 100\%$$

System Eligible Ration reflects the performance of state estimator. A higher System Eligible Ration means the state estimation power flow section is more consistent with the actual power flow.

The upper section in Figure 4 shows the comparison of the SE daily eligible ratio curves using two

different tap changer position estimation methods. The red curve shows the SE daily eligible ratio curve using improved tap changer position estimation method. The blue curve shows the SE daily eligible ratio curve using original tap changer position estimation method. The SE daily eligible ratio is raised from 90% (blue curve) to around 95% (red curve), also SE calculation keep convergent all day, which greatly improves the performance of the state estimation module.

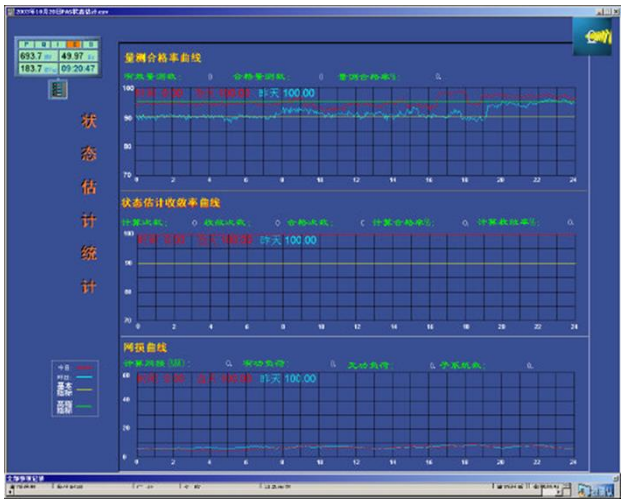

Figure 4. *SE daily eligible ratio curve.*

Table 6 shows the SE calculation statistics using two tap changer position estimation methods based on the same SCADA daily section. When eligible ratio >= 90%, the result of this state estimation calculation is considered qualified to be used by other advanced power software, such as Dispatching Power Flow, Contingency Analysis.

Table 6. *SE calculation statistics using two tap changer position estimations.*

	Eligible Measurement Points	Daily Eligible Ratio (%)	Number of Calculation	Number of Convergence	Number of Qualification	Qualification ratio (%)
Original Method	411	90.73	4265	4265	3967	93.01
Improved Method	428	95.86	4302	4302	4089	95.05

State estimation is calculated based on SCADA real-time telemetry and status in order to obtain a relatively accurate and complete run mode. At the same time, SE verifies SCADA measurements and puts forward the possible abnormal measurement points. The power flow sections of state estimation can be used by power advanced analysis software in real-time mode and historical mode. For example, Dispatcher Power Flow (DPF) can simulate the change of operation mode based on specific SE section and replay the failure situation. Besides, Contingency Analysis can help system operators to find the potential risks if one component is outage resulting in overload or load shedding, which is also simulated based on specific SE section. In summary, improved tap changer can increase the accuracy and reliability of state estimation and other advanced analysis software based on SE to meet the goal of safety and economy, improve the voltage quality and reduce the network loss in power system.

5. CONCLUSION

The process of tap changer position estimation is introduced, and the effect of the improved method is analyzed. The example proves that the improved tap changer position method is more consistent with the actual tap changer position, which is practical. The impact of improved transformer tap changer position estimation method on the performance of the state estimation and other power advanced software. The analysis shows that improved method has greatly enhanced the performance of each module.

The requirement for measurements configuration is more redundant in improved tap changer position estimation method, that is, reactive power flow and voltage magnitude must be measured on primary and secondary side of the estimated transformer. False tap changer position measurement is difficult to pass bad data identification module because this tap changer position needs to be consistent with reactive power flow and voltage magnitude. Therefore, cyber-attackers have to gain access to more relevant measurement at the same time to implement FDIA. The difficulty of breaking the reliability and security of power system is increased.

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Simulation and Analysis of Multi-Vector Energy Systems and Relevant ICT Networks

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Abstract: *This paper illustrates a simulation of a dual-energy system, which is combined of distributed electricity and heat network, in MATLAB (version R2018a). The electrical system is a single line network, which consists of 4 buses and 1 distributed generator. The heat network is a hydrothermal system with a circle line structure. It has 2 pipes (supply & return pipe), 2 loads and 1 heat source. These two energy systems are coupled via Combined Heat & Power linkage (CHP). Simulation with Different linkage components (CHP, Heat Pump, Circulation Pump) are compared and then validated in IPSA. Then a communication system (CS) for this dual-energy network is modeled in Network Simulator 3 (NS-3 version 3.30.1). The CS is based on Multiprotocol Label Switching (MPLS) network. The topology of this ICT network is composed of 9 terminals, 4 switchers and 1 control center. All channels are based on Carrier Sense Multiple Access protocol (CSMA). A combined analysis of the energy and ICT network explores the effects of packet drops and packet delay.*

Keywords: *Combined heat & power (CHP), Communication system (CS)Multi-energy, Multiprotocol Label Switching (MPLS), Package drop & delay, State estimation (SE).*

1. INTRODUCTION

In conventional industry, various energy networks, like electricity, gas, heat, water etc. are usually independent systems without affecting others. With the development of industrial integration technology, in order to achieve the requirement of high efficiency, appropriate economy and low Greenhouse Gas emission, the concept of multi-vector energy systems is proposed. In such a system, separate energy systems and different energy vectors will be coupled and cooperate via some linkage interfaces, like CHP, CCGT, Heat/Cooling pump etc. As a result, different single system can be considered as a whole system to apply power flow calculation and SE. Various energy systems can cooperate and interact to make the most of energy storage and dispatch, which would improve the flexibility as well as the reliability of the whole system.

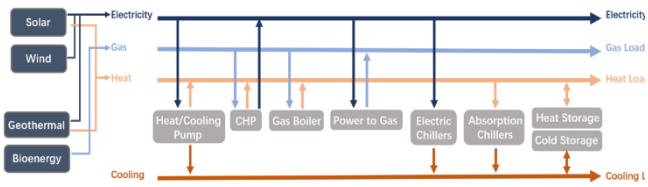


Figure 1. *Diagram of an integrated multi-vector ene8rgy system*

With the development of the power systems, the demands for more efficient and reliable Information and communication technology (ICT) are increasing. Communication systems (CS) is one of the key parts in the Smart Grid, which is also known as cyber-physical power system (CPS) [1]. For energy networks, ICT can make data information and instructions visualized and flow bidirectionally between nodes in systems and between infrastructures and users. It is the guarantee for information, monitoring, control, and protection, which helps to control and coordinate energy networks in multi-vector systems [2]. The main goals of the ICT network can be summarized as follow:

- Making real-time operation to dispatch power efficiently
- Identifying certain aspects related to operation planning such as operation point, working margin, and fault level.
- Identifying the energy flow in systems, like the power generation, power consumption, energy conversion etc.

The ICT systems will be set up based on several internet protocols, such as the Label Distribution protocol (LDP), Multiprotocol Label Switching (MPLS), Carrier Sense Multiple Access & Collision detection (CSMA/CD), etc., which will enable the ICT

networks to label data packets, retrieve the packets' labels, and distribute packets. With the data collection from the phasor measurement units (PMU), the remote terminal units (RTU) and smart meters connected to the ICT network (or SCADA), state estimation (SE) could be carried out. With optimal ICT systems, SE can be more accurate, which can help to locate the energy system working point, analyze operating characteristics, adjust operation plan and predict future peak time and potential fault level. Since the interdependency between CS and energy grids is getting stronger, it is necessary to do some research on the impact of communication network on power systems, such as packet drop & packet delay.

2. DUAL VECTOR ENERGY SYSTEM'S SIMULATION

This paper illustrates a simulation of a dual-vector energy system, as shown in Fig. 2. This integrated energy network combined a distribution electricity network and a district heating network. These two energy systems are coupled by a linkage unit, which consists of CHP, heat pump and circulation pump. There is only one coupling linkage, which means the energy conversion is unidirectional rather bidirectional.

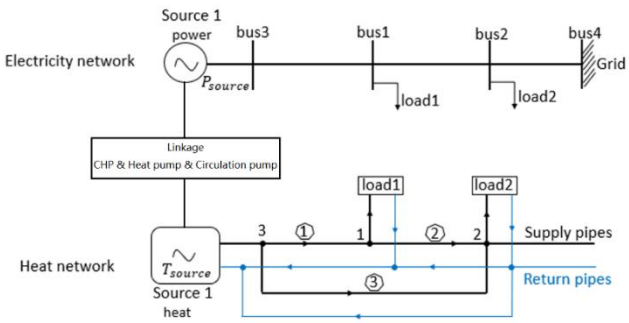


Figure 2. *An electricity and heat combined dual-vector energy system with radial topology*

The power flow direction is from the hydrothermal network to the electricity network. The return heat power of the heat source will be transferred into electricity power via linkage point, which will be regarded as the input to electricity network.

2.1. Electricity networks

The typical computation approach of the power flow is Newton-Raphson, which provides an iterated calculation method for this problem. First, the objective function should be set up. For a single bus, the power balance should be:

$$\dot{S}_{injected} = P_{injected} + jQ_{injected} \quad (1)$$

$$\dot{S}_{injected} = \dot{V} \cdot \dot{I}_{injected} = \dot{V} \cdot \sum_{i\epsilon n} \dot{Y}^* \cdot \dot{V}^* \quad (2)$$

$\dot{}$ represents a vector, $S_{injected}$, $P_{injected}$ & $Q_{injected}$ are the apparent power, active and reactive power injected in the relative nodes, j is the sign of imaginary part, V is the voltage magnitude, $I_{injected}$ is the injected current, Y is the admittance matrix of the relative nodes.

The expression of voltage can be rewritten as:

$$\dot{V} = V\angle\theta \quad \& \quad \dot{V}^* = V\angle -\theta \quad (3)$$

Substitute the equation (3) into equation (2) to get:

$$\dot{S}_{injected} = \sum_{i\epsilon n} V_k V_i (G_{ki} cos\theta_{ki} + B_{ki} sin\theta_{ki}) + j\sum_{i\epsilon n} V_k V_i (G_{ki} sin\theta_{ki} - B_{ki} cos\theta_{ki}) \quad (4)$$

G_{ki} is the conductivity between node k and node i, B_{ki} is the susceptance between the node k and node i. (it should be noticed that node k and node i are connected)

Therefore, the objective function of the power flow is established as:

$$\Delta F = \begin{bmatrix} \Delta P_{k,injected} \\ \Delta P_{Q,injected} \end{bmatrix} = \begin{bmatrix} \sum_{i\epsilon n} V_k V_i (G_{ki} cos\theta_{ki} + B_{ki} sin\theta_{ki}) - P_{k,injected} \\ \sum_{i\epsilon n} V_k V_i (G_{ki} sin\theta_{ki} - B_{ki} cos\theta_{ki}) - Q_{k,injected} \end{bmatrix} \quad (5)$$

ΔF represents the mismatch function.

2.2. Heating networks

2.2.1. Hydraulic model:

In hydraulic model, there are flow continuity and loop pressure formulas for water mass flow rates and pressure head loss calculation, which has the similar forms and functions to Kirchhoff's laws in electrical model [5]. The flow continuity function is used to clarify the relationship between water mass flow consumption and input/output mass flow at relative nodes, which is similar to the Kirchhoff's current law [6]

$$\sum \dot{m}_{input} - \sum \dot{m}_{ouput} = \dot{m}_q \Rightarrow A\dot{m} = \dot{m}_q \quad (6)$$

$\dot{m}_{input}$ and $\dot{m}_{ouput}$ are the input/output water mass flow rates (kg/s), $\dot{m}_q$ is the water mass flow rates (kg/s) at relative nodes, A is direction matrix (The rows and columns in matrix A refer to the number of nodes and pipes [7], +1/-1 represents the mass flow direction is input/output, 0 represents the mass flow is not relevant to the node).

Due to the friction, the water pressure will change with transmission distance along the pipe. The per meter difference of pressure is called head loss [7]. It should be noticed that the total head loss should be zero when the system is in a closed loop. The loop pressure equation is:

$$\sum h_f = Bh_f = BK\dot{m}|\dot{m}| = \sum_{j=1}^{n_{pipe}} B_{ij} K_{ij} \dot{m}_j |\dot{m}_j| = 0 \quad (7)$$

h_f is head loss (m) in plumbing, K is the resistance coefficient of pipes, i is the sequence of loops, j is the sequence of pipes, B is the direction matrix (The rows and columns in matrix B refer to the number of loops and pipes [7], +1/-1 represents the mass flow direction is same/opposite to defined).

2.2.2. Thermal model:

Compared to the hydraulic model, thermal model is a little more complex with more unknown variables and known conditions. The temperature of both supply pipes and return pipes are denoted as T_s and T_r respectively. Besides that, another scalar is also provided, which is the temperature of the outlet line from the heating load and it is denoted as T_o [6]. Generally, T_s and T_r of the heating supply source are known. Besides, T_o of each load nodes also should be a known variable, as it will be used to calculate the T_s and T_r of load nodes. The relationship between T_o and T_s on the load node can be described as below [8]:

$$\emptyset = C_p \dot{m}_q (T_s - T_o) \tag{8}$$

$\emptyset$ is the heat power of the nodes, C_p is the default water specific heat capacity (J/kg℃), $\dot{m}_q$ is the mass flow rates (kg/s) of the load nodes ($\dot{m}_q$ is also an unknown variables), T_s/T_o is the temperature (℃) of the supply/outlet pipes connected to the load nodes.

Due to the heat loss in the form of heat exchange or heat radiation during the transmission, the temperature will change along the pipes. Thus, the temperature drop formula is needed:

$$T_{end} = (T_{start} - T_a) e^{-\frac{\lambda L}{C_p m}} + T_a \tag{9}$$

T_{end}/T_{start} is the temperature (℃) of the pipe's end/start, T_a is the environmental temperature (℃), λ is the per unit heat loss coefficients (W/(m K)) along the pipes, L is the pipe length (m).

For some nodes, there are over two input pipes connected to it. These kinds of nodes are called mixed nodes and the equation (9) is no longer effective to them [9]. For the mixed nodes, the temperature calculation should be:

$$\left(\sum \dot{m}_{output}\right) T_{output} = \sum (\dot{m}_{input} T_{input}) \tag{10}$$

T_{output}/T_{input} is the mixed temperature (℃) at the output/input of the mixed node.

2.3. Dual-vector energy networks

2.3.1. Coupling linkage model:

For CHP units, the energy conversion is from heat to electricity. The ratio of heat-to-power is determined by the input heat power and output electrical power, which is normally a constant value:

$$C_m = \frac{\emptyset_{CHP}}{P_{CHP}} \tag{11}$$

C_m is the heat-to-power conversion ratio, $\emptyset_{CHP}$ is the output heat power (MW), P_{CHP} is the output electrical power (MW).

For heat pumps, the heat can be transmitted from area with low temperature to high temperature via air compressor [10]. The efficiency function of the heat pumps is :

$$COP = \frac{\emptyset_{HP}}{P_{HP}} \tag{12}$$

COP is the efficiency coefficient, $\emptyset_{HP}$ is the heat power (MW) supplied by heat pumps, P_{HP} is the electrical power (MW) consumed by heat pumps.

For circulation pumps, it is used for maintaining the promising water pressure to drive the circulation of water flow [11]. The circulation pump is driven by electricity, which can be regarded as an electrical load, and the power function is [12]:

$$P_{CP} = \frac{\dot{m}_{CP} \cdot g \cdot H_{CP}}{10^6 \cdot \eta_{CP}} \tag{13}$$

P_{CP} is the power consumption (MW) of the circulation pumps, H_{CP} is the head loss (m) of the circulation pumps, η_{CP} is the efficiency of the circulation pump.

For CHP & heat pump combined linkages, the conversion ratio of heat-to-power is:

$$C_m{}' = \frac{\emptyset_{source}}{P_{source}} = \frac{\emptyset_{CHP} + a P_{CHP}\, COP}{(1-a) P_{CHP}} \tag{14}$$

Substitute the equation (12) into equation (14):

$$C_m{}' = \frac{\emptyset_{source}}{P_{source}} = \frac{C_m + a\, COP}{(1-a)} \tag{15}$$

P_{source} is the output electrical power (MW) of the combined linkage, $\emptyset_{source}$ is the output heat power (MW) of the combined linkage, a is proportion of the electricity produced by CHP, $C_m{}'$ is the heat-to-power ratio of the combined linkage.

The function of the combined coupling linkage can be expressed as:

$$P_{source} = \begin{cases} \frac{\emptyset_{source}}{C_m} & CHP \\ \frac{\emptyset_{source}}{C_m} - P_{CP} & CHP \cdot Circulation\ pump \\ \frac{\emptyset_{source}}{C_m{}'} - P_{CP} & CHP \cdot Circulation\ pump \cdot Heat\ pump \end{cases} \tag{16}$$

2.3.2. Integrated energy networks model:

In this dual-vector energy network, the unknown variables and initial conditions are:

Table 1. *Initial conditions and unknown variables of the dual-energy network*

Variables	Initial conditions	Unknown values
Voltage magnitude	$\lvert V_3 \rvert$ $\lvert V_4 \rvert$	$\lvert V_1 \rvert$ $\lvert V_2 \rvert$
Voltage angle	θ_4	θ_1 θ_2 θ_3
Active power	P_1 P_2	P_3 P_4
Reactive power	Q_1 Q_2	Q_3 Q_4
Mass flow rate		$\dot{m}_1$ $\dot{m}_2$ $\dot{m}_3$
Supply temperature	T_{s3}	T_{s1} T_{s2}
Return temperature	T_{o1} T_{o2}	T_{r1} T_{r2} T_{r3}
Heat power	ϕ_1 ϕ_2	ϕ_3

For integrated method, the hydraulic equations, thermal equations and electrical power flow equations are analyzed and solved simultaneously by Newton-Raphson method [6]. As a result, there will be only one matrix of objective functions, and only one Jacobian matrix.

3. ICT NETWORK SIMULATION

3.1. Protocols and concepts of ICT

3.1.1. Label:

A data packet will be labeled before forwarding to the next hop. The information involved by the label is the attributes of the date, including data types, data length, data forwarding method, data processing method, etc. The label attached to the data, is an index to indicate the next hop for the transmitted data. The label will be updated after each hop [13].

3.1.2. Label distribution protocol (LDP):

The Label Distribution Protocol (LDP) is used to establish Multiprotocol Label Switching networks (MPLS) and Label switched path (LSP). There are many routers in the communication networks. Following the existing IP routing table, LPD can be utilized to set up LSP. The basic service of LDP is pseudo-wire, which can be used to simulate nearly every type of wired service. Besides, it can carry almost any kind of data flow.

3.1.3. Label switched path (LSP):

The label switched path (LSP) is the path through the MPLS networks. It is usually established by network transmission protocols, such as LDP, for different purposes. Sometimes, the path is established to create IP virtual private networks, or to guide the data flow through particular paths. Generally speaking, LSP can be regarded as the tunnels between the routers in networks. The LSP is unidirectional. Therefore, it usually set up dual LSP systems to realize the bidirectional communication [14].

3.1.4. Multiprotocol label switching (MPLS):

Multiprotocol Label Switching is a technique rather a service. It can deliver nearly anything from IP VPNs to Ethernet. In conventional internet, when a router receives IP packets, it will only receive the information about the destination, without any other message about how to deliver it. It slows down the data flow speed significantly, since every distribution of the router should refer to the complex routing tables. It will impact some data required high quality, like IP video data.

MPLS will establish pre-determined routes at the beginning of the data transmission process. When the data packet is produced, a label will be attached to it, which involves the forwarding equivalence class (FEC). All the routers in the network have the FEC table. Once the packet starts to be delivered, routers will use the label as index for the FEC table, rather than carry out header analysis. In this way, MPLS networks are able to process packets with specific characteristics in a consistent method, thereby reducing network-wide routing delays. MPLS can only operate after the establishment of LSP. And the key point of the MPLS is the label. The MPLS label is composed of four components, Label, Experimental, Bottom-of-stack, Time-to-live [15].

3.1.5. Carrier sense multiple access/Collision detection (CSMA/CD)

Carrier sense multiple access creates a regulation, which determines the communication methods in a shared communication media. The collision detection is an extension of the CSMA, which determines the solutions for transmission collisions. Transmission collision means several terminals are trying to send data packets through a same channel.

During the process, the station monitors will supervise the data channel. Only when the channel is free, the station will start to send data packet. Then the transmitter will keep monitoring the channel to check the data collisions. If there is no collision, the data transmission will be successful. However, if collisions occur, the station will stop immediately, and begin to send interferential signal (Jam signal) to inform other stations. The stations will then wait for another appropriate time to try it again [16].

3.2. ICT for energy networks

In the distribution network of electrical systems, the plenty of sensors are the main source of electrical data. Generally, these kinds of sensors are some synchro-phasors monitoring units, such as the phasor measurement units (PMU) and the remote terminal unit (RTU). These synchro-phasor measurement units can actively obtain the real-time data with the rate of 10-60 samples per second [17].

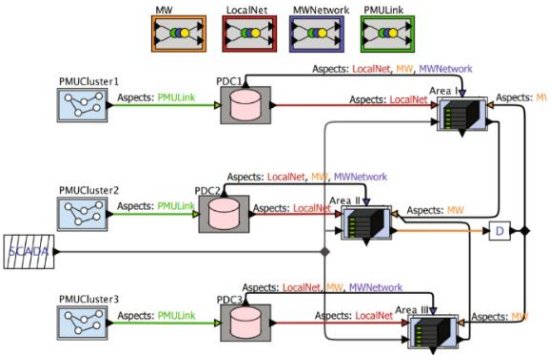


Figure 3. *A typical framework of the ICT network for a distribution network [17]*

From the Figure 3, there are three aspects of the ICT network model with different topology.

For the LocalNet, it models the inter-area links as a server with probabilistic delay characteristics, which involves three kinds of communication links:

- PDC to Area: Local area links are used for PMU readings sending to areas used in distributed network.
- PDC to Middleware: The links used for sending PMU data to middleware layer for data collection and SE.
- Area to Area: P2P connection between areas. The connections determine the topological layout of adjacent areas in power grid.

For the MWNetwork, it models the network connecting PDCs to middleware (MW). In the Figure 4.3, this layer provides a channel to carry the PMU data to middleware.

For PMULink, it is an aggregation of links connecting each PMU to local PDC.

3.3. NS3

In this paper, the simulation of the ICT network will be modeled in NS3 (version 3.30.1). NS3 is a discrete-event network simulator [18]. It mainly focuses on the research of the communication protocols and networks. The motivation of the NS3 is to establish a solid simulation core that is easy to model and debug. It can be interconnected with real world and allow the real internet protocols to be implemented in NS3.

4. SIMULATION RESULTS AND DISCUSSION

4.1. Modelling of the dual-vector energy network

The iteration of the Newton Raphson in Matlab simulation is seven times (as shown in Fig. 4), which shows the integrated algorithm model is convergent.

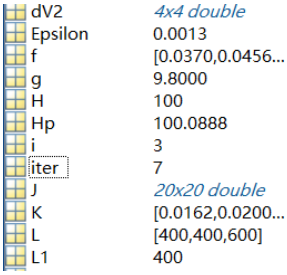
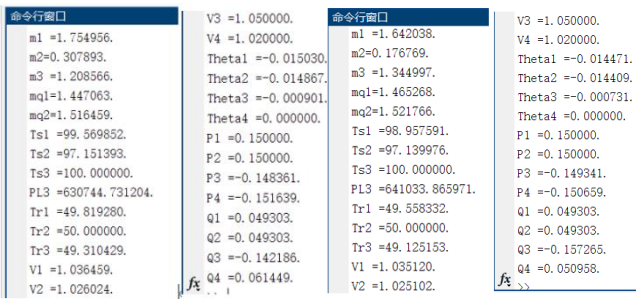


Figure 4. *Iteration number shown in the partial simulation results*

The Fig. 5(a) shows the value of the unknown variables before the iteration, which is calculated with the initial conditions. And the Fig. 5(b) shows the value of the unknown variables after the iteration, which is calculated via the integrated method.



(a) (b)

Figure 5. *(a) The value of the variables before the iteration (b) The value of the variables after the iteration*

Comparing the Fig. 5(a) and Fig. 5(b), it is obvious that, the values of the unknown variables are updated, which can prove the Newton-Raphson method is carried out normally.

Table 2. *The results of MatLab compared with the reference data*

Variables	m_1	m_2	m_3	T_{s1}
Simulation	1.6420	0.17680	1.3450	98.9576
Reference	1.6417	0.17646	1.3449	98.9575
Variables	T_{s2}	T_{r1}	T_{r3}	
Simulation	97.14	49.558	49.125	
Reference	97.14	49.558	49.125	

There is not much difference between the two series of data. With small errors, the accuracy of the integrated method is validated. Nevertheless, for further analysis, these subtle differences may be due to the approximate calculation of the Reynolds number Re in the iteration in this dissertation. As the resistance coefficient of the pipe 'K' depends on the Reynolds number, it will further affect the head loss h_f dominated by K. And then all the results will be affected just like the domino effect.

Table 3. *The results of MatLab compared with IPSA results (Coupling linkage is CHP)*

Results	V_1	V_2	θ_1	
MatLab	1.03390	1.02418	0.05089	
IPSA	1.03392	1.02421	0.05088	
Results	P_3	P_4	Q_3	Q_4
MatLab	0.4931	-0.1931	0.1803	-0.0409
IPSA	0.4931	-0.1889	0.1798	-0.0412

From the Table 3, there is not much difference between the MatLab results and the IPSA simulation results, which means the validation of the model in MatLab is proved.

From the Table 4, it shows the influence on unknown variables' results of the electricity network with different coupling linkage in the dual-energy network.

Table 4. *Comparison of different linkage components*

	CHP	CHP&Pump	CHP&Pump&HeatPump
V_1	1.0339	1.0339	1.0351
V_2	1.0242	1.0242	1.0251
θ_1	0.0509	0.0500	-0.0145
θ_2	0.0185	0.0181	-0.0144
P_3	0.4931	0.4887	0.1497
P_4	-0.1931	-0.1929	0.1461

When the linkage components are CHP & Circulation pump & Heat pump, the power injected on bus 4 P_4 is positive, while under the other two conditions, P_4 is negative. The reason is that, with heat pump, the output of linkage component from the heat network to electrical network is reduced, as heat pump will consume some power. Thus, both linkage component and power grid inject active power in electrical network. Nevertheless, in the other two cases, the power injected on bus 4 P_4 are all negative. That is because, in these two cases, the heat-to-electricity power can not only support the distribution system, but also has some surplus energy to offer to the power grid. Although, the circulation pump will absorb some electrical power, it is a minority of the conversion power.

4.2. Modelling of ICT network

The topology of the ICT network is visualized via the software NetAnim, which is shown in the Fig. 6:

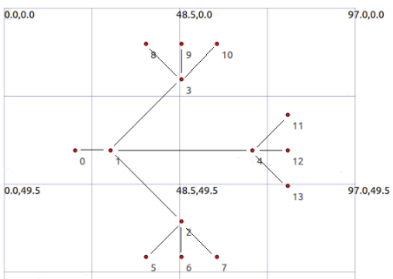


Figure 6. *The topology of the ICT network simulation*

All the data channels are established based on the CSMA protocol. The data rate of the CSMA channels is 10Mbps with 5000ns delay, while the data rate of P2P channel is 100Mbps with 2ms delay. The node 1-4 are switchers, which are configured based on the openflow protocol. With the openflow protocol, all these four nodes will operate as the MPLS node. The node 0 is set up as the control center, and the node 5-13 represent the four buses and power source in electricity network and the three nodes and heat source in heat network respectively. The application server is installed on node 0, while the application clients are installed on node 5-13. All the data distribution process will obey the CSMA/CD protocol regulations.

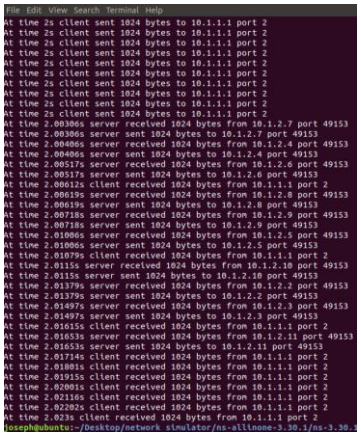


Figure 7. *The results of the ICT network simulation*

From Fig.7 it proves that the ICT network is successfully modeled according to the communication aspect. The server starts at 1 seconds which is consistent with the code. The data transmission process is beginning at 2 seconds which also matches the code. It is terminated at 2.023 seconds. That is because, the number of the packet sent by each client is only one with 1 second interval. And the receiving time of the client is the time, when the feedback from the server returns to clients.

4.3. The impact of ICT irregularities

This paper reviews a case about a co-simulation of an electrical distribution network and an ICT network in paper [19]. It mainly focuses on two types of the ICT irregularities, the packet drop and packet delay.

- For packet delay: It means a packet cannot be transferred instantaneously.
- For packet drop: It means a packet will be lost (dropped) and never received at the final destination.

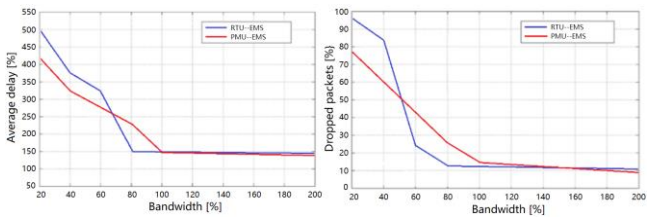


Figure 8. *Average delay and dropped packets of different bandwidths*

Form Fig. 8, higher bandwidth will have less impact by the packet delay and the packet drop. Since with higher bandwidth, the packets will be transferred faster and the time of queueing will be reduced, which will alleviate the packet delay and reduce the probability of the packet drop. However, when the bandwidth reaches a certain value, the delay and drop will not keep decreasing, which is caused by the default attributes of the channels.

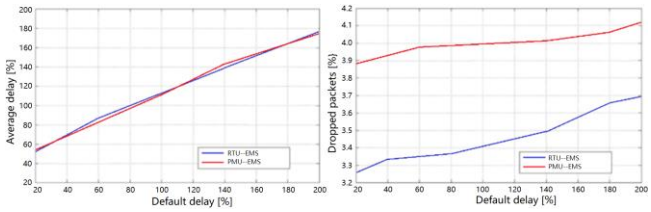


Figure 9. *Average delay and dropped packets of different default delay*

From Fig. 9, it is not difficult to find, the rate of the average delay and the dropped packet is significantly increasing with higher default delay. The reason is the packet needs more time to be sent, which will lead to longer queueing time. As a result, the risk of the packet drops increases.

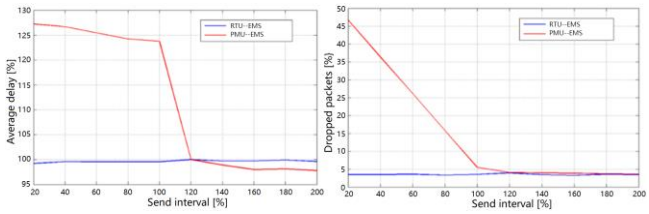


Figure 10. *Average delay and dropped packets of different interval [19]*

From Fig. 10, it is obvious that, with higher interval, the rate of delay and drop will decrease. Higher interval means longer time to take for sending packets, which leads to less sent packets in a certain period. Then there will be less queueing, thus the rate of both delay and drop will decrease. Nevertheless, the delay and drop data of the RTU seems not be affected. That is because, the interval ratio is much bigger than the interval of RTU data. In such case, the RTU data will only be affected by the default attributes of channel.

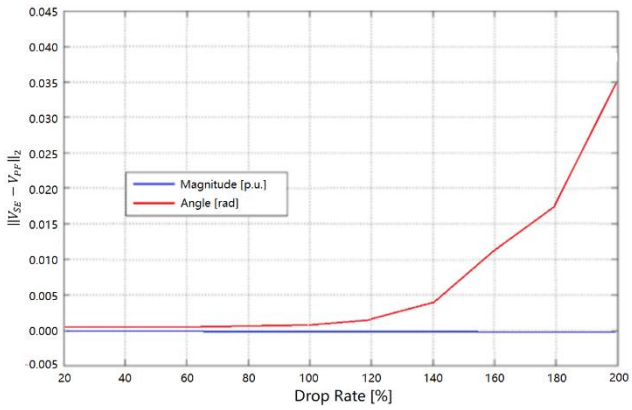


Figure 11. *The mean square errors with different drop rate*

From the Fig. 11, it shows that high drop rate may decrease the measurements for state estimation. And less measurements could lead to higher angle of the mean square errors. In summary, the ICT irregularities could cause the energy measurements missing, which brings negative impact on state estimation for power systems.

5. CONCLUSIONS

There are mainly two parts of this paper. One is the modelling of the dual-vector energy system combined heat and electricity, the other one is the simulation of the ICT network.

For the part of the dual-vector energy system, the iteration time is 7, which is reasonable enough to prove the mathematical model of this energy network is converged. Compared with the input values, the unknow variables is obviously updated, which means the Newton-Raphson process is carried out normally, and the programming code is correct. Since the error between the results and the reference data is really small, which can be ignored, the validation of the dual-energy network model in MatLab is confirmed. Besides, compared with the simulation in IPSA Power, the MatLab model can be proved to be successful. In short, the model of the dual-vector energy network is successfully established and the characteristics of the integrated energy network is proved.

For the ICT part, this paper reviews some basic and typical protocol needed in the establishment of communication network. Following the methodology of the ICT simulation, an ICT network has been set up in NS3 (version 3.30.1). From the results, the data can be distributed in the network, and the data flow is visualized, which indicates the ICT network simulation is successful. Then it analyses the impact of ICT irregularities. For the communication networks with wider bandwidth and longer interval, the impact would be less serious, while for the communication network with larger default data delay, the impact would be much more terrible. For the power system, ICT irregularities would cause

power measurements missing, which will bring negative influence on the state estimation.

Future works:

- For the dual-vector energy network, this radial network with unidirectional power flow could be replaced by a network of loop topology with bidirectional power conversion.
- The dual-energy network is static. It could be changed to a dynamic model, which can carry out the state estimation and reveal more interdependency between the thermal and electrical variables.

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Activation Time Dependent Magnetization of the Fe/$BaTiO_3$ System with Varying Constituent Mass Ratios

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Abstract: *Powdery mixtures of Fe and $BaTiO_3$ with mass ratios of 10% Fe, 20% Fe, 30% Fe, 50% Fe, 60% Fe and 70% Fe were activated in a planetary ball mill for times ranging from 30 min to 300 min. Activated powders were pressed, then sintered for 2 h at 1200 °C. Depending on the activation time, the system changes its chemical composition. It has been experimentally observed that the magnetization of sintered samples rises with the increase of iron in the initial powders. For each sample, two measurements of the magnetization dependency on the activation time were made: the first measurement at room temperature and the second measurement after the heating to Curie temperature and subsequent cooling in the applied magnetic field of 50 kA m^{-1}. The most pronounced increase of mass magnetization before and after the thermal treatment shows the sample with minimal content of iron (10%), with the magnetization of 2.78 A m^2 kg^{-1} (compared to 1.10 A m^2 kg^{-1} at room temperature) which is a net increase of ~152.7%. Further increase of the activation time of initial powders leads to a decrease of magnetization of all sintered samples.*

Keywords: *barium titanate; iron doping; thermomagnetic properties; mechanochemical activation; sintering.*

1. INTRODUCTION

Barium titanate is a well known perovskite with a structure that allows for accommodation of numerous different dopants and, consequently, modification of its functional properties in accordance with the desired results of a research. Investigated intensively since the mid-twentieth century because of its intrinsic properties such as piezoelectricity, ferroelectricity, superconductivity, multiferroicity and others, perovskites have become even more prominent in regard to possible practical applications in data storage industry [1].

Considering the ever growing amount of information in contemporary, digital age we live in, the necessity of their physical storage in the form of microscopic magnetic domains within the suitable material, it becomes clear why this is the case.

Development of technology has always rested on research efforts toward the creation of novel materials that possess coveted, controllable properties.

The latter is of great importance for the class of materials known as multiferroics. Multiferroicity, which entails manifestation of more than one of the ferroic features (ferroelectricity [2], ferromagnetism [3] and ferroelasticity [4]) in the same material, is seldom achievable in nature. In her renowned paper [5] from 2000, while considering conditions requisite for simultaneous occurrence of both ferroelectricity and ferromagnetism in certain A-B-O_3 systems, Spaldin concluded that the cause of this are d-electrons of transition metal which, despite being of fundamental importance for magnetism, suppress tendency toward ferroelectric distortion of cation inside of oxygen octahedron (Figure 1).

The question of what can give rise to ferroelectric - ferromagnetic coexistence in a material provoked the scientific community to search for answers and, by virtue of needed experimental technics already present, the race could commence [6].

Nearly two decades later, the quest for functional multiferroic magnetoelectrics [7] is still equally alive and dynamic. In this paper, we give our modest contribution to multiferroics research by

studying the influence of time of mechanochemical activation on magnetization of perovskite Fe/$BaTiO_3$ system with varying mass ratios of constituents.

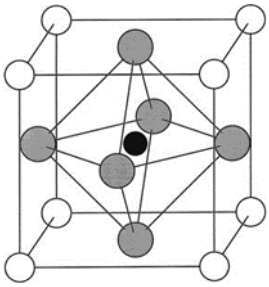

Figure 1. *Cubic perovskite A-B-O_3 structure. Small B - cation (black) is in the center of octahedron comprised of oxygen anions (grey). Large A - cations (white) are situated in corners of the unit cell [5].*

Observing the evolution of magnetization guided by change of these two parameters (time of activation and the amount of doped iron), we determined the mass ratio of constituents in initial powders as well as the activation time in terms of maximum magnetization increase after the heating to Curie temperature and cooling in the applied magnetic field.

2. EXPERIMENTAL

Powders of iron (Aldrich, St. Louis, MO, p.a. 99.99%) and barium titanate (Aldrich, St. Louis, MO, p.a. 99%) were mechanically mixed with mass ratios of 10% Fe, 20% Fe, 30% Fe, 50% Fe, 60% Fe and 70% Fe.

These initial powders were activated in a planetary ZrO_2 ball mill (Retsch PM 400) for duration of 30 min, 60 min, 90 min, 120 min, 150 min, 180 min, 210 min, 240 min, 270 min and 300 min, in the air atmosphere with rotation speed of 400 rpm. After the milling, samples were pressed into tablets under the pressure of 500 MPa and then sintered for 2h at temperature of 1200 °C.

Thermomagnetic measurements were performed by modified Faraday method (Figure 2) [8] in the temperature interval from 293 K – 873 K at a heating rate of 10 K/min, in an argon atmosphere. The applied magnetic field intensity at the point where the sample was positioned was 50 kAm^{-1}, whereas the field gradient was $dH/dz = 4\cdot10^{-9}\ Am^{-1}m^{-1}$. The sensitivity of the laboratory balance (Sartorijus 2462) was 10^{-7} kg.

Analytical and graphical scrutiny of experimental results were performed using appropriate software solutions [9, 10].

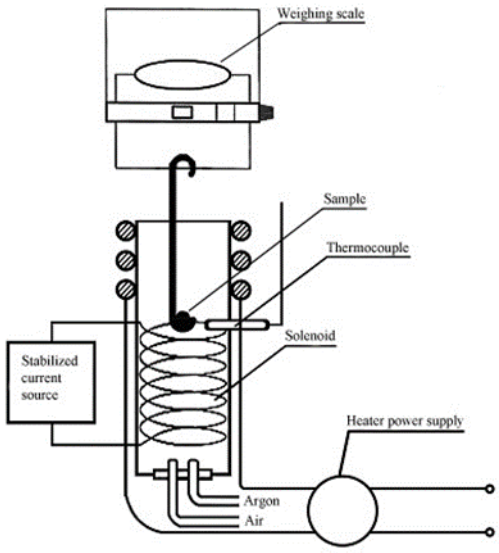

Figure 2. *Schematics of the apparatus used for thermomagnetic measurements. Force that acts upon thermally regulated sample during its insertion into the magnetic field, equals by intensity to $F = \Delta m\cdot g$, where Δm is the difference in masses of a given sample outside the magnetic field and inside the field.*

3. RESULTS AND DISCUSSION

Mechanochemical activation of initial mixed powders affects the content of iron and its oxide forms, given that, according to conditions of the experiment and the amount of energy that the system absorbs during activation, Fe could transition from wustite, hematite or magnetite configuration into $BaTiO_3$ (BTO) matrix. Site of incorporation of iron (and, withal, of other dopants, primarily belonging to the transition metals group) into BTO lattice is determined mainly by relevant ionic radii [11], i.e. ones which are involved in the process of incorporation. It is known that iron, predominantly as Fe^{3+}, can embed itself on site of Ti^{4+} ion within the oxygen octahedron cage [12]. The experiment validates the thesis that the activation time plays a significant role in these affairs (Figure 3). Evolution of magnetization in all of the samples exhibits a similar pattern: with the activation time increasing, magnetization rises as well to a certain maximum value within the 90 min $\leq \tau \leq$ 120 min interval after which it follows a more or less pronounced decline. Longer milling decreases the average crystallite grain size and initial powders are becoming finer.

From the relation:

$$M = \frac{\Delta m \cdot g}{m_s} \qquad (1)$$

magnetization value M could be monitored as a function of the observed change in weight of a sample Δm·g, when the field is applied. In equation (1) Δm is the apparent change in mass of the sample, m_s is the mass of a measured sample without the applied field and g is standard gravity constant (~9.80665 ms^{-2}).

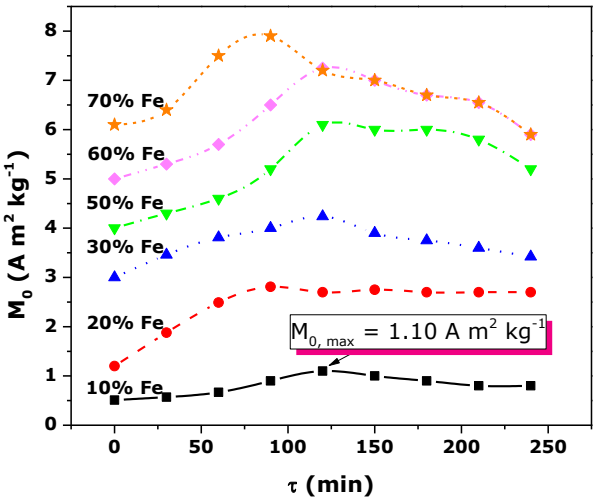

Figure 3. *Change in the magnetization of samples with different initial content of iron, caused by an increase in the time of mechanochemical activation (τ), without the applied magnetic field and at room temperature (before the thermal treatment).*

Notwithstanding, it is noticeable that for each sample there exists some critical value of the average size of crystallite (determined by the time of activation), after which coalescence of grains into larger agglomerates could occur, leading to decrease of magnetization due to randomization and reorienting of local magnetic moments.

Activation gives rise to defects as well as microstrain in the structural lattice – these factors influence the mobility of the Bloch wall [13] between magnetic domains, effectively reducing it (in addition, results of X-ray diffractometry obtained from the complementary Fe/$BaTiO_3$ (BFTO) systems [14, 15] seem to support this).

During the heating, defects and microstrain vanish and the system relaxes its structure, increasing the mobility of the walls between magnetic domains, leading to an increase in the total magnetization of samples. The magnetization maxima shift towards higher activation times and are found to be in the 120 min ≤ τ ≤ 180 min interval (Figure 4).

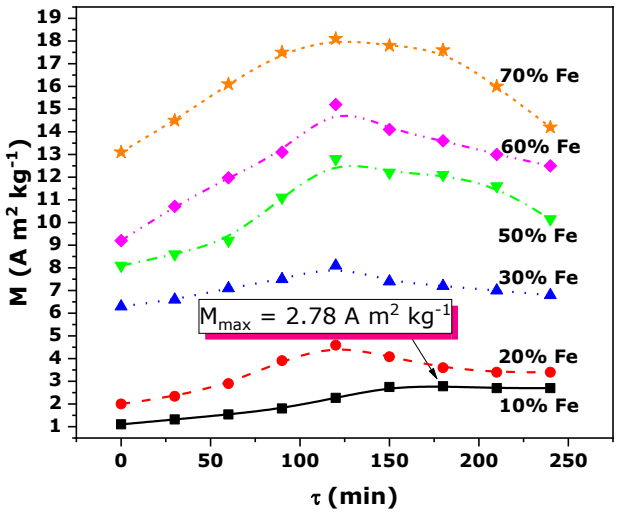

Figure 4. *Magnetization of samples with different initial content of iron after the thermal treatment (heating to Curie temperature [15] and subsequent cooling to room temperature in the applied magnetic field of 50 kA m^{-1}) depending on time of mechanochemical activation (τ).*

Figure 5 shows that increasing the content of iron in the initial powder affects the growth of magnetization at room temperature. Growth is even more noticeable after the thermal treatment and an increase in the difference between maxima of magnetization measured before and after the thermal treatment is observed, with the rise of iron content in the system (Table 1), but this growth is not monotonous.

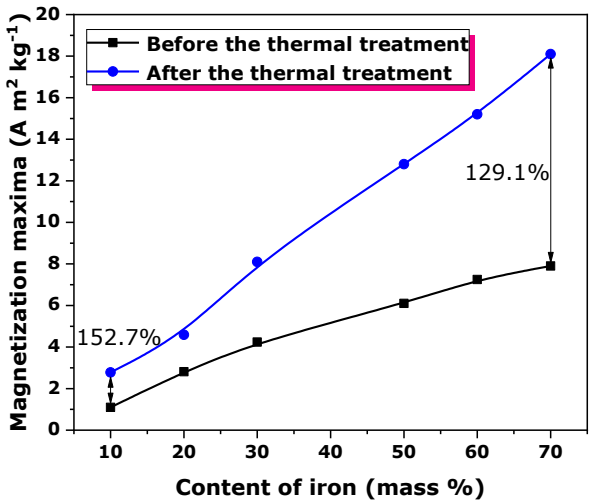

Figure 5. *Maximum magnetization values of samples with different content of iron, before and after the heating to Curie temperature and cooling in the applied field of 50 kA m^{-1}.*

Table 1. *Influence of the content of iron in initial powders on the difference in increase of mass magnetization before and after the thermal treatment.*

Fe content (mass %)	$M_{max} - M_{0,max}$ (%)
10	152.7
20	63.3
30	91.0
50	109.8
60	109.7
70	129.1

The greatest difference in the increase of mass magnetization is shown by the sample with the lowest content of iron (10%). Such a small amount of iron available leads to a more efficient distribution and incorporation into a BTO structure compared to, for example, a sample containing 70% of iron (see Figure 5). The excess of Fe ions can interfere with their migration into the grains due to their available free surface being limited. Further increase in the content of iron saturates the system and drives the growth of magnetization.

Although the incorporation of Fe^{3+} ions is predominant, flexibility of the BTO lattice allows for accommodation of iron ions with different valences, which can interact with each other twofold: via the mechanism of exchange of nearest neighbours (antiferromagnetic interaction) and the mechanism of alteration of next nearest neighbours (ferromagnetic interaction) [16-18].

Moreover, Apostolova et al. reminded us of empirical findings that clearly indicate the presence of incorporated Fe^{4+} ion [19]. Ferromagnetic Fe^{4+}-O^{2-}-Fe^{4+} interaction is dominant in comparison with antiferromagnetic Fe^{3+}-O^{2-}-Fe^{4+} and Fe^{3+}-O^{2-}-Fe^{3+} interactions, which incipiently explains the increase in magnetization [20, 21] in all of the samples. Magnetization increase, induced by the rise of iron content in the system, can be fairly well described by the function shown in Figure 6.

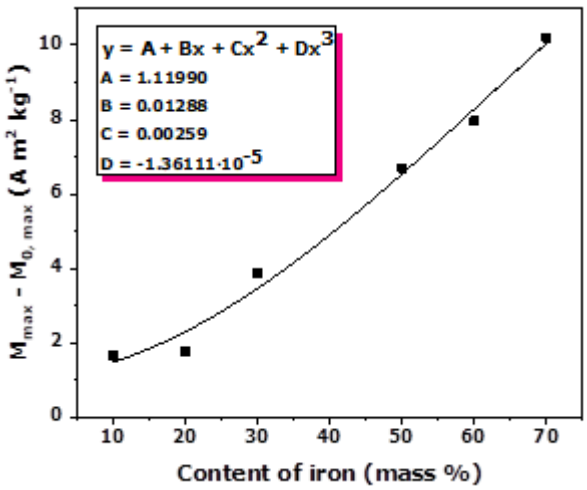

Figure 6. *Difference in maximum values of mass magnetization of samples depending on the content of iron. Increase of the difference follows a polynomial function.*

4. CONCLUSION

Flexible, perovskite nature of barium titanate structure permits incorporation of a large number of different dopants, which alters its functional properties, including magnetization. Mixtures of Fe and $BaTiO_3$ powders with mass ratios of 10% Fe, 20% Fe, 30% Fe, 50% Fe, 60% Fe and 70% Fe were activated in a planetary ball mill for time intervals ranging from 30 min to 300 min. Activated powders were pressed, then sintered for 2 h at a temperature of 1200 °C. Duration of mechanochemical activation changes the chemical composition of the system. As the activation time increases, the magnetization rises to a certain maximum and then decreases, which is directly related to the change in crystallite size in the examinated samples.

Activation gives rise to defects and microstrain in the structural lattice that reduce the mobility of walls between magnetic domains. Heating relaxes the BFTO structure, with defects and microstrain disappearing and the total magnetization of samples increases. The content of iron affects magnetization and the largest difference in mass magnetization increase of ~152.7% is shown by the sample with the lowest iron content of 10%. Superposition of various mechanisms of Fe ion exchange could explain the observed increase in magnetization, which is well described by a polynomial type function $y = A + Bx + Cx^2 + Dx^3$, where A, B, C and D are constants.

Overall, magnetization of the Fe/$BaTiO_3$ system is determined by the complex influence of time of mechanochemical activation coupled with the presence of iron in the initial powders, with grain size as a parameter of paramount importance.

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The Application of Microalloyed Alumo-Silicate Ceramics, as a Multifunctional Agent for Distilled Water Passivation and H_2O_2 Aqueous Solution Decomposition

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Abstract: *Modified porous alumo-silicate ceramics, alloyed with manganese and microalloyed with aluminum, belongs to modern multifunctional ceramic materials. Microalloyed element represents the corresponding nano-phases layered at the grain boundaries that act as functional groups in different valent manganese states. Significant electrochemical and electrophysical activity of this structurally modified material makes it an excellent agent for decomposition of H_2O_2 via spontaneous redox processes, providing active oxygen and hydrogen and small local changes in pH value. This unique material with amorphous-crystalline structure can be used in technological processes of removing large concentrations of organic phase from waste water. All of these changes are reflected in the change of redox water potential, which plays a very important role in the use of drinking water.*

Keywords: *ceramics; microalloying; water passivation; decomposition; redox processes.*

1. INTRODUCTION

Microalloying is most commonly used procedure in microelectronic technology, especially in thin film technologies, where microalloying is performed by ion implantation, chemical deposition from the gas phase and plasma chemical processes. Microalloyed and structurally modified multifunctional materials have a remarkable electrochemical and electrophysical activity. There is a primary modification of the microstructure, induced by synthesis and the sintering process, and secondary, due to the development of numerous physical-chemical interactions in a heterogeneous multiphase system solid-solid and heterogeneous system solid-liquid [1].

Alumo-silicate ceramics modified with manganese and microalloyed with aluminum has such a microstructure that provides an amorphous-crystalline structure with two electrochemical active metals (Mn and Al) and a modified matrix, with respect to the non-stoichiometric composition of alumo-silicate and manganese-silicate amorphous and crystalline layers. In terms of this type of ceramics, amorphous metal layers on the matrix are expressed, which provide high porosity, developed surface and non-equipotential surface. Priority application of the new and unique material is directed to the use in technological processes of removing large concentrations of organic phase from fecal and other waste water by active oxygen and hydrogen, obtained by extremely rapid decomposition of H_2O_2 via redox processes on the granules of multifunctional ceramics. A very serious problem of all modern biological water treatment technologies is aeration and aerators with complex technical and technological supply systems [1, 2].

In this paper, the procedure is based on a completely new principle of providing active oxygen and hydrogen from H_2O_2, by spontaneous redox processes. The principle is based on the fact that with a small change in the local pH value, for example for one unit, hydrogen peroxide can be an oxidation or reduction agent. The oxidative decomposition of H_2O_2 in the acidic environment is defined by the relation: $H_2O_2 \rightarrow H_2O + O$, and the reduction decomposition with a slight displacement of the pH value in the alkaline region is defined by the relation: $H_2O_2 \rightarrow O_2 + H_2$. Thus small local changes in pH value is provided by multifunctional alumo-silicate ceramics microalloyed with

manganese, with highly expressed spontaneous redox properties. These properties are related to the transition of valence electrons by changing the valency state of manganese, which enters by microalloying into the non-stoichiometric optically active solid phase, with F and V optical centers. Thus, the microalloying element is not an ordinary mixture with the Al-Si-O lattice, but it represents the corresponding nano-phases layered at the grain boundaries that act as functional groups in different valent manganese states starting from Mn^{2+}, Mn^{3+}, Mn^{4+} to Mn^{7+}, in addition to the natural elements Al, Si, Mg, Na and K from bentonite clays. When granules of multifunctional ceramics come into contact with H_2O_2 aqueous solution, from 3% to concentrated H_2O_2, H_2O_2 is completely decomposed in a short time. Regardless of the participation in the process, microalloyed ceramics retains its activity in redox properties, thanks to very pronounced changes related to the transition of valence electrons of redox pairs, which are included in the solid phase [3-5].

2. EXPERIMENTAL

Experiments with the separation of diluted and concentrated H_2O_2 solutions showed an extremely rapid decomposition at high pressure. With only one kilogram of multifunctional ceramic granules, it is possible to decompose 700-1000 kg of H_2O_2, with retaining its redox and catalytic activity. By decomposing H_2O_2, oxygen is obtained as an active element for all oxidation processes and changes in the redox potential of the aqueous medium. Reduction decomposition produces hydrogen in two possible states, such as atomic and molecular hydrogen, which participates in the processes of removing hydroxyl, peroxide, organic and other radicals in fecal and other waste waters. Interesting and scientifically based results were obtained by the influence of Mn-alumo-silicate ceramics on distilled water, where local changes in pH and redox potential of distilled water were found, as an example of active waters. Otherwise, water hardly "tolerates" the removal of any harmful or other ingredient from water, by electrochemical and redox processes, electrophoresis or membrane separation. All of these changes are reflected in the change of redox water potential, which plays a very important role in the use of drinking water.

3. RESULTS AND DISCUSSION

The changes of redox potential and pH value of distilled water after the treatment with Mn-alumo-silicate catalyst are given in Fig. 1-7.

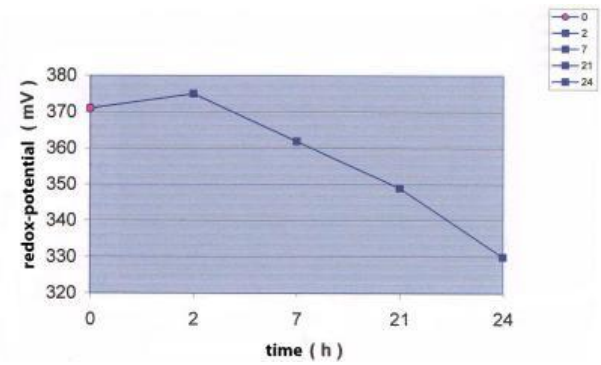

Figure. 1. *Change of redox potential with time during contact of distilled water with Mn-alumo-silicate catalyst, where the circle shows the value before and the square after the treatment.*

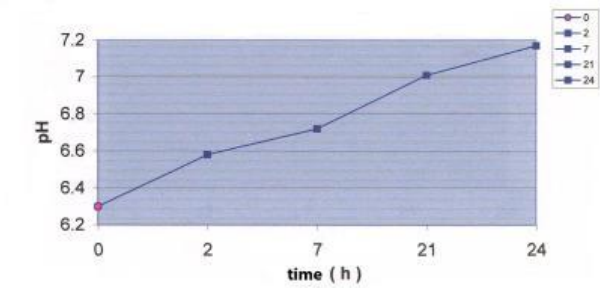

Figure 2. *Change of pH value with time during contact with distilled water with Mn-alumo-silicate catalyst, where the circle shows the value before and the square after the treatment.*

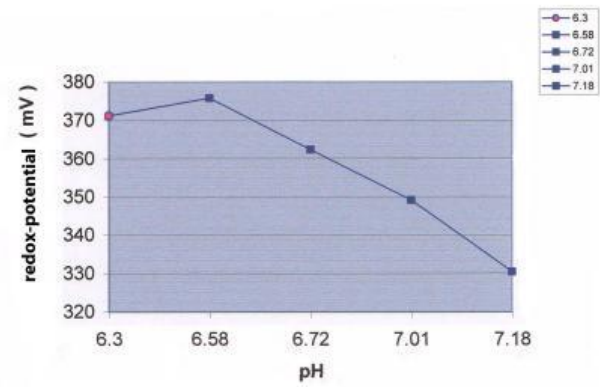

Figure 3. *Change of redox potential with pH during contact of distilled water with Mn-alumo-silicate catalyst, where the circle shows the value before and the square after the treatment. (Ag/AgCl as reference electrode).*

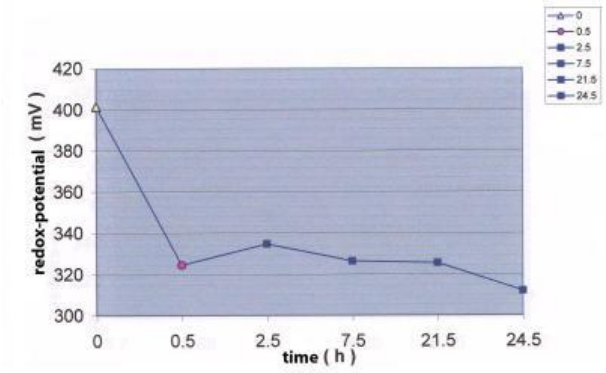

Figure 4. *Change of redox potential of distilled water with time, where the triangle shows the value before aeration, the circle before the treatment and after aeration and the square after the treatment with Mn-alumo-silicate catalyst.*

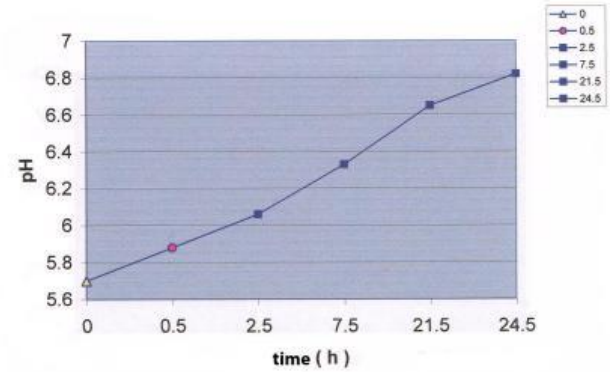

Figure 5. *Change of pH value of distilled water with time, where the triangle shows the value before aeration, the circle before the treatment and after aeration and the square after the treatment with Mn-alumo-silicate catalyst.*

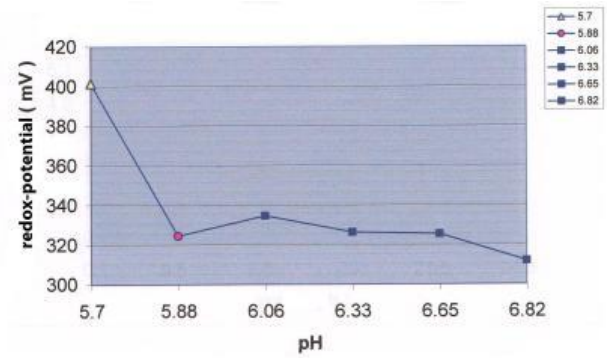

Figure 6. *Change of redox potential with pH during contact of distilled water with Mn-alumo-silicate catalyst and aeration, where the triangle shows the value before aeration, the circle before the treatment and after aeration and the square after the treatment with Mn-alumo-silicate catalyst (Ag/AgCl as reference electrode).*

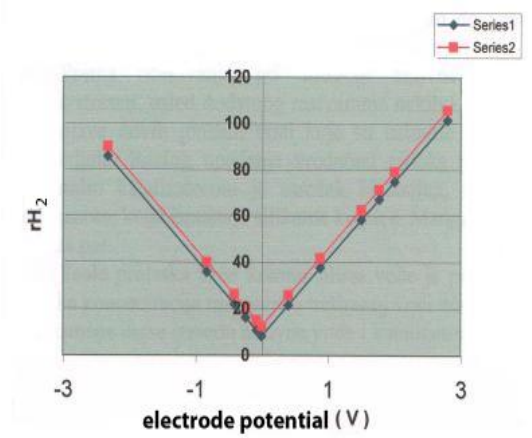

Figure 7. *Change of rH_2 factor with electrode potential of distilled water before (series 1) and after the treatment (series 2) with Mn-alumo-silicate catalyst (H_2 as reference electrode).*

3.1. Redox reactions

$1/2\ H_2 + e^- \rightleftharpoons H^-$	(E= -2,33) V
$2H_2O + 2e^- \rightleftharpoons H_2 + 2OH^-$	(E= -0,83) V
$2H^+ + 2e^- \rightleftharpoons H_2$	(E= -0, 414) V
$O_2 + H_2O + 2e^- \rightleftharpoons HO_2^- + OH^-$	(E= -0,076) V
$HO_2^- + H_2O + e^- \rightleftharpoons OH^{\cdot} + 2OH^-$	(E= -0,24) V
$2H^+ + 2e^- \rightleftharpoons H_2$	(E= -0,00) V
$O_2^{\cdot} + H_2O + e^- \rightleftharpoons OH^- + HO_2^{\cdot}$	(E= 0,4) V
$O_2 + H_2O + 4e^- \rightleftharpoons 4OH^-$	(E= 0,401) V
$HO_2^- + H_2O + 2e^- \rightleftharpoons 3OH^-$	(E= 0,88) V
$HO_2^{\cdot} + H^+ + e^- \rightleftharpoons H_2O_2$	(E= 1,5) V
$H_2O_2 + 2H^+ + 2e^- \rightleftharpoons 2H_2O$	(E= 1,77) V
$OH^{\cdot} + e^- \rightleftharpoons OH^-$	(E= 2,0) V
$OH^{\cdot} + H^+ + e^- \rightleftharpoons H_2O$	(E= 2,8) V

$$rH_2 = Eh/0.03 + 2pH\ (V)$$

rH_2 factor indicates whether the medium is oxidative or reductive, depending on the redox potential.

The microalloyed aluminum composite was destructively acting on water molecules and water-dissolved oxygen, which essentially displaced the balance of hydronium and hydroxyl ions. rH_2 factor has a very important role in water electrochemistry and its redox potentials. The main ionic species produced by water and water-dissolved oxygen reduction is peroxide ion or peroxide radical (HO_2^-, $HO_2^{\cdot}$). Reduction of this ions, or radicals, is carried out only in the acidic environment and on very positive potentials, with the formation of hydrogen peroxide. Water aeration is necessary in order to return the dissolved oxygen, but first it is necessary to adjust the pH to 6.5 - 7.0 [6, 7].

4. CONCLUSION

Mn-alumo-silicate ceramics has unique amorphous-crystalline microstructure, modified by synthesis and the sintering process and due to the development of numerous physical-chemical interactions. Amorphous metal layers on the matrix provide high porosity, developed surface and non-equipotential surface.

Microalloyed alumo-silicate ceramics, as electrochemical and electrophysical active multifunctional material can be used for decomposition of H_2O_2 via redox processes, providing active oxygen and hydrogen and small local changes in pH value. Therefore, this unique material can be used as agent in technological processes of removing large concentrations of organic phase from waste water.

Distilled water passivation can be carried out by multifunctional microalloyed ceramics. Changes of redox water potential, pH value and rH_2 factor are noticed during the contact of distilled water with Mn-alumo-catalyst.

ACKNOWLEDGEMENTS

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Evaluation of Energy Performance of School Building

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Abstract: *Buildings play a major role in total annual energy used worldwide. There are a lot of important factors that have an influence on building energy consumption: climate, building envelope and energy services systems, operation and maintenance, indoor comfort conditions and occupants' behaviour. The aim of this paper is to describe the current condition of the school building in order to identify whether there are suitable conditions for energy rehabilitation of the building. The analysis performed showed that there is a significant potential for building energy rehabilitation. The effect of energy efficiency measures on reducing the building energy demand was analysed. Results shows that the annual heating energy consumption of the simulated building could be reduced by up to 50 %. By being more energy efficient, schools can help prevent greenhouse gas emissions and improve the students' learning environment. Also, it should be mentioned that improving the energy efficiency of the school can serve as a key learning tool for students in terms of science and environment and social responsibility.*

Keywords: *energy performance; school building; energy saving measures; energy efficiency; energy improvements.*

1. INTRODUCTION

The Directive 2002/91/CE (EPBD - Energy Performance of Buildings Directive) was the first European regulation on the energy performance of buildings. The EPBD define the procedures in order to establish the requirements for energy performance in buildings to be followed by the member states. In May 2010, the EU Directive 2010/31/EU was issued, which targets are to reduce the greenhouse gas emissions by 20% by 2020 and in 80% to 2050, in relation to the 1990 emissions levels, in order to achieve the goals outlined in the Kyoto Protocol [1]. The Energy Efficiency Standards in Buildings, which has been applied in Serbia since 2013, has set a methodological framework which prescribes energy properties and the method of calculating the thermal properties of buildings, as well as energy requirements for new and existing buildings.

A plenty of studies have considered the effect of improving thermal building envelope on heating energy consumption and some of them provide strong evidence on why we need to improve buildings' energy efficiency [2-4]. It is well known that existing buildings often have a low level of energy efficiency. However, there is a high potential for cost-effective energy savings in the building sector in the whole of Europe. Although there are a large number of buildings with high energy consumption in Serbia, there is a possibility to reduce it by investing in the renovation of such buildings [5].

As school buildings usually have great potential for improving energy efficiency and children in school can benefit from increased knowledge on how to use energy efficiently, schools are a promising location for addressing energy savings. The efficient use of energy is a goal of the expected outcome of educational procedures and is adopted within various subjects in Serbia's educational system. In order to develop a positive awareness of the importance of energy efficiency, education in this field should be implemented at all levels of education.

There are many challenges to including energy education in the school curriculum [6-8]. Among these challenges are funds for resources and support materials. Fortunately, one of the best resources to teach students about energy is readily available to teachers: their school building.

One way to improve energy efficiency is the rehabilitation of public buildings because schools are among the most important public facilities in Serbia. In this paper, the possibilities of improving energy efficiency of the school building are analysed. The current energy condition of the object has been presented, and increased energy efficiency and the energy state of the object after the application of the proposed measures are shown.

2. MATERIALS AND METHODS

2.1. Case study

The subject of energy efficiency analysis is the building of the Technical School in Čačak (Fig. 1). The location of the building is in the urban part of the city and has an open space in the environment on all sides. The facility was built in 1947 and the structural system of the building is a medium-heavy type of construction. The position of the building to the wind exposure is moderately sheltered.

The total area of the building is 5218 m^2 with the heating area of 4372 m^2. Thermal envelope of the building is an area of 14259 m^2. The school is equipped with two heating oil boilers with a capacity of 0.93 MW. The installed heating capacity of the Technical school is 0.825 MW. The adaptation of the building during 1986 was performed due to the new needs for the use of space, unreliable installations and parts of equipment, damage to the walls, floors, roof and carpentry.

Figure 1. *The school building used for energy performance analysis*

Most of the exterior walls, with a total area of 2059 m^2, are made of hollow bricks 20 cm thick, while other exterior walls of 994 m^2 are made of 30 cm thick concrete. Exterior walls have no thermal insulation. The partitions are constructed using the hollow brick with a thickness of 12 cm.

The windows have a total area of 838 m^2 and are oriented to all four corners of the world, with the majority orientation to the east and west. Wooden windows with low-emission double-glazed glass 4 mm thick, with a 12 mm thick with air filling, are located on the most of the buildings' window area, i.e. 522 m^2. On the remaining glass surfaces of 317 m^2, wooden windows were replaced with six-chamber PVC windows with low-emission double-glazed glass 4 mm thick with a 12 mm thick krypton filling. Most of the replaced windows are east orientated.

The floors of the building have a total area of 2366 m^2. Most of the floors are located in classrooms and offices and have an area of 831 m^2 and are covered with a floorboard without waterproofing. The roof structure above the heated space is sloped, with a total area of 3405 m^2 and is made without thermal insulation.

To calculate the annual energy required for heating and determine the energy efficiency of the building and energy classes, *KnaufTerm2 Pro* software is used. The software is fully compliant with the current regulatory framework in Serbia.

This software enables testing of each thermal envelope component's performance, and also enables complete building performance calculation for the existing and proposed state of the building. Climatic data used for the calculation are: location of the city of Čačak, number of heating degrees day is 2755, number of heating season days is 190, an average temperature of heating period 5.5 ^{o}C and internal winter design temperature 20 ^{o}C.

2.2. KnaufTerm2 Pro software

KnaufTerm2 Pro is a specialized software intended for designers in the phases of designing the preliminary and main project and development of technical documentation of energy efficiency studies and energy passports. The program contains numerous databases from which the parameters required for the calculation are being selected: location and type of building, wind effect, parameters of the heating system, etc. There is also an extensive database of thermophysical characteristics of materials and structures that make up the thermal envelope of the building, including exterior elements and structures (walls, roof, windows and doors), internal partition structures and ground structures. After defining the geometric parameters of the thermal envelope, the program enables the visualization of the characteristics of the assemblies as a function of orientation (Fig. 2).

Figure 2. *Building model - north view*

Regulations on energy efficiency of buildings defines the maximum allowed values of the heat transfer coefficient for all elements of the thermal envelope of a building. These values are different for existing and new buildings. When the thermal envelope is defined, the program checks whether the overall heat transfer coefficient is below the maximum allowed value for each envelope element (Fig. 3). The calculation results include temperature change in all elements of the wall, water vapor diffusion, checking of condensation and checking of heat transfer coefficient.

The software calculates the exterior wall's thermal resistance and the properties of the product which used in walls can be select by performance. Also, the software can define the insulation material's type and thickness which will be used on the outer face of a wall according to the climate conditions, as well as the reduction of heat bridges and condensation risks.

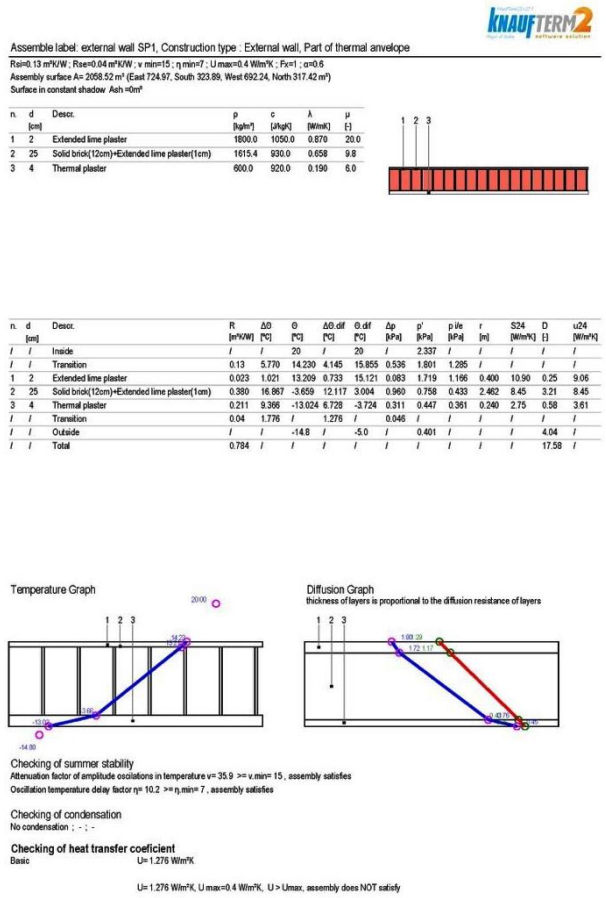

Figure 3. *Modeling of exterior walls in current state of building*

For the current condition of the building described in this paper, the overall heat transfer coefficient for the exterior wall is not satisfied, so certain improvement measures were proposed. In this case it was necessary to apply a 7 cm thick thermal insulation and thermal facade (Fig. 4). The parameters based on the materialization of other elements of the thermal envelope are changed in a controlled manner according to a precisely determined plan in order to obtain the desired results.

The software generates an energy efficiency study that contains data on transmission and ventilation heat losses (Q_t and Q_v), solar energy gains (Q_{sol}) and heat gains from people and electrical devices (Q_p and Q_{el}). Solar gains are an important part of the calculation of the energy performance of the building, and have a large impact on the calculated values of annual needs of energy, and therefore, the energy class of the building.

The calculations also include energy needed for sanitary hot water and energy losses in the heating system. Monthly heat losses and energy gains are given in Fig. 5. Based on the calculated gains and losses of thermal energy, the program generates the energy passport of the building which is a certificate which contains information about the energy class of the building and points to the final annual consumption of thermal energy for heating, as well as the primary energy for heating as well as the calculation of CO_2 emissions based on the selected energy source.

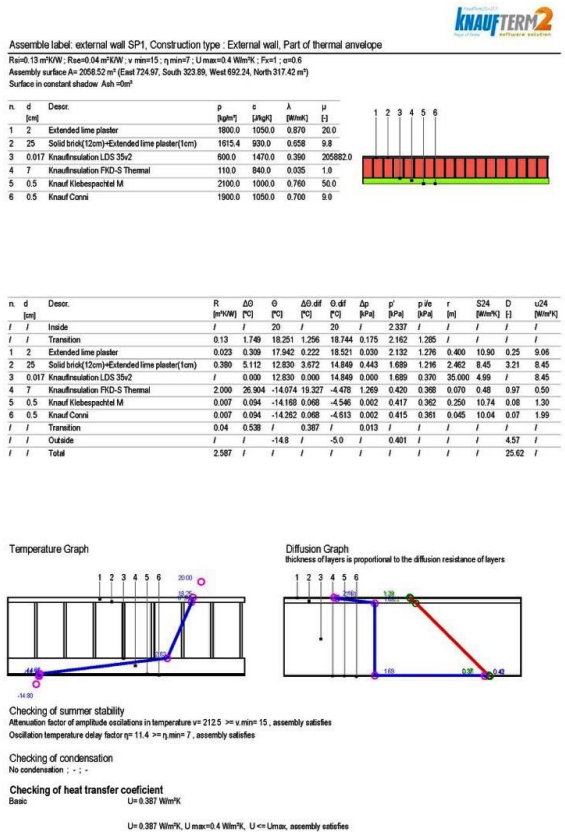

Figure 4. *Modeling of exterior wall with applied measures for increasing energy efficiency*

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Te =	0.7	2.8	7.1	12.3	17.4	20.4	22.0	21.5	17.4	12.5	7.0	2.4
HDD =2755.00	599.680	482.866	401.288	143.569	0.000	0.000	0.000	0.000	0.000	189.197	391.355	547.045
HD= 190	31	28	31	16	0	0	0	0	0	23	30	31
Te.hd=	0.655	2.755	7.055	11.027	0.000	0.000	0.000	0.000	0.000	11.774	6.955	2.353
1. Qt=386.42 MWh	84.11	67.73	56.28	20.14	0.00	0.00	0.00	0.00	0.00	26.54	54.89	76.73
2. Qv=169.81 MWh	36.96	29.76	24.73	8.85	0.00	0.00	0.00	0.00	0.00	11.66	24.12	33.72
3. Qt+Qv=556.23 MWh	121.07	97.49	81.02	28.99	0.00	0.00	0.00	0.00	0.00	38.20	79.01	110.45
4. Qsol=53.88 MWh	5.55	8.98	12.83	8.08	0.00	0.00	0.00	0.00	0.00	8.22	5.85	4.36
5. Qp=46.51 MWh	7.59	6.85	7.59	3.92	0.00	0.00	0.00	0.00	0.00	5.63	7.34	7.59
6. Qel=22.76 MWh	3.71	3.35	3.71	1.92	0.00	0.00	0.00	0.00	0.00	2.75	3.59	3.71
7(4+5+6): Qgn=123.15 MWh	16.85	19.19	24.13	13.91	0.00	0.00	0.00	0.00	0.00	16.61	16.79	15.66
8(3-7): Qnd=433.09 MWh	104.22	78.30	56.89	15.08	0.00	0.00	0.00	0.00	0.00	21.59	62.22	94.78

Figure 5. *Monthly energy balances*

2.3. Existing state energy audit

The analysed object belongs to the category of objects for education, as defined by the State Energy Efficiency Standards in Buildings. It is necessary to perform energy rehabilitation for school buildings, which is also defined in the Energy

Efficiency Standards in Buildings for existing buildings.

Based on the conducted research, it is possible to analyse and evaluate the energy efficiency of the building of the Technical school in Čačak in the current state. The results show that the annual transmission heat losses through certain parts of the building envelope in the current state are:

1. Exterior walls: 290044 kWh;
2. Pitched roof: 124503 kWh;
3. Windows and doors: 92004 kWh;
4. Partitions: 38094 kWh;
5. Ceilings: 81269 kWh;
6. Ground walls (basement): 68361 kWh;
7. Ground floors: 44697 kWh.

Fig. 6 shows the heat loss percentage through certain components of the facility of the total heat losses. The analysis shows that the largest transmission losses are due to heat transfer through the exterior walls of the school building, although this area covers 21.40% of the total area of the thermal envelope of the building and is not the largest of all surfaces of the thermal envelope. The largest area of the buildings' thermal envelope is a pitched roof with 16.85% of the total heat transmission losses. Then, there are the heat losses through windows and front doors, although their total area is 5.10% of the total area of the thermal envelope, where one part of the old wooden windows was previously replaced. Large heat losses occur through the mezzanine structure under the unheated space since its surface is significantly large and takes to 20.37% of the total area of the building thermal envelope. The smallest transmission heat losses are through the ground walls, ground floors and through the walls towards the unheated space.

The total energy demand for transmission losses of the building is 833.25 MWh and for ventilation losses 170 MWh, in its present state. Annual energy gains in the current state of the building are:

1. Solar gains: 72.76 MWh;
2. Persons: 46.51 MWh;
3. Electrical appliances: 22.76 MWh.

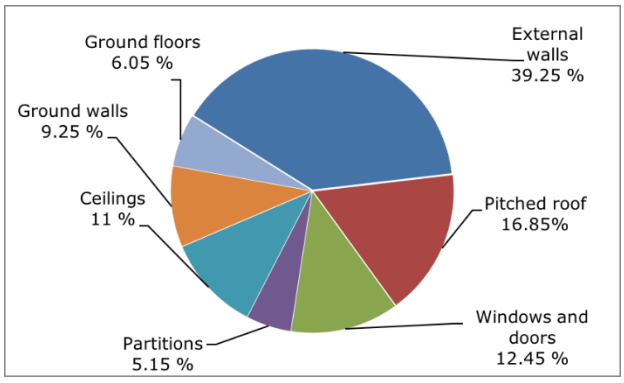

Figure 6. *Heat losses of construction components in the current state of building*

Annual energy consumption of the building in the current state is 861 MWh (the oil central heating system), while specific annual heat consumption is 179 kWh/m^2. Since the adoption of energy-class benefits of the specific thermal energy for heating systems are operating with a recess, that is the basis of which this building belongs to the energy class F. Energy Efficiency Standards in Buildings defined that the maximum annual consumption of heat energy for educational buildings is 75 kWh/m^2. Based on the results of the analysis, the annual energy heat consumption of Technical school in Čačak is 2.6 times higher than allowed for this type of object.

2.4. Energy saving measures

Based on the analysis of energy efficiency of the building, it was noticed that it is necessary to improve the thermal characteristics of all components of the building envelope: exterior walls, wooden windows, mezzanine structures, roof structures, ground walls and walls oriented to unheated space and floors [9].

In order to reduce the energy required for heating and improve the energy class of the building, it is proposed to install the following types of insulation:

1. To all exterior walls of the building made out of brick, a 7 cm thick layer of Knauf thermal insulation made of stone wool is necessary to be added on outer surface of the walls. A similar reconstruction was proposed on the exterior walls of the building, which are made of concrete, with the required thermal insulation thickness of 8 cm.
2. In order to reduce the overall heat transfer coefficient and prevent the occurrence of condensation in the roof structure, it is necessary to reconstruct the roof. It is necessary to remove the layer of reed board, wood wool board and PVC foil from the roof structure. Under the roof, install a layer of vapor permeable foils and between them place two layers of thermal insulation of stone and mineral wool, 14 cm thick. On the inner side of the roof structure, install stone wool insulation - stone lamellas 2 cm thick.
3. For glass surfaces, it is necessary to replace the existing wooden windows with low-emission double-layer glass 4 mm thick, with air filling 12 mm thick, with six-chamber PVC windows with krypton filled low-emission double-layer glass (4+12+4).
4. On the walls towards the unheated space, it is necessary to install 5 cm thick stone mineral wool thermal insulation . Also, a thermal insulation made of mineral wool 8 cm thick is required to be installed under the unheated space on mezzanine construction.
5. On the walls in the basement of the building, it is necessary to add 5 cm thick thermal insulation made of stone mineral wool on the inside.
6. On the floors of the building in classrooms and offices, a waterproofed 3 cm thick mineral wool boards was proposed to be installed. On the floors in the corridors and rooms in which the toilets and

auxiliary rooms are located, a 4 cm thick thermal insulation panels made of stone mineral wool is proposed to be installed.

7. On the remaining floors of the school was proposed to install a 3 cm thick with waterproofed thermal insulation made of stone mineral wool.

The proposed measures refer only to the installation of insulating material. The results of the research included all the accompanying elements on the improvement of the energy efficiency of the building, which include the dismantling of the old layers and the installation of other accompanying elements of the structure, which is performed for the complete energy rehabilitation of the building.

The proposed measures for improving the energy efficiency of buildings are the minimum measures that are necessary to apply in order to obtain the heat transfer coefficients of the analysed assemblies that are less than the corresponding maximum values defined by the National Energy efficiency standard in buildings.

Table 1. *The overall heat transfer coefficients U (W/m²K) through the thermal envelope of the building*

Building envelope structure	Umax W/m²K	Current state	Proposed state
Exterior walls: Brick Concrete	0.40	1.23 1.87	0,38 0.38
Pitched roof	0.20	0.55	0.11
Window Old wooden	1.50	1.80	1.30
Partitions	0.55	1.92	0.52
Ceilings	0.40	0.53	0.36
Ground wall	0.50	1.29	0.48
Floors: Classrooms Toilets Hallways	0.40	0.55 0.60 0.61	0.38 0.37 0.37

2.5. Results of implemented energy performance improvement

The application of the proposed measures to increase the energy efficiency of the building of the Technical School in Čačak is fully justified. After the implementation of measures to improve the energy efficiency of the building annual transmission heat losses through thermal envelope component of the building envelope should have the following values:

1. Exterior walls: 76956 kWh
2. Pitched roof: 24765 kWh
3. Windows and doors: 74758 kWh
4. Partitions: 10242 kWh
5. Ceilings: 55921 kWh
6. Ground walls (basement): 20074 kWh
7. Ground floors: 29421 kWh.

A comparative analysis of heat transfer losses and their percentages in total building heat losses, for the current and proposed case, is shown in Fig. 7 and 8. After the application of measures used to improve the energy efficiency of the building, transmission losses through all elements decreased, but their share in total losses is changed.

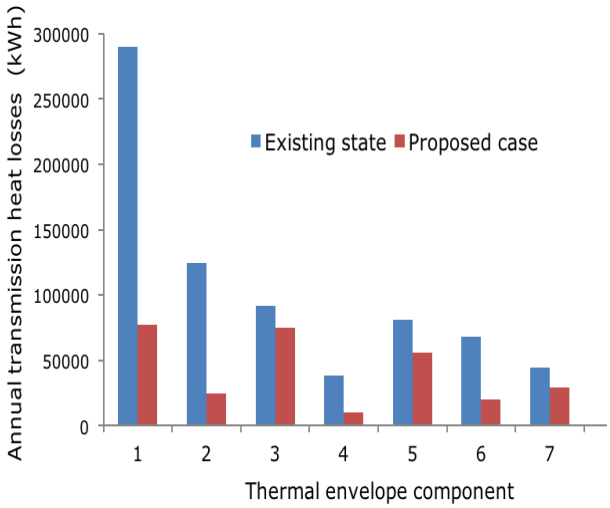

Figure 7. *Transmission heat losses for current and propose state*

After the application of the proposed measures for the improvement of the energy efficiency of the building, the largest reduction of transmission losses can be expected with a pitched roof, when the losses can be reduced by up to 80%. The reduction of heat transfer losses through exterior walls and partition walls towards unheated space after the application of the proposed measures is 73%, while a reduction of less than 63% can be achieved after the reconstruction of the walls in the ground of the building. The smallest reduction of transmission losses of 18% is achieved with windows because part of the old energy inefficient wooden windows has been replaced previously.

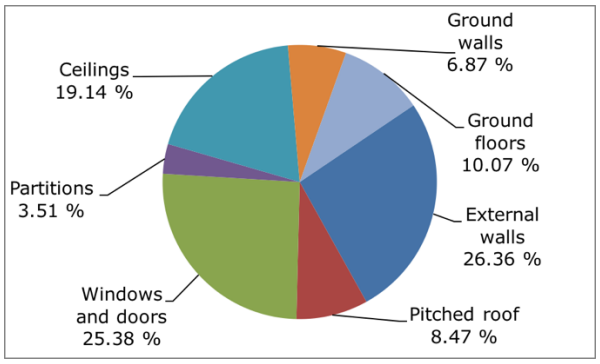

Figure 8. *Heat losses of construction components* in the proposed state of building

The total energy required to compensate for the transmission losses of the building in the proposed case is 386 MWh. By applying the proposed measures, annual energy savings can be achieved to compensate for transmission losses of up to 54 % for the entire facility.

Solar heat gain in the proposed case were reduced by 26 %, while energy gains from people and electrical appliances remained unchanged.
The annual energy required for heating the building of the Technical School in Čačak in the proposed case is 433 MWh, which is 50 % less than the building consumes in its current state.
In this research, the energy certificates of the building were also determined (Fig. 9). In the proposed state, the annual specific consumption of thermal energy for heating is 99 kWh/m2, which is a reduction of 45% compared to the specific consumption of thermal energy consumed by the building of the Technical School in the current state. To adopt the energy class, specific heat energy is used for systems that work with interruption, on the basis of which the building belongs to the D energy class.

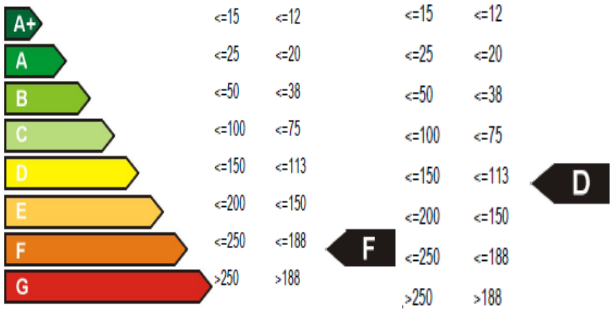

Figure 9. Energy classes of the building in current and proposed state

Energy retrofit and renovation of existing buildings have an effective role in reducing carbon dioxide emissions and ultimately global warming [10]. Results show that after applying the proposed measures CO_2 emission can be reduced from 264 t CO_2/year to 137 t CO_2/year.

3. CONCLUSION

The purpose of this study is to evaluate the energy performance of Technical school building in Čačak and assess the effects of selected energy efficiency measures on energy performance. This paper considered the impact of retrofit schedule influence on energy use. The results show that improving all building envelope structure insulation level will reduce energy consumption for heating that implies improvements in energy efficiency of the object, from F to D energy classes. However, even in objects that have achieved specific standards, the energy consumption may be dramatically different depending on the occupants' energy use behaviour, so more research is needed to analyse more targeted interventions to be applied. By teaching students to be mindful of how they use energy early on, we can ensure a better future for the energy industry and for the planet.

ACKNOWLEDGEMENTS

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Programming of an Industrial Robot and Optimization of its Path Using the PSO Algorithm

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Abstract: *Modern technical systems must meet the high technical and technological requirements that the market offers today. The introduction of robot systems into the production process is produced from the basic steps to increase the flexibility and productivity of the technological system. The paper uses the program RobotStudio for programming the movement of robots and the Particle swarm optimization (PSO) algorithm for optimizing the path of movement of the robot. The aim of this paper is to obtain optimal values of the rotation angles of the robot segments so that the trajectory of the robot is minimal.*

Keywords: *industrial robot, path optimization, PSO algorithm*

1. INTRODUCTION

Based on the analysis conducted in the assembly sector of 355 German companies in the machine industry, it is pointed out that the main potentials of rationalization of production costs lie in the design of assembly-oriented products and in the automation of assembly operations [1]. This paper presents the application of the SCARA robotic system for the assembly of a single assembly. The programming of the robotic system was done in the RobotStudio software, and with the help of the biologically inspired PSO algorithm, the optimal values of angles were obtained, which should be entered into the program in order for the robotic system to avoid obstacles during installation with the shortest distance traveled.

Before introducing the robotic system into the configuration of the technological system, it is necessary to perform a systematic analysis of all aspects of economy and technological justification. There are several criteria on the basis of which the justification of the use of robots in performing certain technological operations in the technological system can be assessed, and they can be classified into three groups [2]:

- Technical and technological criteria,
- Economic criteria for justifying process automation and
- Criteria for humanization of the work process.

2. SOFTWARE ROBOTSTUDIO

Offline programming is the best way to maximize return on investment for robot systems. ABB's simulation and offline programming software, RobotStudio, allows robot programming to be done on a PC in the office without shutting down production.

RobotStudio provides the tools to increase the profitability of your robot system by letting you perform tasks such as training, programming, and optimization without disturbing production. This provides numerous benefits including:

- Risk reduction,
- Quicker start-up,
- Shorter change-ove,
- Increased productivity.

RobotStudio is built on the ABB VirtualController, an exact copy of the real software that runs your robots in production. This allows very realistic simulations to be performed, using real robot programs and configuration files identical to those used on the shop floor [3].

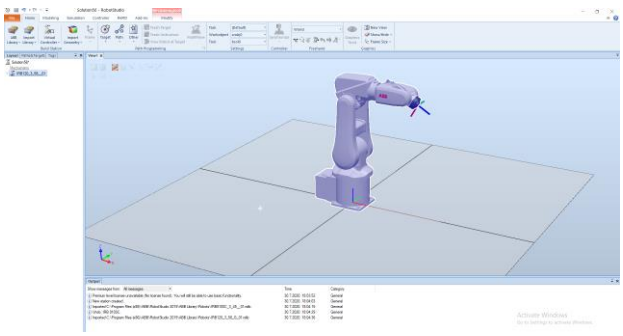

Figure 1. *Appearance of the home screen of ABB's RobotStudio robot programming software.*

3. ALGORITHM PSO

Particle swarm optimization PSO (Figure 1) 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 behavior of bird flocking [4]. 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.

$$\mathbf{x} = (x_1, x_2, ..., x_n) \quad (1)$$

or potential solution. Random position in space which is explored, as well as initial 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.

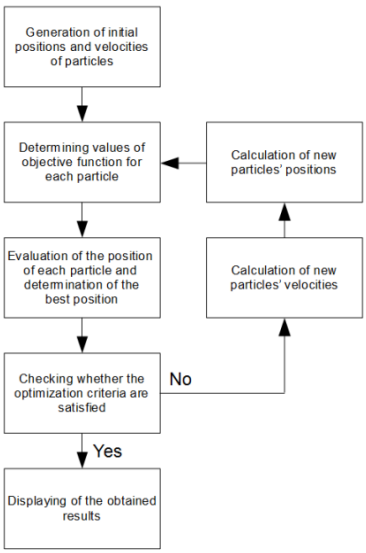

Figure 2. *Algorithm of the method of particle swarm optimization.*

Figure 2 graphically shows how to determine new velocities and positions in two-dimensional space of search.

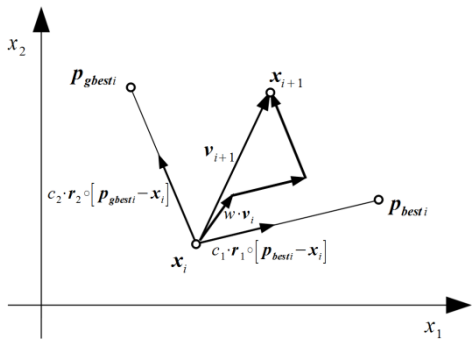

Figure 2. *Updating of velocity and position of the i particle.*

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.

$$\mathbf{v}_{i+1} = w \cdot \mathbf{v}_i + c_1 \cdot \mathbf{r}_1 \circ (\mathbf{p}_{\mathbf{best}i} - \mathbf{x}_i) + c_2 \cdot \mathbf{r}_2 \circ (\mathbf{p}_{\mathbf{gbest}i} - \mathbf{x}_i) \quad (2)$$

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:

$$(A \circ B)_{i,j} = (A)_{i,j} \cdot (B)_{i,j} \quad (3)$$

Inertia weight w impacts the first component, and for the values in the range of 0,9 – 1,2 [5] 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 $\mathbf{r}_2$, stochastically 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 $\mathbf{v}_{i+1}$.

$$\mathbf{x}_{i+1} = \mathbf{x}_i + \mathbf{v}_{i+1} \quad (4)$$

The values of the goal function for new positions of the particle are determined again, and for each particle new and old values of the goal function are compared. If the new value is smaller, then it becomes new best value and the current position becomes the best position of that particle. The position of the particle with the smaller value becomes new best position for the entire swarm. Again, it needs to be checked whether the optimization criteria are satisfied; if they are, the results are shown, and if not, the entire procedure will be repeated until the criteria are satisfied.

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 MOUNTING ASSEMBLY TO BE INTRODUCED FOR ROBOTIC SYSTEM

The assembly to be assembled consists of a pump body (15), a timing shaft subassembly (25), and a washer subassembly (24). Skop is a part of the manual pump for lifting the cabin of the "Kamaz" truck. The pump body is fixed while first the pin (25) is inserted into the body and then on the other side of the washer subassembly (24) as shown in the assembly plan:

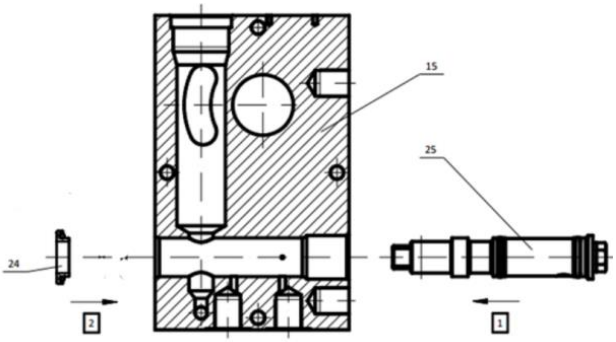

Figure 3. *The assembly plan*

In the SolidWorks software package, we have to model these components, which we later import into RobotStudio together with the robot. In this way we form a real environment and the programming and optimization of robot movements is performed in a real environment. Figures 4 and 5 show the two assembly steps that the robot needs to perform.

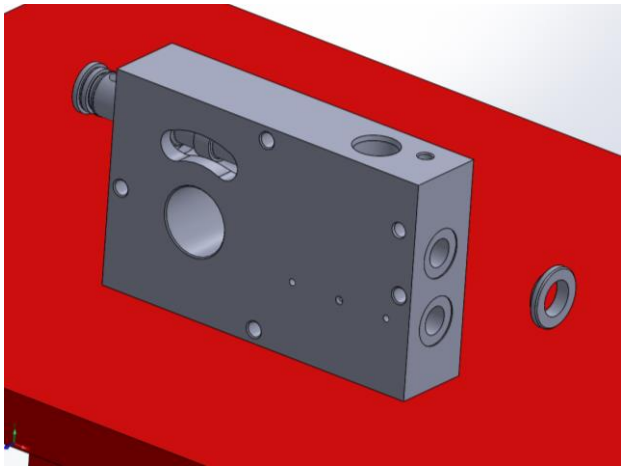

Figure 4. *Pin assembly*

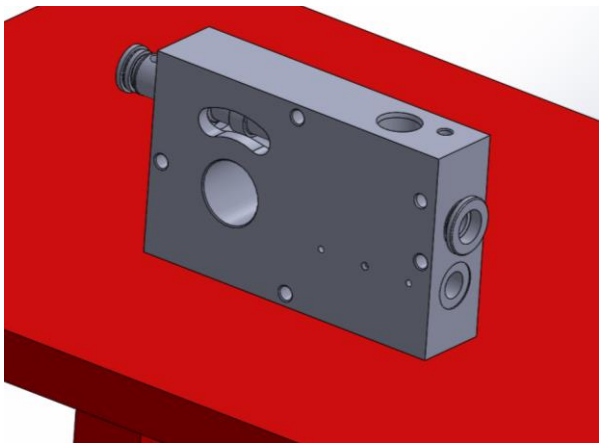

Figure 5. *Assembly of the washer subassembly*

For these assembly operations, a SCARA robot should be introduced and the shortest assembly path determined. RobotStudio is used to program the robot's movement and the biologically inspired PSO algorithm is used to optimize the path.

5. OPTIMIZATION OF THE ROUTE OF THE ROBOT SYSTEM USING THE PSO ALGORITHM

By analyzing the assembly plan and the need to move the robotic system, it can be concluded that we have the movement of the robotic system around the obstacle that the housing makes. Analysis of this problem can be found in scientific papers [6].

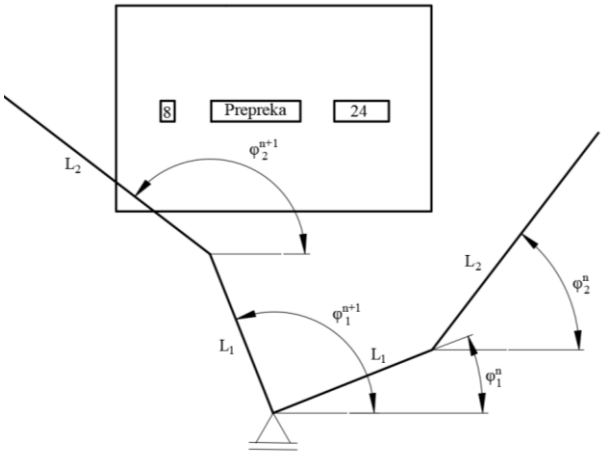

Figure 6. *Schematic representation of optimization problems*

In order to determine the optimization problem, the path of the robot during assembly is first analyzed. We see that the disputed path is "3" then the robot must go around the obstacle (pump body) and continue with the assembly.

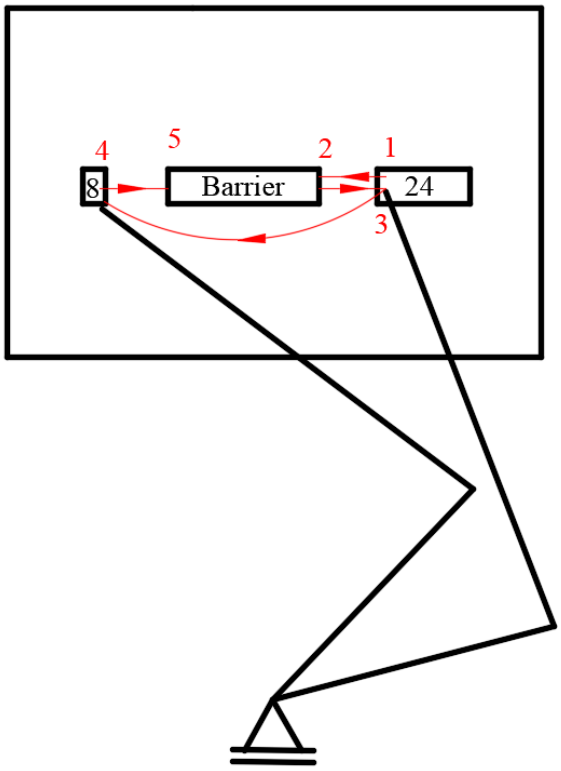

Figure 7. *Robot system motion analysis*

The robotic system consists of two segments that can rotate around the "Z" axis. The final equations of motion of the robot endpoint called the Tool Center Point (TCP) can be written in the form of expression (1):

$$\begin{aligned} X_P &= L_2 \cdot \cos(q_1+q_2) + L_1 \cdot \cos(q_1) \\ Y_P &= L_2 \cdot \sin(q_1+q_2) + L_1 \cdot \sin(q_1) \end{aligned} \tag{1}$$

The robotic system consists of two segments that can rotate around the "Z" axis. The final equations of motion of the robot endpoint called the Tool Center Point (TCP) can be written in the form of expression (1).

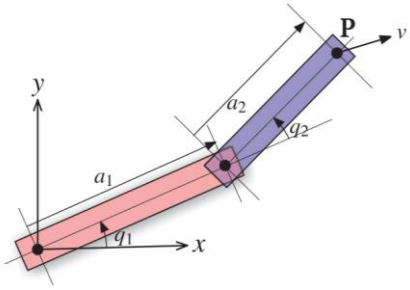

Figure 8. SCARA robot configuration [6]

The desktop space where the assembly is performed is actually the space searched by the PSO algorithm (green surface) and the area occupied by the pump body is the restriction where the robot must not pass (red surface).

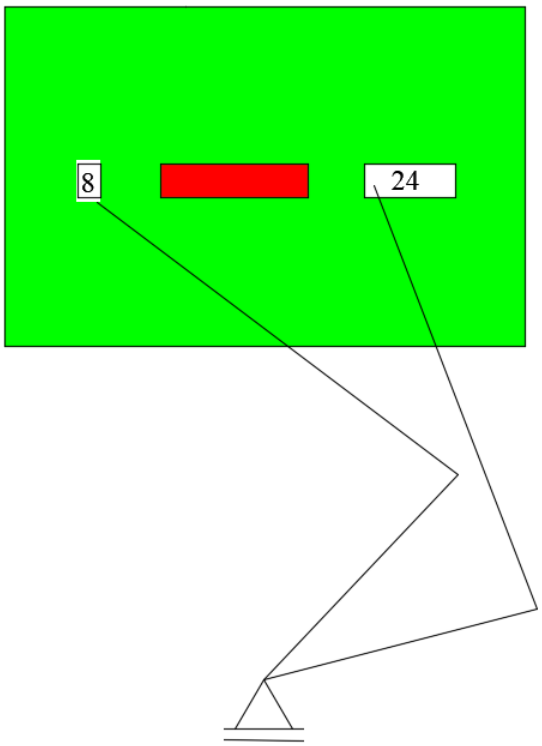

Figure 9. Workspace with barrier

The limitations that must be met are:

$$\begin{aligned} &0 < q_1 < 360 \\ &0 < q_2 < 360 \\ &X_P \in \{0,180\} \cup \{320,460\} \\ &Y_P \in \{0,130\} \cup \{160,300\} \end{aligned} \tag{2}$$

Figure 10 shows the limitations of the area occupied by the pump body.

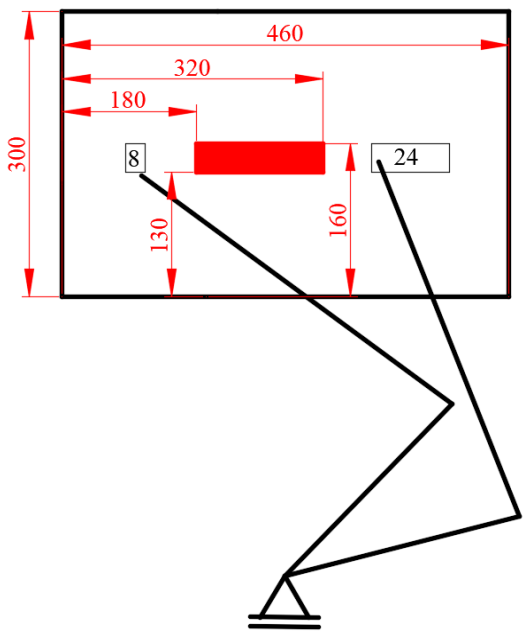

Figure10. *Position of the barrier in the workspace*

Based on the objective function (1) and constraint (2), with the help of the PSO algorithm, the values of the coordinates k1 and k2 are obtained, which the robotic system should occupy while crossing the shortest path. We enter these values when we program the movement of the robotic system in RobotStudio and by simulating the movement we can check if the path we have programmed is adequate.

6. ROBOT SYSTEM PROGRAMMING IN THE ROBOT STUDIO SOFTWARE PACKAGE

In the RobotStudio studio package, we can import the robot we want and the product that is mounted in the right size. In this way, we perform programming in a real environment. The product is modeled in SolidWorks, and the robot is in the RobotStudio database.

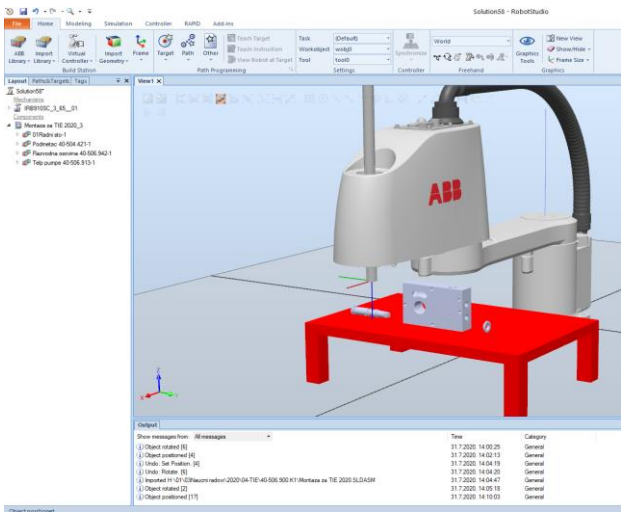

Figure 11. *The first step, forming a real environment*

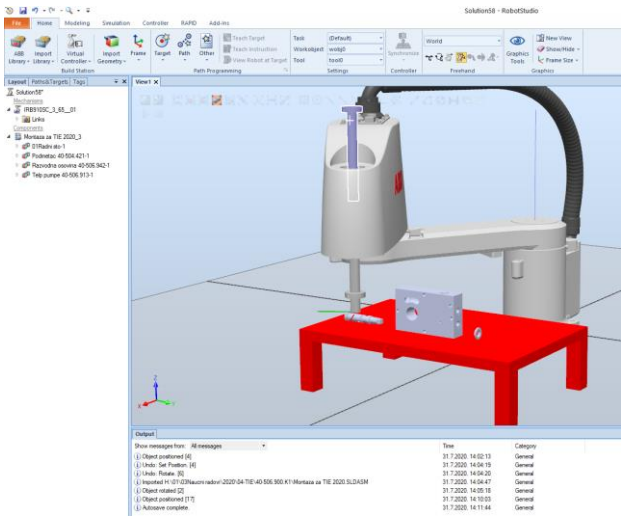

Figure 12. *The second step, mounting an axle*

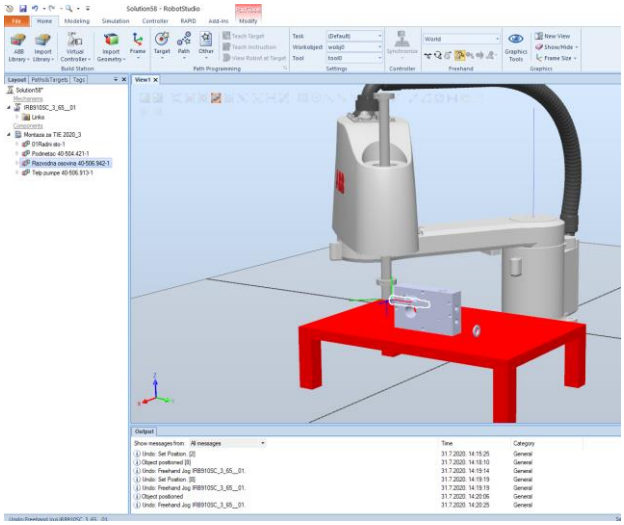

Figure 13. *The third step, bypassing the obstacle*

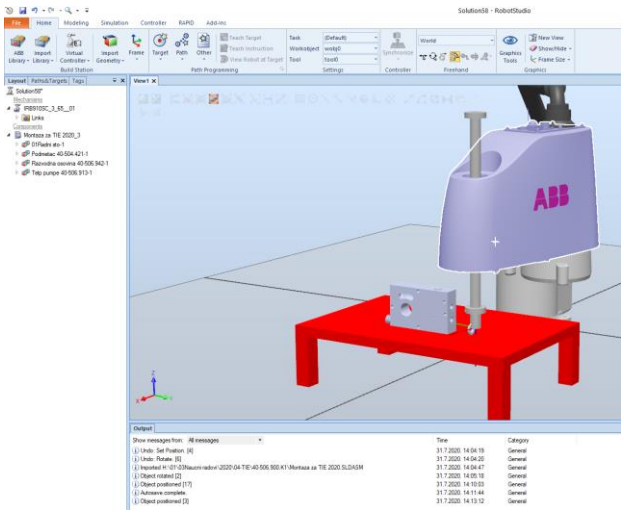

Figure 14. *The fourth step, mounting the washer subassembly*

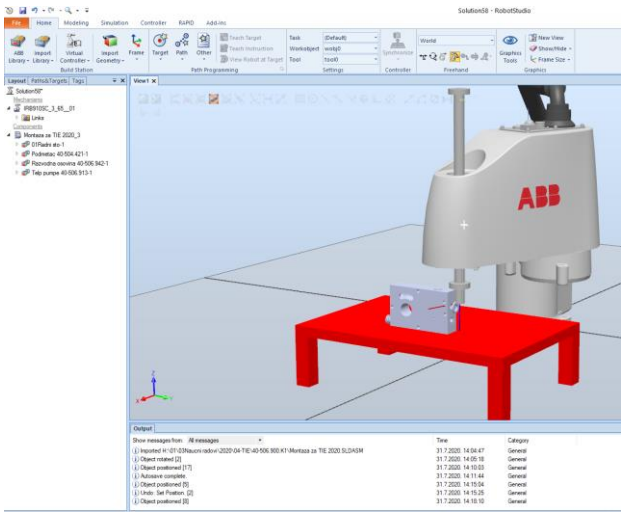

Figure 15. *Fifth step, mounting the washer subassembly*

7. CONCLUSION

Modern technological systems must be able to respond to all the challenges posed by the market today. That is, they must be intelligent technological systems. The application of biologically inspired algorithms in combination with the simulation of production processes enable the technological system to increase its productivity.

In addition, the application of application programs for robot programming is more efficient than for the designer to determine the paths that the robot must describe.

The paper shows on the example of the assembly of a hand pump that it is possible to find the minimum path that the robot should go during the assembly in order to make the assembly process as short as possible and therefore cheaper.

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Faculty of Technical Sciences, Čačak, Serbia, 18-20th September 2020

Session 3: *Engineering Education and Practice*

Professional paper
UDC: 533:378.147

Design and Simulation of Electro-Pneumatic Motion Control System

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Abstract: *Teaching of technical subjects is an extremely complicate and complex process and it is demand on logical thinking and imagination. Use of computer simulation in education is growing rapidly and has become a major trend in technical education. Design of the educational setting for electro-pneumatic control of the movement of the sheet bending machine is presented in this paper. After designing, the educational set is built with real electrical and pneumatic components in laboratory conditions. The paper also discusses the simulated design of pneumatic systems with FluidSIM software. The outcomes of the simulation show that the pneumatic system parameters can serve adequately.*

Keywords: *design; simulation; electro-pneumatic; FluidSim; educational set.*

1. INTRODUCTION

A modern curriculum in professional education cannot be fully realized if it does not provide the application of modern equipment that enables students to acquire and develop practical skills and at the same time simulate a real work environment. An intense technological development, especially in the field of information technology, has significantly affected the modernization of educational and didactic equipment. Modern teaching equipment is compliant with the industry needs, so that it provides an opportunity for students to develop practical skills of the 21st century.

The application of simulation software is also very important for relating theory with practice, so that the students can develop engineering aspects and understand how process behaviour can be captured using real time simulations. Students need to get a feel for sizes and sensitivities of system parameters, to examine the relationship between and responses of such parameters and to understand the value and limitations of numerical methods used in system solutions. By acknowledging the discrepancies between the model of a physical system and a system in a virtual environment, students can perform optimizations, in terms of cost and time-consumption. [1,2]

Compressed air is one of the oldest man-known form of energy that is used as a substitute for physical labour. Today's modern industry cannot even be imagined without compressed air since every branch of industry uses compressed air devices. That's the reason why knowing the principles of operation of basic pneumatic elements and the correlation of parameters that affect the pneumatic systems operation is very important in teaching of technical subjects. The control of pneumatic components using electrical impulses is known as electro-pneumatics.

Design of the educational setting for electro-pneumatic (EPM) control of the movement of the sheet bending machine is presented in this paper. The system is built using real industrial components and enables the implementing of practical knowledge and skills that are easily applicable in practice.

Simulation of the pneumatic system operation is realized in FluidSim software which is a comprehensive software for simulation of fluid control systems and it is mostly fitted for use in educational purposes. FluidSim software helps students to analyse and solve problems with relevant knowledge and enhance their practical abilities. [3]

2. STRUCTURE OF THE DESIGNED EPM SYSTEM

Motion sequence control is a mandatory step by step process in which the next control is programmed by the previous step. In an electro-pneumatics control system, three major circuits must be identified: a pneumatic circuit, a control circuit (electric) and a power circuit. The control circuit and power circuit are electric. [4]

Fig. 1 shows the design of the electro-pneumatic system for bending of metal elements. Tools and equipment needed for designing this system are compressor, air treatment unit, pressure regulator,

pipeline, educational set „Sheet metal bending" and a computer with software.

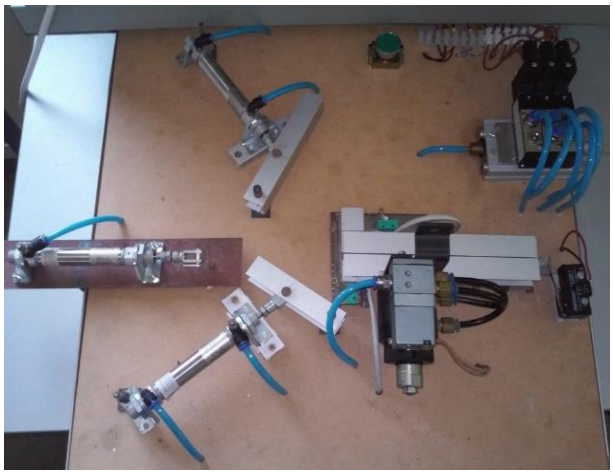

Figure 1. *Electro-pneumatic system for sheet metal bending*

The basic function of a compressor is to convert the supplied mechanical energy into the energy of compressed air.

The main characteristics of the compressor are airflow rate, i.e. the amount of compressed air and the pressure achieved after compression. A reciprocating compressor with rectilinear piston movement, which is most often used in practice today, is used in this educational set. Compressed air and moisture increase the wear rate of surface and sealing, and it is reducing the efficiency and service life of pneumatic components. Also, unstable pressure poorly affects the operation of the complete system.

Therefore, before entering the pneumatic devices, it is necessary to prepare compressed air, i.e. to perform air purification, lubrication and to regulate the air pressure. An air treatment group consists of a filter, a lubricator and a pressure regulator. The filter is used to eliminate impurities from the air, such as water, steam, compressor oil, dust and corrosion products. A lubricator is used to inject oil in the form of a fine mist into the air stream. The role of the pressure regulator is to provide a stable desired operating pressure. The pressure regulator dampens the pressure oscillations due to the variable air consumption that occurs as a disturbance on the outlet side of the regulator and reduces the air pressure from the main line to the required value of the working pressure.

„Sheet metal bending" educational set consists of the following pneumatic and electrical components: single-acting and double-acting pneumatic actuating cylinders, solenoid impulse valves, pushbutton, limit switches and PC with software. Pneumatic linear motors - cylinders convert the energy of compressed air into mechanical work. In pneumatic systems, the cylinder is usually the executive element. They can be with one-way (single acting cylinder) or two-way (double acting cylinder) operating mode. Single acting cylinders have the working fluid supplied only from one side of the piston and push it, whereby the connecting rod is pulled out and perform the mechanical work. Return of the piston to its starting position is done either with a spring or its weight. Double acting cylinders have the working fluid supplied from both sides of the piston so that the cylinder has a working stroke in both directions. A pneumatic distributor is used to control the double acting working cylinder.

Distributors are valves that pass, close and direct the flow of working fluid. Distributor type is determined by the number of connections, number of positions (states), activation method, return method and connection sizes. The label of distributor corresponds by the number of connections and distribution positions. In the realization of described educational set, electromagnetic controlled air distributors type 5/3 and 3/2 were used. Type 3/2 means three ports and two positions: one port connects to the source of compressed air; second port serves as outlet and the third port connects to the cylinder. The valve has two positions: filling or emptying the cylinder. The required valve size can be calculated once the cylinder and application properties are known.

By working on this educational setup, students get familiarized with the principles of operation of applied pneumatic components. They learn to design pneumatic systems and simulate their operation, and most importantly they learn to implement this type of systems. [5]

The task needed to be solved using this educational setting is to bend the sheet metal to make a "J" profile. A complete sequence for solution of the metal sheet bending task is shown in the Fig. 2.

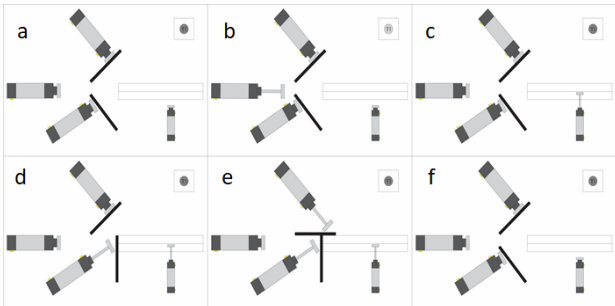

Figure 2. *Sequencing of sheet metal bending operations*

The control sequence consists of the following steps: (a) Manually place the sheet metal in the form of a strip in the machine. The cycle starts by pressing the T1 pushbutton; (b) single acting cylinder C pushes the sheet metal strip until the position CX is reached; (c) Cylinder C then returns to the home position; (d) One-way cylinder D clamps the sheet metal into the tool; (e) Then the double acting cylinder A bends the strip until it reaches AX position, the two-way cylinder B then bends the sheet metal to the limit position BX; (f)

At the end of the cycle, all cylinders return to the home position.

3. PNEUMATIC SYSTEM DESIGN

Pneumatic system design contains two parts: pneumatic and electrical. FESTO FluidSim software is used for simulation of pneumatic power system (Fig. 3). FluidSIM is a comprehensive software for the creation, simulation, instruction, and study of electro-pneumatic, electro-hydraulic, digital and electronic circuits. All the program functions interact smoothly, combining different media forms and sources of knowledge in an easily accessible manner. FluidSIM unites an intuitive circuit diagram editor with detailed descriptions of all components, component photos, sectional view animations and video sequences [6]. Pneumatic components are explained with textual descriptions, figures, and animations that illustrate underlying working principles [7].

Electrical part of the design should be done in different ways. Each student can apply their logic by designing their own circuit diagram for the system to do the required sequence. This electrical design stays only in simulation, so students can use all electrical component they think they need. One of the electrical schematics is shown on the Fig. 4.

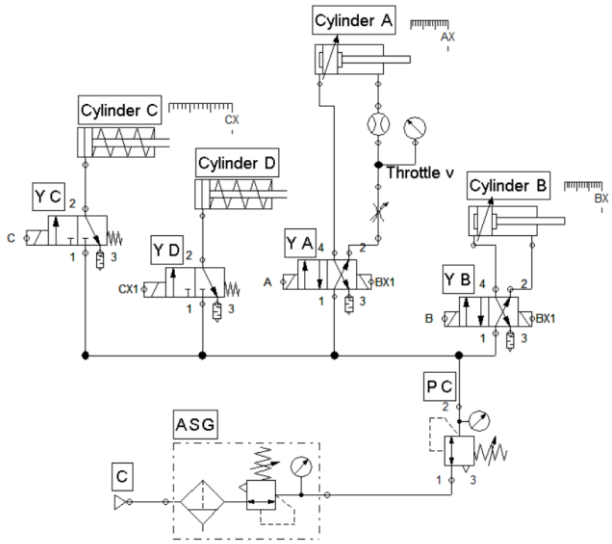

Figure 3. *FluidSim schematic diagram of the pneumatic circuit*

Pressing the button (F9) starts the simulation while button T1 is used to start the sequence that is being simulated. This simulation helps students to see if their logic is working or not. After their logic is working in simulation, pneumatic and electrical schematics can be implemented on a real system.

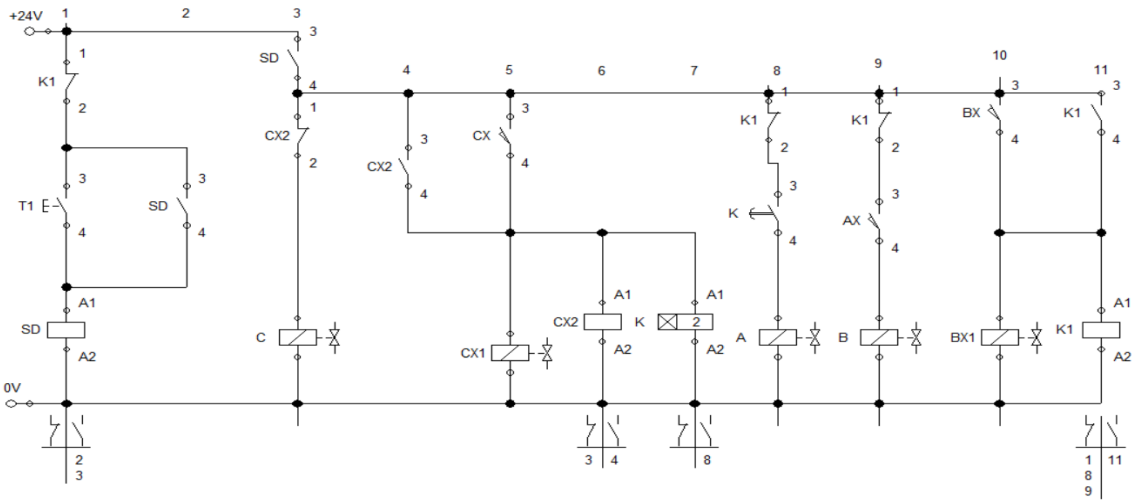

Figure 4. *Electrical schematic of the system*

The component part of the EPM system is as shown in Table 1, for pneumatic and electrical circuit of the system.

Each symbol can be parametrized as physical component in the system. For example, double-acting pneumatic actuating cylinder A (PCU-16-50-DD-A) has 50 mm maximum stroke, 16mm piston diameter and 5mm rod diameter [8]. Those parameters must be configured in cylinder configurator software section shown in the Fig. 5.

Table 1. *Description part list for EPM system*

Number of items	Designation	Description
1	C	Compressed air supply
1	ASU	Air service unit, simplified representation
2	Cylinder A, B	double-acting actuating cylinders
2	Cylinder C, D	single-acting actuating cylinders
2	AY, BY	4/2-way valves
2	CY, DY	3/2 -way valves
1	T1	Pushbutton

3	AX, BX, CX	Limit switch
1		Electrical connection 24V
1		Electrical connection 0V
1	SD	Self-holding relay
8	C, CX1, A, B BX1	Valve solenoid
2	K, K1	Relay
1	K	Time delay relay

Solenoid valves must be configured in the same way as cylinders (Fig. 6). The parameters must be in accordance with the documentation for every valve in the system. Each component must be properly configured for the simulation to be done properly.

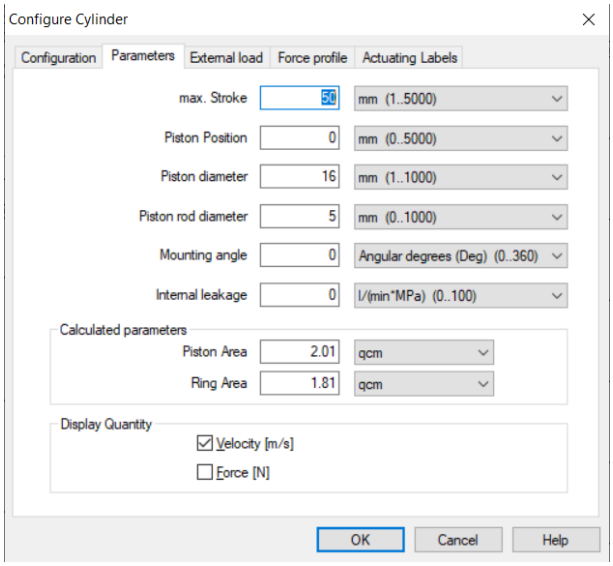

Figure 5. *Configuration of the double-acting cylinder A*

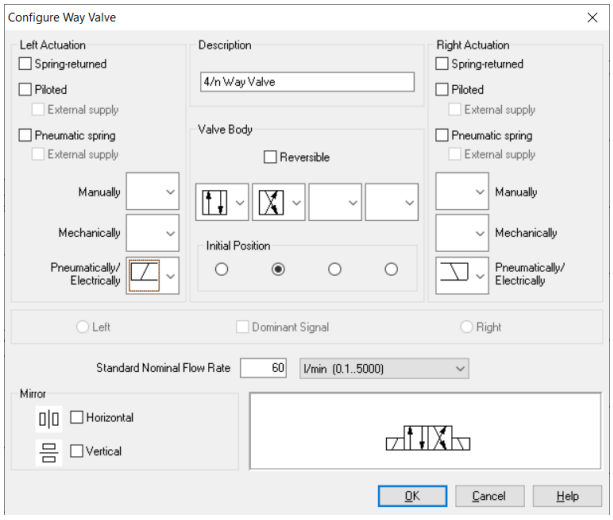

Figure 6. *Configuration of the solenoid valve*

4. FLUIDSIM SIMULATION ENVIRONMENT

Advantages of using FluidSim for simulation of the system is seen through easy access modelling and user-friendly options. Different computer simulations and experimental process ware carried out by means of the developed model shown in Fig. 3. The following results were obtained to ascertain the workability of the system. In addition to simulating logic, the program FluidSim can also simulate states of the system on the time axis. Those states can be speed and position of cylinder, pressure and flow rate on the desired component. In this paper cylinder acting with flow change in his one input is simulated. Flow has been changed with decrease from 1% to 20% in steps (1%, 2%, 3%, 5%, 10%, 20%). Graph with position and velocity of cylinder A and B as well as graph of pressure and flow if throttle valve are shown in the Fig. 7.

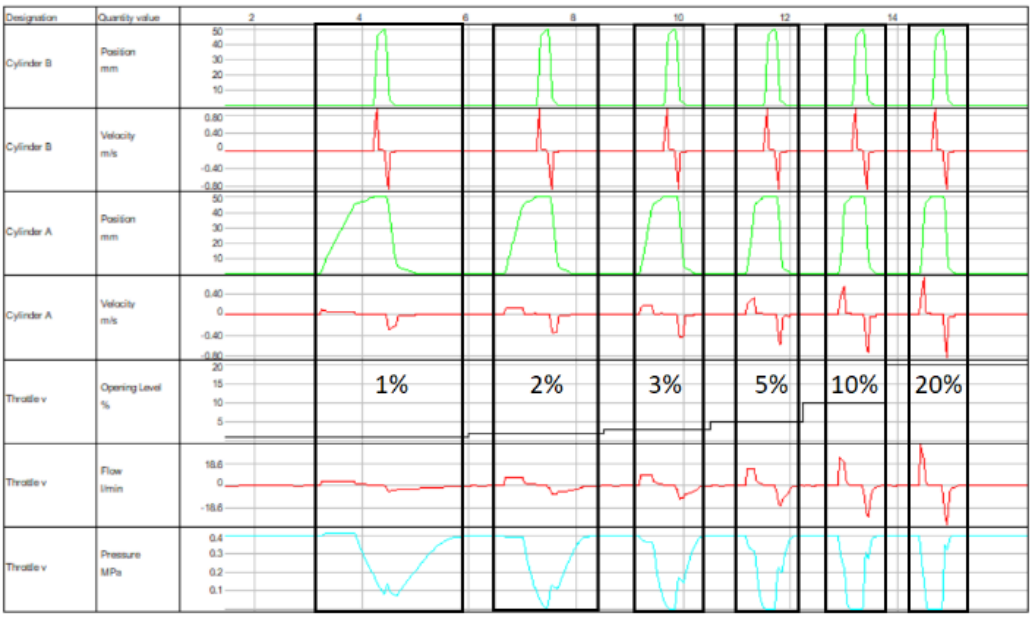

Figure 7. *The simulation diagram result of dependence of position and velocity on different throttle valve openings for cylinders A and B*

This graph shows that acting cylinder speed is proportional with flow through it. As flow is increasing the acting cylinder speed is increasing, and it takes lower amount of time to react. Cylinder A has one input flow regulation, but it impacts on both inputs as graph shows. Throttle valve on one side reduces the flow change in the cylinder on both sides (extraction and retraction).

With this type of simulation, cylinder speed can be adjusted to the value that has to be achieved on a real system. Acting speed of the cylinder A in analysed system is important because if it is not tuned well, it can cause collision with the other cylinder in the system.

5. CONCLUSION

In the past decades, the context of engineering education has changed dramatically. Modelling and simulation can significantly boost the learning and teaching process of electro-pneumatics. In this paper design and simulation of an educational set for electro-pneumatic motion control system is analysed. The simulated pneumatic system is built using the main components of the machine for sheet metal bending. The most important advantages of these computer simulation in education are interactive feature, fostering students' visualization, and enhancing their problem-solving process. The experimental and simulation results show the characteristics and behavior of the air movement within the system. A further upgrade of the system should be adding a PLC controller, and thus make it more flexible. This can be helpful to improve the performance and optimization of the analysed system. By applying the presented educational set in teaching courses, increased motivation of students was noticed, and a higher level of student's practical knowledge and skills was achieved in relation to the traditional model of teaching.

ACKNOWLEDGEMENTS

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[8] DIN ISO 6432 Pnevmatski cilindri / Pneumatic cylinders, cylinder manual UNI-AIR

8th International Scientific Conference
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Faculty of Technical Sciences, Čačak, Serbia, 18-20th September 2020

Session 3: *Engineering Education and Practice*

Review paper
UDC: 37:621

Training and Development of Mechatronics and Micro- and Nanosystems Technology in Technical University of Gabrovo Bulgaria

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Abstract: *The aim of the study is training and research work in mechatronics and micro- and nanotechnology. A resolution to this question was presented at the present at the TU of Gabrovo, BG. The paper discusses the curriculum and educational program in Bachelor's degree and Master's degree in Mechatronics. Special attention is given to the educational and methodological materials on micro- and nanotechnology and the training opportunities for graduates. There are also major R & D- topics in this area and works for the habilitation of teachers. The training and development period covers the last 10-12 years (2009-2020).*

Keywords: *Mechatronic, Micro- and Nanosystems*

1. INTRODUCTION

The aim of the study is training and research work in mechatronics and micro-and nanotechnology. The subject of attention is the historical development of mechatronics and nanotechnology and the state of the problem worldwide in Bulgaria. The term „Nanomehatronika" introduced by the chief engineer and founder T. Mori S. Yashkava Company Yashkawa Electric, Japan in 1969 and is registered as a trademark in 1972 to receive priority in the competition in the market [1]. Widespread and popular it is accepted that the term „Mechatronics" combines concepts Mechanics (mechanism) and electronics (microelectronics and informatics). Synthesis, however, lies in the concept of katakana (one of the letters of the alphabet or Japanese Alfavit) word composed of elements of English words and manner of entry into language is the same as for a number of Anglo-Americanism - Modernism in the expression of people in the modern world. Later it introduced the concept „Mechatronic approach", an integrated or inter-disciplinary approach for mechatronic systems. It can be discerned in the following features in development: optimizing the design through CAD / CAE - systems, upgrading drives and controls, development of advanced technology related to micro-and nanotechnique and integration in CIM; deployment of intelligent systems meet people's needs. In Bulgaria priority were automation systems engineering developed in the works "Mechatronics - Gabrovo, peripheral and computer engineering at "Orgtehnika" - Silistra, robotic systems and automation of production in the IMM and ITCR - Sofia GAPS in Stara Zagora, but more recently have systems to protect the environment, controllers controls CLM-Procesors BG Academy of Sciences, nanotechnology became strategic and others.

Mechatronics is a set of tools and principles in mechanics, electronics and informatics, synthesis of existing technologies used effectively to achieve a specific goal [2]. Surely, in the other literature to find additional definitions, views and analysis of their contents [3, 4]. However, they do not consider themselves Micro- and nanomehatronics as part of mechatronics. According to the German-Russian electronic dictionary [5] mikromehatronic a subfield of mechatronics, which relates to devices and systems with dimensions of several mm and smaller. Similarly, nanomehatronics is a subfield of mechatronics, which relates to devices and systems commensurate with the molecules of substances. That is to say, a special section on mechatronics, due to its merger with nanotechnology and the vocation to deal with the theory and practice of nanomehatrons systems. Unknown up until about the year 2000, the "Nanotechnology" has become the most common and important word in science, it came into operation in politics and its adoption become a strategic direction in programs (NNI), plans and projects. The author of this paper has already published a study on the state of nano-technology to the 2003-5 year [6, 7].

Mechatronics is a new science that began to teach in universities around 15-25 years as a discipline, an area of specialization, and now has established itself as an interdisciplinary specialty including mechanical, electronic and information systems.

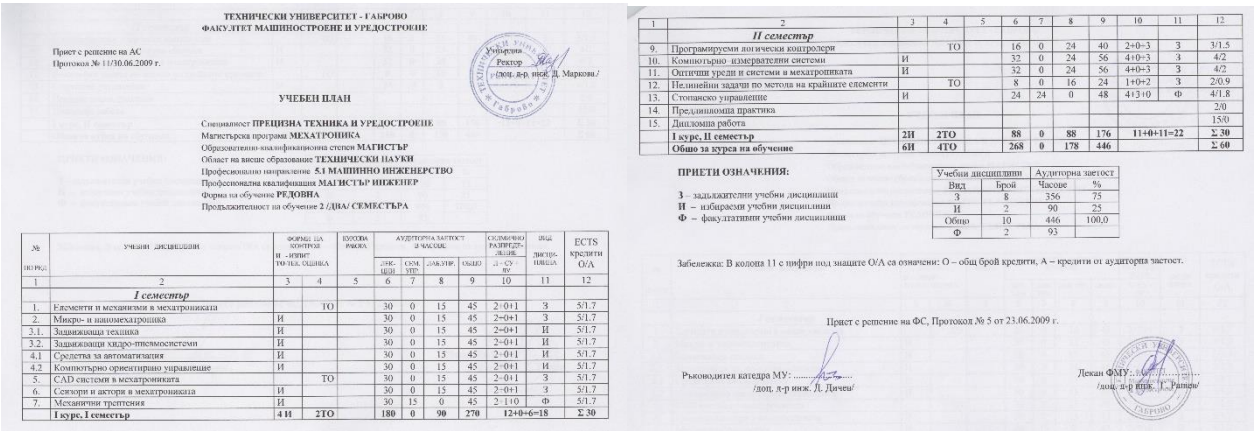
The symbiosis between many studies in mechatronics consists of many levels, from data collection to generate ideas in the design process to implement and introduce products in action [8]. There are several similar versions of the synthesized representation of mechatronics, as here in Fig. 1 which provides a principled and two of them advanced version. Mechatronic systems (MS) is characterized by its integration of components and functions implemented in varying degrees as micro / nanosystem engineering and mechatronics are part of the Precision Engineering. The essence of a mechatronic approach is to merge into a single module / s of the constituent elements in varying degrees of integration. Usually mechatronics is presented as a unity of three parts: 1 - drive 2 - actuators, 3 - management. Area 4 is traditionally called the Electromechanical, Automation - 5, control - 6 and 7 - Core.

Figure 1. *Principle and performance of advanced mechatronics and applied in areas subject (in Russian)*

The area of specialization in Mechatronics is being studied worldwide in manufacturing departments of prestigious universities (Russia - 13 U.S. - 10, Germany - 8 Canada - 5 Holland - 4, Japan, Australia, Belgium -3, Finland and Hungary - 2, New Zealand and Bulgaria - 2, Serbia and Macedonia – 1 and in other countries). According to UNESCO, specialty is one of ten most desired, new and promising in the world.

2. RESULTS

In the year 2009, at the TU-Gabrovo both a regular and part-time training courses in Mechatronics, were established as a Master's degree program after completing a Bachelor of Science degree Precision Engineering, already Mechatronics. The degree allows graduates to gain a thorough theoretical and practical training to the creation, implementation and operation of MS. The Leading Department is "MU", but the teachers from the participating departments such as ET, PC-system and technologies, EE and others. The curriculum is coordinated and consistent with the Technical University of Gabrово and allows students and teachers from Europe to participate. Is shown in Fig. 2. Curriculum and programs have already been presented in detail in [12, 13, 15].



ТЕХНИЧЕСКИ УНИВЕРСИТЕТ - ГАБРОВО
ФАКУЛТЕТ МАШИНОСТРОЕНЕ И УРЕДОСТРОЕНЕ

Приет с решение на АС
Протокол № 11/30.06.2009 г.

Ректор
/доц. д-р инж. Д. Маркови./

УЧЕБЕН ПЛАН

Специалност **ПРЕЦИЗНА ТЕХНИКА И УРЕДОСТРОЕНЕ**
Магистърска програма **МЕХАТРОНИКА**
Образователно-квалификационна степен **МАГИСТЪР**
Област на висше образование **ТЕХНИЧЕСКИ НАУКИ**
Професионално направление **5.1 МАШИННО ИНЖЕНЕРСТВО**
Професионална квалификация **МАГИСТЪР ИНЖЕНЕР**
Форма на обучение **РЕДОВНА**
Продължителност на обучение **2 /ДВА/ СЕМЕСТЪРА**

№ по ред.	УЧЕБНИ ДИСЦИПЛИНИ	ФОРМА НА КОНТРОЛ И - изпит ТО-ТЕК. ОЦЕНКА		БУХОВА РАБОТА	АУДИТОРНА ЗАТЕТОСТ В ЧАСОВЕ				СЕМЕСТРИЧНО РАЗПРЕДЕЛЕНИЕ	ВИД ЛИСТО-ВИЗИТА	ECTS кредити О/А
					ЛЕК-ЦИИ	СЕМ. УПР.	ЛАБОРТР.	ОБЩО	Д – СУ – ПУ		
1	2	3	4	5	6	7	8	9	10	11	12
	I семестър										
1.	Елементи и механизми в мехатрониката		ТО		30	0	15	45	2+0+1	З	5/1.7
2.	Микро- и наномехатроника	И			30	0	15	45	2+0+1	З	5/1.7
3.1.	Задвижваща техника	И			30	0	15	45	2+0+1	И	5/1.7
3.2.	Задвижващи хидро-пневмосистеми	И			30	0	15	45	2+0+1	И	5/1.7
4.1	Средства за автоматизация	И			30	0	15	45	2+0+1	И	5/1.7
4.2.	Компютърно ориентирано управление	И			30	0	15	45	2+0+1	И	5/1.7
5.	CAD системи в мехатрониката		ТО		30	0	15	45	2+0+1	З	5/1.7
6.	Сензори и актори в мехатрониката	И			30	0	15	45	2+0+1	З	5/1.7
7.	Механични трептения	И			30	15	0	45	2+1+0	Ф	5/1.7
	I курс, I семестър	**4 И**	**2ТО**		**180**	**0**	**90**	**270**	**12+0+6=18**		**Σ 30**

1	2	3	4	5	6	7	8	9	10	11	12
	II семестър										
9.	Програмируеми логически контролери		ТО		16	0	24	40	2+0+3	З	3/1.5
10.	Компютърно измервателни системи	И			32	0	24	56	4+0+3	З	4/2
11.	Оптични уреди и системи в мехатрониката	И			32	0	24	56	4+0+3	З	4/2
12.	Нелинейни задачи по метода на крайните елементи		ТО		8	0	16	24	1+0+2	З	2/0.9
13.	Стопанско управление	И			24	24	0	48	4+3+0	Ф	4/1.8
14.	Предипломна практика										2/0
15.	Дипломна работа										15/0
	I курс, II семестър	**2И**	**2ТО**		**88**	**0**	**88**	**176**	**11+0+11=22**		**Σ 30**
	Общо за курса на обучение	**6И**	**4ТО**		**268**	**0**	**178**	**446**			**Σ 60**

ПРИЕТИ ОЗНАЧЕНИЯ:

З – задължителни учебни дисциплини
И – избираеми учебни дисциплини
Ф – факултативни учебни дисциплини

Учебни дисциплини		Аудиторна заетост	
Вид	Брой	Часове	%
З	8	356	75
И	2	90	25
Общо	10	446	100,0
Ф	2	93	

Забележки: В колона 11 с цифри под знаците О/А са означени: О – общ брой кредити, А – кредити от аудиторна заетост.

Приет с решение на ФС, Протокол № 5 от 23.06.2009 г.

Ръководител катедра МУ: .....
/доц. д-р инж. Л. Личев/

Декан ФМУ: .....
/доц. д-р инж. Г. Рашев/

Figure 2. *Curriculum of a Master's degree program in Mechatronics*

The courses encompass a set of modular training of ADC Company National Instrument (USA) and LAB View a demonstration of virtual instruments and sensors and actuators of the Mitsubishi (Japan) company. An academic laboratory was established using CAD / CAM-systems of PTC Proingeneer Wild Fire 3.0, and the module was equipped with a program for designing printed circuit boards and integrated circuits. Using the system AutoCad students developed a design of pneumatic tools, three dimensional models of a device for checking gears and precision quartz clock as their theses by students (fig. 3). Examples of the designs are presented in the learning process in this course "CAD-systems in mechatronics".

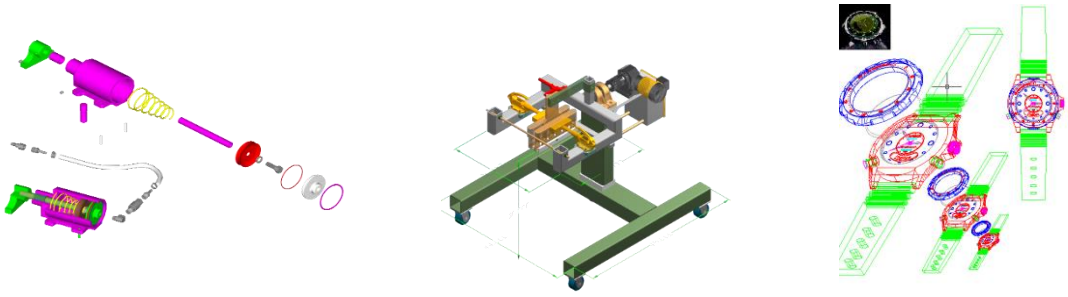
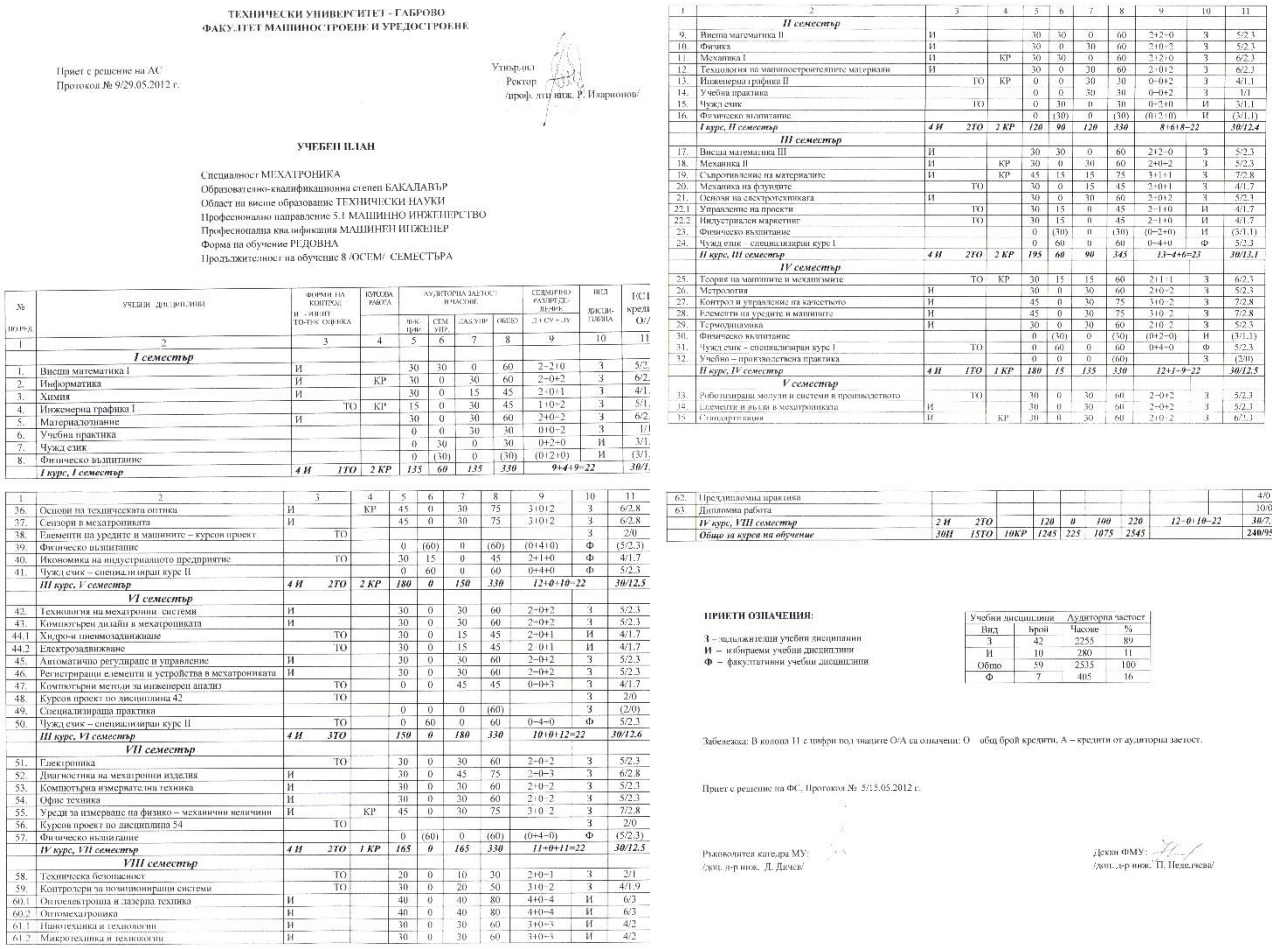


Figure 3. *Examples: Construction of pneumatic tools, three dimensional models of a device for checking gears and precision quartz clock*

In various training practices modular robots were developed (e.g. a robotic supplis us a with a glass of water on sloping terrain). The module 9841 NXT LEGO Company is a programmable controller program secured with a friendly interface and convenient for this purpose, allowing it to include servomotors and sensitive sensors (fig. 4). Contains 9787 NXT contains structural elements and servomotors, 9648 – has an additional design kit, color sensor, accelerometer, IR-sensor, touch sensor and ultrasonic sensor (fig. 9).

Fig. 4. *The module 9841 NXT*

Beginning in the academic year 2013/14, the TU-Gabrovo established the specialty „Mechatronics" with a Bachelor of Science degree. For this purpose special were prepared teaching aids such as [16]. Training will be in operation with Higher school Shmalkalden, Germany for direction „Total engineering" and University of Thrace - Edirne, Turkey "Automotive engineering" to obtain a double diploma in the EU. Practical training takes place in the companies "Mechatronics" AD-Gabrovo, AMK - Gabrovo, a carmaker with China in Lovech and others. Curriculum have already been presented in fig. 5.



ТЕХНИЧЕСКИ УНИВЕРСИТЕТ - ГАБРОВО
ФАКУЛТЕТ МАШИНОСТРОЕНЕ И УРЕДОСТРОЕНЕ

Приет с решение на АС
Протокол № 9/29.05.2012 г.

Утвърдил:
Ректор
/проф. д-р инж. Р. Иванов/

УЧЕБЕН ПЛАН

Специалност МЕХАТРОНИКА
Образователно-квалификационна степен БАКАЛАВЪР
Област на висше образование ТЕХНИЧЕСКИ НАУКИ
Професионално направление 5.1 МАШИННО ИНЖЕНЕРСТВО
Професионална квалификация МАШИНЕН ИНЖЕНЕР
Форма на обучение РЕДОВНА
Продължителност на обучение 8 /ОСЕМ/ СЕМЕСТЪРА

№ по ред.	УЧЕБНИ ДИСЦИПЛИНИ	ФОРМИ НА КОНТРОЛ И ОЦЕНКА	КУРСОВА РАБОТА	АУДИТОРНА ЗАСТОСТ В ЧАСОВЕ				СЕДМИЧНО РАЗПРЕДЕЛЕНИЕ	ВИД ДИСЦИПЛИНА	ECTS кредити
				ЛЕК. УПР.	СЕМ. УПР.	ЛАБ.УПР.	ОБЩО			
1	2	3	4	5	6	7	8	9	10	11
	I семестър									
1.	Висша математика I	И		30	30	0	60	2+2+0	З	5/2.
2.	Информатика	И	КР	30	0	30	60	2+0+2	З	6/2.
3.	Химия	И		30	0	15	45	2+0+1	З	4/1.
4.	Инженерна графика I	ТО	КР	15	0	30	45	1+0+2	З	5/1.
5.	Материалознание	И		30	0	30	60	2+0+2	З	6/2.
6.	Учебна практика			0	0	30	30	0+0+2	З	1/1
7.	Чужд език			0	30	0	30	0+2+0	И	3/1.
8.	Физическо възпитание			0	(30)	0	(30)	(0+2+0)	И	(3/1.
	I курс, I семестър	***4 И***	***1ТО***	***2 КР***	***135***	***60***	***135***	***330***	***9+4+9=22***	***30/1.***
1	2	3	4	5	6	7	8	9	10	11
	II семестър									
9.	Висша математика II	И		30	30	0	60	2+2+0	З	5/2.3
10.	Физика	И		30	0	30	60	2+0+2	З	5/2.3
11.	Механика I	И	КР	30	30	0	60	2+2+0	З	6/2.3
12.	Технология на машиностроителните материали	И		30	0	30	60	2+0+2	З	6/2.3
13.	Инженерна графика II	ТО	КР	0	0	30	30	0+0+2	З	4/1.1
14.	Учебна практика			0	0	30	30	0+0+2	З	1/1
15.	Чужд език	ТО		0	30	0	30	0+2+0	И	3/1.1
16.	Физическо възпитание			0	(30)	0	(30)	(0+2+0)	И	(3/1.1)
	I курс, II семестър	***4 И***	***2ТО***	***2 КР***	***120***	***90***	***120***	***330***	***8+6+8=22***	***30/12.4***
	III семестър									
17.	Висша математика III	И		30	30	0	60	2+2+0	З	5/2.3
18.	Механика II	И	КР	30	0	30	60	2+0+2	З	5/2.3
19.	Съпротивление на материалите	И	КР	45	15	15	75	3+1+1	З	7/2.8
20.	Механика на флуидите	ТО		30	0	15	45	2+0+1	З	4/1.7
21.	Основи на електротехниката	И		30	0	30	60	2+0+2	З	5/2.3
22.1	Управление на проекти	ТО		30	15	0	45	2+1+0	И	4/1.7
22.2	Индустриален маркетинг	ТО		30	15	0	45	2+1+0	И	4/1.7
23.	Физическо възпитание			0	(30)	0	(30)	(0+2+0)	И	(3/1.1)
24.	Чужд език – специализиран курс I			0	60	0	60	0+4+0	Ф	5/2.3
	II курс, III семестър	***4 И***	***2ТО***	***2 КР***	***195***	***60***	***90***	***345***	***13+4+6=23***	***30/13.1***
	IV семестър									
25.	Теория на машините и механизмите	ТО	КР	30	15	15	60	2+1+1	З	6/2.3
26.	Метрология	И		30	0	30	60	2+0+2	З	5/2.3
27.	Контрол и управление на качеството	И		45	0	30	75	3+0+2	З	7/2.8
28.	Елементи на уредите и машините	И		45	0	30	75	3+0+2	З	7/2.8
29.	Термодинамика	И		30	0	30	60	2+0+2	З	5/2.3
30.	Физическо възпитание			0	(30)	0	(30)	(0+2+0)	И	(3/1.1)
31.	Чужд език – специализиран курс I	ТО		0	60	0	60	0+4+0	Ф	5/2.3
32.	Учебно – производствена практика			0	0	0	(60)		З	(2/0)
	II курс, IV семестър	***4 И***	***1ТО***	***1 КР***	***180***	***15***	***135***	***330***	***12+1+9=22***	***30/12.5***
	V семестър									
33.	Роботизирани модули и системи в производството	ТО		30	0	30	60	2+0+2	З	5/2.3
34.	Елементи и вериги в мехатрониката	И		30	0	30	60	2+0+2	З	5/2.3
35.	Стандартизация	И	КР	30	0	30	60	2+0+2	З	6/2.3
36.	Основи на техническата оптика	И	КР	45	0	30	75	3+0+2	З	6/2.8
37.	Сензори в мехатронните	И		45	0	30	75	3+0+2	З	6/2.8
38.	Елементи на уредите и машините – курсов проект	ТО							З	2/0
39.	Физическо възпитание			0	(60)	0	(60)	(0+4+0)	Ф	(5/2.3)
40.	Икономика на индустриалното предприятие	ТО		30	15	0	45	2+1+0	Ф	4/1.7
41.	Чужд език – специализиран курс II			0	60	0	60	0+4+0	Ф	5/2.3
	III курс, V семестър	***4 И***	***2ТО***	***2 КР***	***180***	***0***	***150***	***330***	***12+0+10=22***	***30/12.5***
	VI семестър									
42.	Технология на мехатронни системи	И		30	0	30	60	2+0+2	З	5/2.3
43.	Компютърен дизайн в мехатрониката	И		30	0	30	60	2+0+2	З	5/2.3
44.1	Хидро-и пневмозадвижване	ТО		30	0	15	45	2+0+1	И	4/1.7
44.2	Електрозадвижване	ТО		30	0	15	45	2+0+1	И	4/1.7
45.	Автоматично регулиране и управление	И		30	0	30	60	2+0+2	З	5/2.3
46.	Регистриращи елементи и устройства в мехатрониката	И		30	0	30	60	2+0+2	З	5/2.3
47.	Компютърни методи за инженерен анализ	ТО		0	0	45	45	0+0+3	З	4/1.7
48.	Курсов проект по дисциплина 42	ТО							З	2/0
49.	Специализираща практика			0	0	0	(60)		З	(2/0)
50.	Чужд език – специализиран курс II	ТО		0	60	0	60	0+4+0	Ф	5/2.3
	III курс, VI семестър	***4 И***	***3ТО***		***150***	***0***	***180***	***330***	***10+0+12=22***	***30/12.6***
	VII семестър									
51.	Електроника	ТО		30	0	30	60	2+0+2	З	5/2.3
52.	Диагностика на мехатронни изделия	И		30	0	45	75	2+0+3	З	6/2.8
53.	Компютърна измервателна техника	И		30	0	30	60	2+0+2	З	5/2.3
54.	Офис техника	И		30	0	30	60	2+0+2	З	5/2.3
55.	Уреди за измерване на физико – механични величини	И	КР	45	0	30	75	3+0+2	З	7/2.8
56.	Курсов проект по дисциплина 54	ТО							З	2/0
57.	Физическо възпитание			0	(60)	0	(60)	(0+4+0)	Ф	(5/2.3)
	IV курс, VII семестър	***4 И***	***2ТО***	***1 КР***	***165***	***0***	***165***	***330***	***11+0+11=22***	***30/12.5***
	VIII семестър									
58.	Техническа безопасност	ТО		20	0	10	30	2+0+1	З	2/1
59.	Контролери за програмируеми системи	ТО		30	0	20	50	3+0+2	З	4/1.9
60.1	Оптоелектроника и лазерна техника	И		40	0	40	80	4+0+4	И	6/3
60.2	Оптомехатроника	И		40	0	40	80	4+0+4	И	6/3
61.1	Нанотехника и технологии	И		30	0	30	60	3+0+3	И	4/2
61.2	Макротехника и технологии	И		30	0	30	60	3+0+3	И	4/2
62.	Предипломна практика									4/0
63.	Дипломна работа									10/0
	IV курс, VIII семестър	***2 И***	***2ТО***		***120***	***0***	***100***	***220***	***12+0+10=22***	***30/7.***
	Общо за курса на обучение	***30И***	***15ТО***	***10КР***	***1245***	***225***	***1075***	***2545***		***240/95***

ПРИЕТИ ОЗНАЧЕНИЯ:

З – задължителни учебни дисциплини
И – избираеми учебни дисциплини
Ф – факултативни учебни дисциплини

Учебни дисциплини		Аудиторна застост	
Вид	Брой	Часове	%
З	42	2255	89
И	10	280	11
Общо	59	2535	100
Ф	7	405	16

Забележка: В колона 11 с цифри под знаците О/А са означени: О – общ брой кредити, А – кредити от аудиторна застост.

Приет с решение на ФС, Протокол № 5/15.05.2012 г.

Ръководител катедра МУ:
/доц. д-р инж. Д. Дачев/

Декан ФМУ:
/доц. д-р инж. П. Неделчева/

Figure 5. *Curriculum of a Bachelor's degree program in Mechatronics*

Current projects of research and applications in nanotechnology quantum dots (semiconductor nanosized) carbon nanotubes (CNTs), fullerenes (formations of carbon atoms), nanocomposite materials for advanced technology, metal nanoparticles (mainly precious metals, gold, silver, platinum) magnetic nanoparticles (for diagnostics in medicine.), polymeric nanoparticles (as carriers of medicinal products for targeted treatment), nanostructured ceramic materials for sensors and for TU-Gabrovo - nanopowders, materials, packaging and others purposes. Based on the research conducted by the Department „MU"of the Technical University of Gabrovo, a three coordinate measuring machine was developed using the elemental basis of modular construction system for automation Heron ROBOTUNITS (fig. 6). The machine has a PLC-control and connection with CAD-CAM-system, operating in 1000 x 700 x 660 mm, with precision 10-20 μm. Measurement results are automatically recorded in the minutes in English. The management system is built using controllers from company MITSUBISHI ELECTRIC. The Microcontrollers FX2N and FX3U the MELSEC FX family of MITSUBISHI provide a good basis for economical solutions to problems of governance and regulation requiring from 10 to 256 inputs and outputs built for industrial applications and automation applications, likewise the use of the GT1150-QLBD - connection module, MR-E-20A-QW003 – servo power, HF-KE23KW1-S100 - servo motor. They can be expanded to respond to changes in schedules and increasing demands of consumers. The FX3U and FX2N controllers can communicate with other PLC-systems and controllers and interfaces for management and control panels. These two controllers have the opportunity for modular expansion and can be used to solve complex applications and tasks that require special features such as analog-digital and digital to analog conversion and the capability for networking (fig.7).

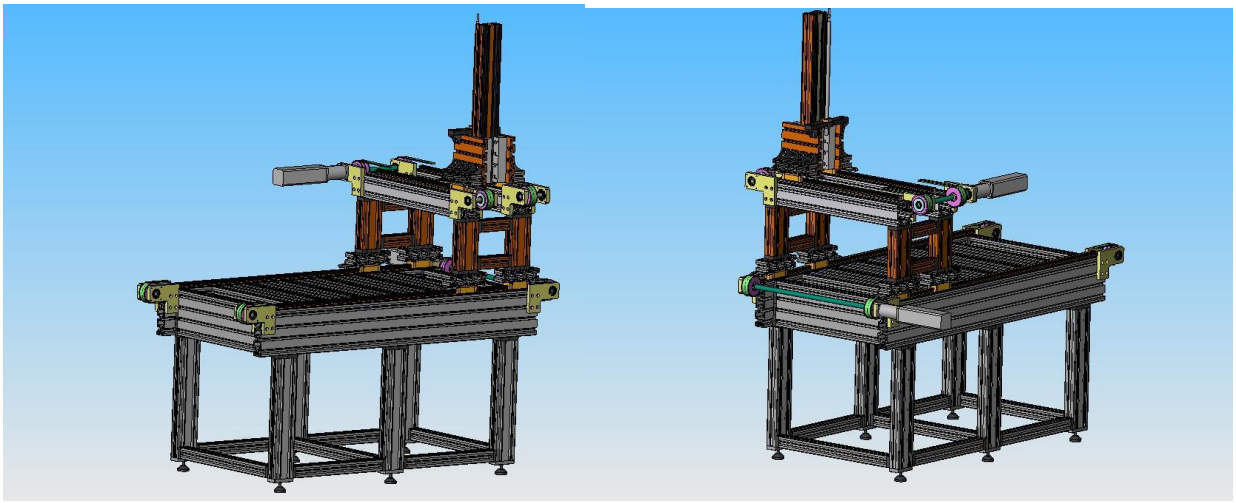


Figure 6. *Three coordinate measuring machine*

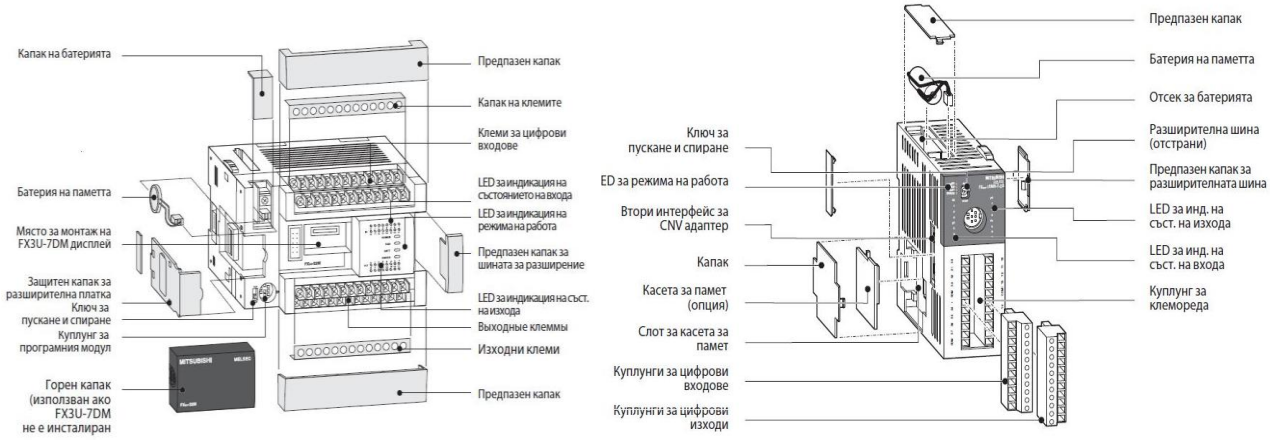


Figure 7. *PLC-programmable logic controllers FX2N and FX3U (in Bulgarian)*

Computerization in the mechatronic industry requires constant miniaturization and automation. Therefore, the author has developed the following products and software. It is basic to have an integrated system for automated design of functional elements of the micro-technique and selection processes for their preparation [9, 10], which sets out several examples of production of micronutrients. Moreover, in the front conference in Kaunas a microsensor for pressure was presented [11]. Here I want to focus on joint development in the form of a thesis on the Erasmus program, EMK Institute at the Technical University Darmstadt, Germany "Delta-Robot invasive surgery" (fig. 8). The first option was used with an external gear mesh, but not reduced weight of the robot. The second option is applied to the internal gear meshing and slight changes the suspension because the mechanism becomes more compact. The range of work is complemented by optical elements, miniature gears with asymmetric profile of engagement, dosimetry devices and other modifications. The aim of the training and development is to develop products for the market or to develop "Market Mechatronics". Additional information on the research can be drawn from the publications [14, 17, 18, 19, 20, 39, 40].

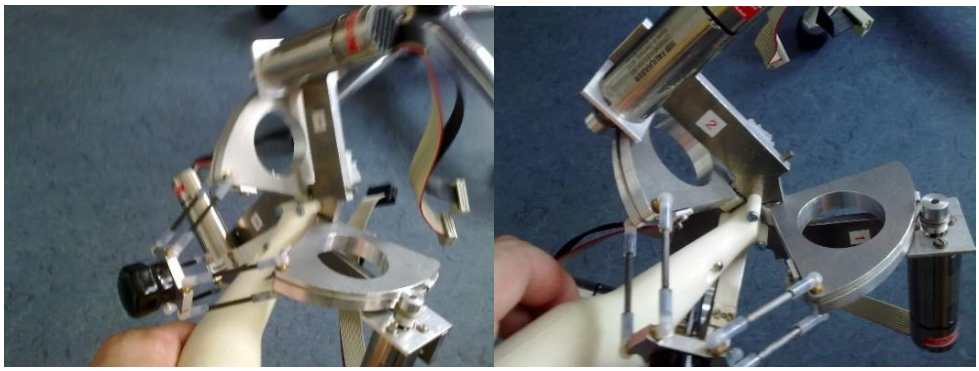


Figure 8. *An invasive surgical robot developed jointly with TU – Darmstadt, Germany*

My participation in a number of Mechatronics conferences has enabled me to express my view of its development in the publications [21, 22]. In articles [23, 24, 26] are proposed model and engineering-pedagogical techniques of training of technological disciplines in engineering specialties of TU – Gabrovo has been developing in the last 20 years. The training is divided into 8 thematic cycles and is oriented towards self-awareness as Bulgarian specialists in the profession. Specific developments in mechatronics are presented in publications [25, 27, 28]. Apply didactic approach that is very modern in the learning process for students of specialty Mechatronics. With Lego Mindstorms easily can be developed a small model of industrial robot or some system that is used in real life. These options are very diverse (fig. 9).

Figure 9. *Examples of robots - Stairclimber, Gyro Boy, Color Sorter and Robot Arm*

Research work on projects is presented in articles [29–35, 38] and includes Contract Reports 1308-M/2013 "Research and Modeling of Optical, Optoelectronics and Production and Organization Systems and Devices", 1636-C /2016 and 1722-M/2017 "Study of nanocomposites of silicon structures for application in mechatronics" at the University Centrum of Research and Technology in TU-Gabrovo. The bibliography on the topic of mechatronics will end with the textbook "Robotic modules and production systems" [36], developed new curricula in 2017 [41] and issued papers on educational project [37, 42].

3. CONCLUSION

The essence of a mechatronic approach is to merge into a single module / s the constituent elements in varying degrees of integration. To achieve the above mentioned goal, the rubber plant training was taken and research work was conducted. The curriculum for Master's and Bachelor's degree in Mechatronics at the Technical University of Gabrovo and are described in lectures, seminars and practical lessons (refer to the author). Topics related to practical implementation are as follows: pressure micro sensor, robotic invasive surgery, micro mechanisms and other. Research works on the subject are discussed in the University of Gabrovo. Proposed information can be used not only in the educational process of students inspecialty „Mechatronic", but also specialists in practice. The author is open for discussion, consultation and presentations on the topic.

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Simulations of Temperatures in the Cutting Zone and Cutting Forces

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Abstract: *Today, simulations are increasingly used in education and training (in mechanical engineering, medicine, army, etc.). They can be successfully used for the education of pupils and students at all levels of education, as well as for all ages. The use of this approach enables the understanding of complex processes and the development of skills in various disciplines without the use of expensive equipment or the implementation of time-consuming or dangerous experiments. This paper describes the application of simulations in order to better understand the cutting process, ie, the influence of individual cutting parameters on temperatures and cutting forces. The simulations were realized in the AdvantEdge software package. 2D simulations of turning machining were performed. In the first three simulations the feed **f** was varied, while in the next three simulations the cutting speed **v** was varied. The change in temperature in the cutting zone and cutting forces, depending on the feed **f** and the cutting speed **v** is analyzed. The results of the simulations are in accordance with theoretical and experimental data. Simulations of machining with a larger feed and higher values of the cutting speed show higher values of the temperature in the cutting zone and the cutting forces.*

Keywords: *simulation; temperature; cutting forces*

1. INTRODUCTION

The first application of computer simulations began during and immediately after World War II. Mathematicians John Von Neumann and Stanislav Ulam used newly developed computer techniques to model nuclear detonation in the design of a nuclear bomb [1]. As this method proved to be very successful, simulations were increasingly applied in various fields, both in science and in industry. The improvement of simulation technology has led to expanded possibilities of its application. The development of the computer industry and the advent of personal computers have made this form of learning practical and accessible to the general population. Real-time simulations and 3D simulations were developed in the 90s of the twentieth century. Today, simulations are applied in all branches of industry and in education because of their advantages over the traditional method of study. The main advantage of simulations is that they save time and money. Expensive materials and equipment are not necessary for simulations. Also, the preparation of experiments is sometimes very complex and time consuming.

With the help of simulations, abstract phenomena that are not visible during the realization of the experiment can be easily understood (for example, the propagation of heat in the cutting zone). In addition, users have the opportunity to analyze a large number of scenarios, which results in the rapid acquisition of new knowledge and skills while neutralizing risks. In the long run, investments in equipment and software package are a worthwhile investment.

2. APPLICATION OF THE SOFTWARE PACKAGE THIRD WAVE ADVANTEDGE FOR THE SIMULATION OF THE MACHINING PROCESS

The development of computers has enabled the introduction of the finite element method in everyday engineering practice. The essence of the finite element method is in the physical discretization of the examined domain (continuum) to the finite number of elements and the degree of freedom of movement. The interconnection of finite elements is defined by a finite number of nodal points whose positions are on the contour of each element.

Determining the state at each of the individual node points is enabled through known distribution functions within the elements (interpolation function) and by determining the unknown values of the function at the node points (node unknown). FEM analysis is a useful and effective method, in terms of both time and cost savings, for obtaining fast results [2]. FEM analysis is able to lower the

operational cost compared to physically conducting the machining experiment.

The Third Wave AdvantEdge software package is a commercial program for designing, improving and optimizing the machining process. It is primarily intended to simulate cutting process. The solver of this program (the part of the software that solves the mathematical problems) is adapted for metal cutting. Fig. 1 gives a graphical overview of the most frequently used software packages for simulation of the machining process with finite element method based on 116 scientific papers published in the period 2000-2014. [3]

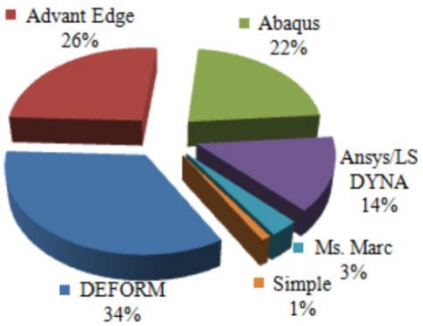


Figure 1. *An overview of research activities in the area of finite element simulation [3]*

The structure of the program consists of three modules: pre-process module, simulation module and post-process module. The pre-process module allows users to define the entire simulation, to define the geometry and material of the tool, the properties of the workpiece (dimensions and material) and the parameters of the machining process. The simulation module is the module where the simulation actually takes place. When the simulation is defined and started, the solver performs calculations based on the finite element method. When the calculations are completed, the results are processed in the post-process module and displayed in various forms such as graphs and images. The results that can be displayed are also chip shape, tool and chip temperature, cutting forces, tool wear and so on.

The simulation can be done in demonstration and standard mode. Demonstration mode reduces the duration of the simulation, but it is less accurate, while standard mode requires more time, but it is much more accurate.

3. TEMPERATURES IN THE CUTTING ZONE AND CUTTING FORCES

The appearance of heat in the cutting zone is a consequence of the conversion of mechanical energy into heat. Temperatures at characteristic points of the cutting zone are important for studying the cutting process (Fig. 2). The temperature θ1 occurs as a consequence of material breakage, ie rupture of the structure of the base material of the workpiece. The temperature θ2 occurs at the shear plane as a result of compression and deformation of the chip. Temperature θ3 is the contact temperature of the chip surface and the rake face of the cutting tool. It reaches its maximum at half of the contact. A contact temperature θ4 occurs on the contact of the side clearance surface of the cutting tool and the machined surface of the workpiece. The cutting zone temperature is the mean cutting temperature θsr.

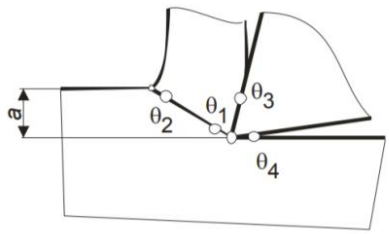


Figure 2. *Cutting zone temperatures [4]*

The heat in the cutting zone increases until an equilibrium state between the generated and dissipated heat is established. After the establishment of the equilibrium state, a quasi-stationary heat field is created [5]. The heat field can be considered stable only for a certain period of time. It has been experimentally determined that the establishment of the equilibrium state of the thermal field takes about 15 seconds.

The forces impacting on the cutting tool during machining process are named cutting forces.(Fig. 3) The understanding the phenomenon of the cutting forces has a significant role in the process of defining the machinability of materials, wear of cutting elements of tools, sizing of machine elements, driving power of the machine, etc. In orthogonal cutting, the resulting cutting force $\mathbf{F_R}$ can be decomposed into:

• tangential force (friction force) F_T, which acts in the plane of the rake surface and normal force F_N, which acts in the plane normal to the rake surface of the cutting wedge;

• shear plane force (shear force) F_S and normal force F_{SN}, which acts in the plane normal to the shear plane and

• the main force (main cutting force) F_1 and the penetration force (force F_2), which acts normally on the machined surface of the workpiece.

The equation for calculating the main cutting force F_1 is usually defined. Other components are determined based on the value of the main cutting force. The main cutting force is most influenced by the material of the workpiece and the parameters of the cutting process, above all the depth of cut and feed.

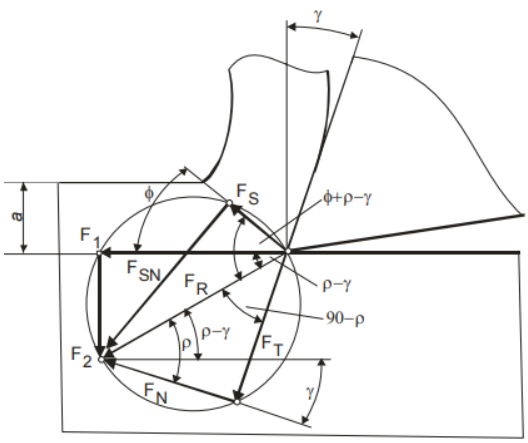


Figure 3. *Cutting force components in orthogonal cutting [4]*

The expression form, that is most often used to calculate the main cutting force, is:

$$\mathbf{F_1 = C_{k1} \cdot a^{x1} \cdot f^{y1}}, \qquad (1)$$

where ***a*** is the depth of cut and ***f*** is the feed, while k_1, x_1 and y_1 are constant and exponents of the influence of the workpiece material, tool geometry and machining conditions.

4. DEFINING PARAMETERS FOR 2D SIMULATION OF TURNING

The paper presents the process of model formation and 2D simulation of the turning process in the Third Wave AdvantEdge software package. After choosing the type of machining, it is necessary to choose the dimensions and material of the workpiece. As this is a 2D simulation of turning process, the workpiece is shown as a prismatic part. The material that is removed by turning is chip. After that, the tool is selected, and the shape, dimensions and material of the tool are defined. Finally, the parameters of the turning process are defined: cutting speed, feed, depth of cut (Fig. 4).

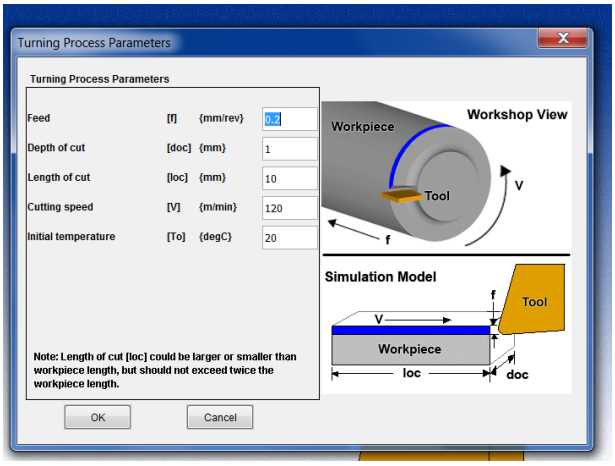


Figure 4. *Defining of the process parameters*

The workpiece and tool that are imported from existing databases have already defined mesh parameters and they can be changed. The *Tecplot* subroutine allows users to define the simulation output parameters to be displayed. After all preparations, a simulation is started. For the appropriate processing modes (Table 1), six simulations were created.

Table 1. *Process parameters in simulations*

Cutting parameters	Simulation name					
	TIO-1	TIO-2	TIO-3	TIO-4	TIO-5	TIO-6
Cutting speed, v [m/min]	120			110	130	150
Feed, f [mm/o]	0,2	0,7	1,2	0,3		
Depth of cut, a [mm]	1					

On the basis of these six simulations, the influence of the cutting speed and the feed on the temperature in the cutting zone and cutting forces was analyzed. The material of the workpiece was C45, Ø100 mm. The tool was a turning knife with a cutting plate made of P20 carbide. The rake angle of the knife is γ = 10 ° and the side clearance angle is α = 5 °. The cutting length was 10 mm. The comparative views of the simulations are taken after 10 mm long cutting, (Fig. 5.) Fig. 5 shows the differences in temperature distribution in the cutting zone for different parameters of cutting process. The option to display the mash in the simulations views is turned off, so the temperature fields can be noticeabled. If necessary, individual parts of the image can be displayed enlarged, so the temperatures in the cutting zone can be seen more clearly.

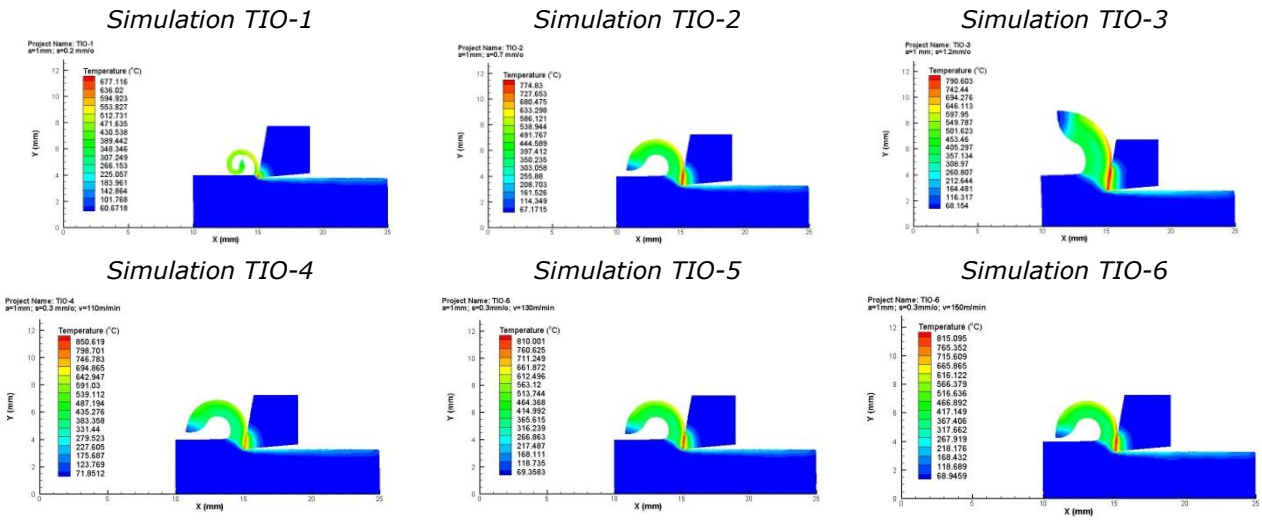


Figure 5. *Comparative views of temperature in the cutting zone simulations, for different cutting parameters*

Also, comparative diagrams of changes in cutting forces and temperatures in cutting zone for different cutting parameters were chosen as the output parameters of the simulations. Fig. 6 shows comparative diagrams of the temperatures in cutting zone, and Fig.7.a and 7.b show comparative diagrams of the cutting forces for different cutting parameters.

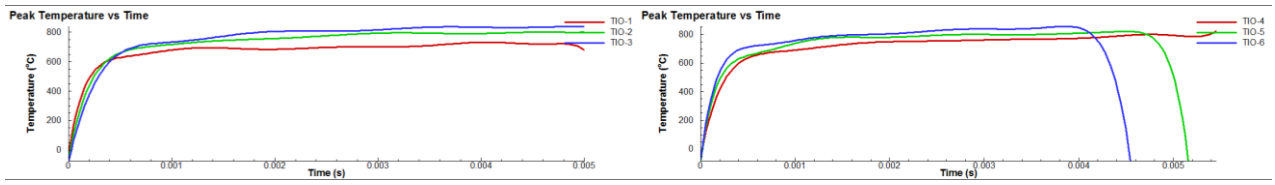
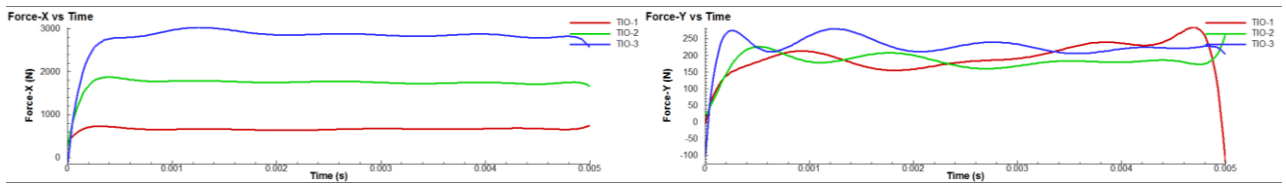
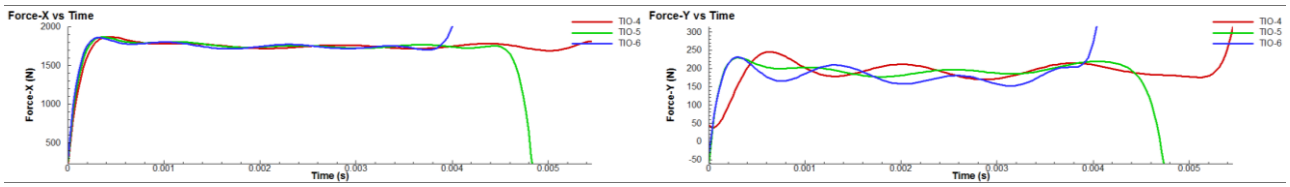


Figure 6.*Comparative diagrams of temperatures in the cutting zone(TIO-1: s=0,2mm/o; TIO-2: s=0,7mm/o; TIO-3: s=1,2mm/o; TIO-4: v=110m/min; TIO-5: v=130m/min; TIO-6: v=150m/min)*



a)$F_X = F_1$; b) $F_Y = F_2$



a)$F_X = F_1$; b) $F_Y = F_2$

Figure 7. *Comparative diagrams of cutting forces(TIO-1: s=0,2mm/o; TIO-2: s=0,7mm/o; TIO-3: s=1,2mm/o; TIO-4: v=110m/min;TIO-5: v=130m/min; TIO-6: v=150m/min)*

5. CONCLUSION

Based on the diagrams obtained by simulating the turning process, it can be seen that machining with increasing the feed leads to an increase in temperature. Machining with higher cutting speeds also results in an increase in temperatures in the cutting zone. On the diagrams of the temperature distribution in the cutting zone, the difference in temperatures and their distribution, depending on the cutting parameters can be noticed. The paper also presents diagrams of changes in cutting forces F_1 (Fx on diagrams) and F_2 (Fy on diagrams) depending on the cutting parameters. From the

diagrams, it can be seen that the feed has a significant impact on main cutting force F_1. Because the increase of the feed, the cross section of the chip also increases, which leads to an increase in the main cutting force F_1. The cutting force F_2 does not change significantly with the feed change. The influence of the cutting speed on the cutting forces F_1 and F_2 is not significant as the influence of the feed. In the images obtained on the basis of simulations, a difference in the shape of the chip can be noticed, depending on the cutting parameters. The influence of the process parameters on the temperatures in the cutting zone and the cutting forces is a rather abstract concept for students. Due to the results of simulations, images and diagrams, these phenomena become visible, and thus more understandable to students. The simulations presented in the paper were taken out in demonstration mode, which takes less time, but the results are less accurate. Such simulations give a satisfactory concept of the temperatures in the cutting zone and cutting forces. They also give an idea of the influence of the cutting parameters on the temperatures in the cutting zone and cutting forces. In the case of more precise research, simulations should be done in simulation mode.

ACKNOWLEDGEMENTS

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Load Analysis for the Design of Cutting Teeth for Bucket Chain Excavators

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Abstract: *This paper presents an approach to facilitating the design of cutting teeth for bucket chain excavators. The approach combines the theoretical load model and the laboratory determination of the static load capacity of the bucket tooth. Engineering analysis using the FEM was applied in testing the presented approach in the course of development of modular cutting elements for the bucket chain excavator.*

Keywords: *design, cutting teeth, force, load, FEM, bucket chain excavator.*

1. INTRODUCTION

In bucket chain excavators, rock breakage in the course of the excavation process is directly executed by buckets that have cutting teeth along the front edge. The forces generated by the interaction between the bucket teeth and the rock material during penetration and cutting processes are the dominant tooth load values. Overall, load intensity is not constant and is stochastically distributed over time.

Stress and change of stress are the main cause of fatigue, deformation, crack formation and fracture in the cutting tooth. As a rule, stresses are distributed non-uniformly throughout the tooth volume. The degree of non-uniformity is directly associated with the magnitude and distribution of external loads, the form and mode of tooth attachment to the bucket, as well as with the position and orientation of the cutting tooth during the cutting operation. When sizing bucket teeth and selecting the right material to be used for their fabrication, it is necessary to determine the magnitude, characteristics and duration of the load induced by the interaction between the cutting tooth and the rock. However, there are states and processes which have not been fully elaborated in theory or which are too complex to yield satisfactory results in engineering practice [1]. This exactly is the case with the determination of the external load acting on the cutting teeth. The expressions derived until now are based on a large number of interrelated impact factors which have not been fully investigated or defined. Existing theoretical and empirical models can only provide a rough estimate of the load acting on the bucket teeth since the calculated values span a wide range, depending on the model applied and the variables adopted [2].

Given the above considerations, designing cutting teeth for bucket chain excavators involves making decisions based on incomplete data, since assumptions regarding the characteristics of rock materials, the unpredictability of the digging process, the imperfection of the cutting tooth material, etc. are unsuitable in terms of measurement, qualification and documentation. With respect to this uncertainty, the designer must use an idealised computational model with clear boundary conditions describing the process of rock breakage by cutting teeth. The key to success in the light of these three seemingly uncontrolled circumstances is to use scientific uncertainty qualification. This means that the basic settings of digging-related problems and understanding of the necessary assumptions, along with a proper stress analysis of the bucket teeth for different load and boundary conditions, can facilitate making fundamental engineering decisions based on incomplete data.

This paper presents the Evans two-dimensional model for performing bucket tooth load calculations. The Evans model is a simple model of rock breakage i.e. cutting element loading. This model can be used in bucket chain excavators for the simple calculation of external loads acting on the cutting teeth during the digging operation. The main idea is to use this model for performing load calculations for different operating conditions of the excavator in order to obtain starting data to be used in preliminary calculations for cutting tooth design. In addition to these data, the design process would also employ data obtained from the laboratory testing of the maximum static load

capacity of existing cutting teeth. Laboratory test data would also be used for the verification of the computational model and implementation of the finite element method. The established model for the maximum loading of existing cutting teeth would be used for the analysis of future similar designs as well as for the optimisation of new cutting tooth designs.

The cross analysis of the data obtained by observing the calculated values of tooth load and maximum load before failure under laboratory conditions can be used in cutting tooth calculations and optimisation with a certain degree of certainty.

Accordingly, ensuring a higher degree of certainty would simplify the determination of the cutting tooth load. Moreover, all major impact parameters, such as rock hardness, tooth geometry and tooth movement would be included, and the limit load capacity and tooth behaviour at fracture would be determined.

2. BUCKET TOOTH LOAD

Due to the high complexity of the digging process, and considering the inability to adequately record or measure the spatial and temporal effects of this process, approximation is made by means of appropriate two-dimensional models [3], [4], [5], [6]. The same principle can be use in analysing the total load on the cutting teeth in bucket chain excavators [7], [8].

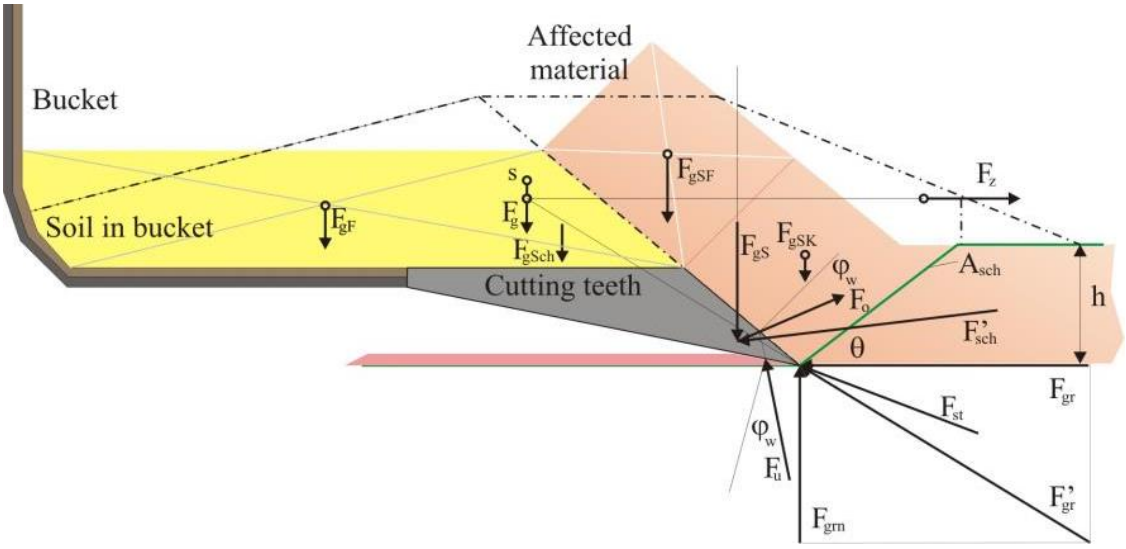


Figure 1. *An in-plane model (two-dimensional) of loads acting on the cutting tooth interacting with the rock material*

Figure 1. shows an in-plane mechanical model providing an analysis of the forces generated during the interaction of the cutting teeth and the bucket with the rock material. The model involves penetration, cutting and scooping processes, where F_{gF}, F_{gSF}, F_{gSK} –weight of the excavated material, s – centre of gravity of the excavated material, F_g – total weight of the excavated material at the centre of gravity, F_{gS} – total weight of the separated material, F'_{sch} – resulting tangential force, A_{sch} – tangential surface, φ_w – angle of external friction, h – depth of the cut, F_{gr} – tangential component of cutting resistance, F_{grn} – normal component of cutting resistance, F'_{gr} – total cutting resistance, F_u – resistance on the back of the tooth, F_o – resistance on the tooth face, F_z –total bucket filling resistance.

The theoretical calculation of digging resistance is very complex, given the dependence of this resistance on a range of interrelated factors, with the interrelation, however, not being clearly defined. The complexity of the processes occurring during the digging operation leads to very intricate and insufficiently clear theoretical explanations. Therefore, an important role in calculating the digging resistance is given to the experimentally derived empirical equations. However, as general laws of simplicity are not applicable in this case, the empirical equations apply only to cases approximately corresponding to the calculated values. The complex correlations among the impact parameters lead to simplification in experimental measurements as well; accordingly, only the most important factors or factors having the greatest influence on the problem analysed are taken into consideration.

The considerations elaborated in [9] have defined the first cutting model used in the description of the process of excavation of coal and similar rock materials. In this research, for the first time in theory, it has been shown that the tensile and compressive strengths of the rock are the dominant characteristics used in calculating the load sustained during rock breakage by a wedge-shaped cutting element. Subsequent experimental studies [10], [11] have confirmed that this theory can also be used for brittle rock materials such as lime and sand. The Evans theoretical model has been further improved and experimentally verified. The

improvements of this model have mostly been targeted towards solutions to certain single problems [12], [13], [14], but the basic philosophy and approach have remained unchanged. For its simplicity and the wide range of applications in different rock materials, this model is analysed in more detail below.

3. EMPLOYMENT OF THE EVAN'S LOAD MODEL

The starting point in the Evans plane model is the assumption regarding movement of the ideal symmetrical cutting element and its penetration into the rock material. During the penetration of the cutting element (moving along the path which is normal to the material), the stress generated in the rock material leads to the formation of an initial crack, which further spreads radially starting from the tip of the cutting element to the free surface of the material (arc CD), as presented in figure 2 [15]. The basic Evans model entails the following additional assumptions:

- A force R is acting at the angle δ (external friction angle) relative to the normal of the surface AC of the cutting element (wedge).
- A resultant tensile force of the rock T is acting at the symmetry line of the angle 2θ in the arc CD.
- The depth of penetration of the wedge is very small compared to the cutting depth d.
- The width of the wedge (w) is much greater than the depth (d) ($w>>d$) i.e. the model of the two-dimensional cutting theory can be applied.
- A state of plane stress is applicable.

During its movement, the wedge tends to split the rock, while rotating it about point D. Therefore, it is assumed that the force S acts through point D. Along the fracture line CD, it is assumed that a state of plane stress applies and the equilibrium of forces is considered per unit of width of the wedge.

The force due to the tensile strength of the rock (σ_z) is defined by the following expression:

$$T = \sigma_z \cdot r \cdot \int_{-\theta}^{\theta} cos\omega \mathrm{d}\omega = 2 \cdot \sigma_z \cdot r \cdot sin\theta \qquad (1)$$

Where $r\mathrm{d}\omega$ is an element of the arc CD making an angle ω with the symmetry line of the angle. The depth of penetration of the wedge tip into the rock may be neglected in comparison with the depth of the cut (d). This means that the point of application of force R is near point C.

$$\sum M_D = 0 ,$$

$$R \frac{d}{sin(\theta - \beta_E)} \cdot cos(\theta + \beta_E + \delta) = T \cdot r \cdot sin\theta \qquad (2)$$

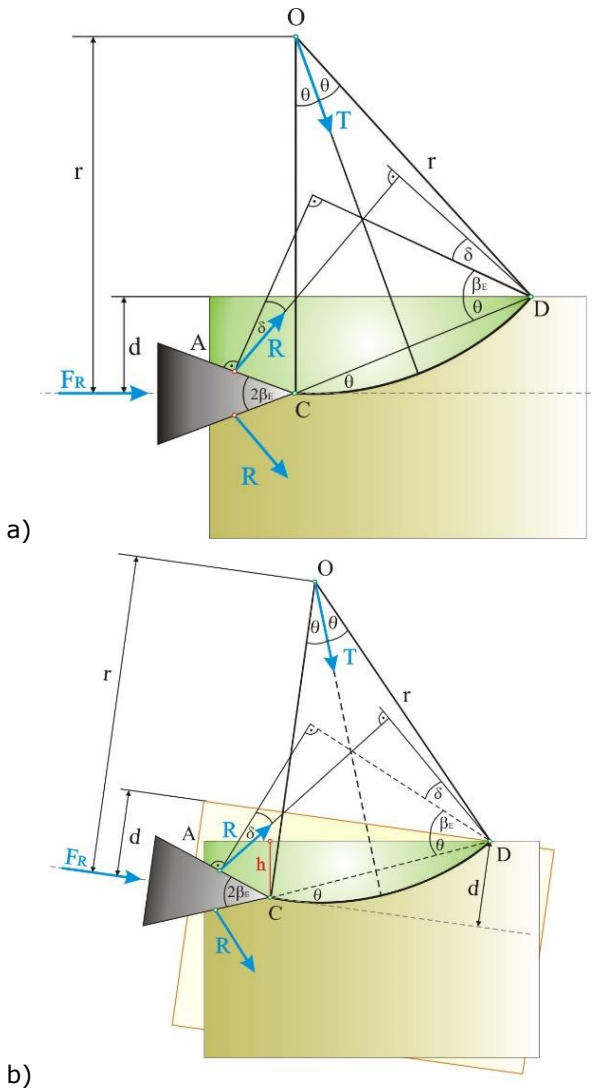


Figure 2. *a) Tensile breakage theory of Evans, b) Approximation of cutting by a tooth on excavators.*

In accordance with $r \cdot sin\theta = \frac{d}{2sin\theta}$, it follows that

$$R = \frac{\sigma_z \cdot d}{2sin\theta \cdot cos(\theta + \beta_E + \delta)} \qquad (3)$$

The horizontal component of R is $R \cdot sin(\beta_E + \delta)$, and due to the symmetry of the forces acting on the wedge the total cutting force is:

$$F_R = 2 \cdot R \cdot sin(\beta_E + \delta) = \sigma_z \cdot d \cdot \frac{sin(\beta_E + \delta)}{sin\theta \cdot cos(\theta + \beta_E + \delta)} \qquad (4)$$

The normal force is (for one side of wedge):

$$F_n = R \cdot cos(\beta_E + \delta) = \sigma_z \cdot d \cdot \frac{cos(\beta_E + \delta)}{2 \cdot sin\theta \cdot cos(\theta + \beta_E + \delta)} \qquad (5)$$

The angle θ is defined at the minimum value of F_R, and therefore:

$$\frac{\mathrm{d}F_R}{\mathrm{d}\theta} = 0 , \quad \frac{\sigma_z \cdot d \cdot sin(\beta_E + \delta)}{sin\theta \cdot cos(\theta + \beta_E + \delta) \cdot \mathrm{d}\theta} = 0 \qquad (6)$$

$$cos\theta \cdot cos\left(\theta + \beta_E + \delta\right) - sin\theta \cdot sin\left(\theta + \beta_E + \delta\right) = 0,$$
$$cos\left(2\theta + \beta_E + \delta\right) = 0 \quad (7)$$

Resulting in the angle value: $\theta = \frac{\pi}{4} - \left(\beta_E + \delta\right)$

$$sin\theta \cdot cos\left(\theta + \beta_E + \delta\right) =$$
$$= sin\left(\frac{1}{2}\left[\frac{\pi}{2} - \beta_E - \delta\right]\right) cos\left(\frac{1}{2}\left[\frac{\pi}{2} + \beta_E + \delta\right]\right) =$$
$$= \frac{1}{2}\left[sin\left(\frac{\pi}{2} - sin\left(\beta_E + \delta\right)\right)\right]$$

According to previous, the total cutting force is:

$$F_R = 2 \cdot \sigma_z \cdot d \cdot \frac{sin\left(\beta_E + \delta\right)}{1 - sin\left(\beta_E + \delta\right)} \quad (8)$$

The normal force for one side is (in this case, total normal force is zero due to the symmetry):

$$F_n = \sigma_z \cdot d \cdot \frac{cos\left(\beta_E + \delta\right)}{1 - sin\left(\beta_E + \delta\right)} \quad (9)$$

For cutting teeth of bucket chain excavators, two assumptions can be achieved:

- the path of the cutting tool has the same direction as the fracture.
- the maximum thickness of the chip is almost the cutting depth.

With the aid of figure 2.a, and with two above assumptions:

$h = 2 \cdot r \cdot sin\theta \cdot sin\left(\theta - \alpha\right)$ and

$$d = 2 \cdot r \cdot sin^2\theta, \; d = h \cdot \frac{sin\theta}{sin\left(\theta - \alpha\right)} \quad (10)$$

The total force (per unit of width) will be:

$$F_R = 2 \cdot \sigma_z \cdot d \cdot \frac{sin\left(\theta + \delta\right)}{1 - sin\left(\theta + \delta\right)} =$$
$$= 2 \cdot \sigma_z \cdot h \cdot \frac{sin\left(\theta + \delta\right)}{1 - sin\left(\theta + \delta\right)} \cdot \frac{sin\theta}{sin\left(\theta - \alpha\right)} \quad (11)$$

The cutting force (horizontal component) is:

$$F_c = F_{RH} = 2 \cdot \sigma_z \cdot h \cdot \frac{sin\left(\beta_E + \delta\right)}{1 - sin\left(\beta_E + \delta\right)} \cdot \frac{sin\theta}{sin\left(\theta - \alpha\right)} \cdot cos\alpha \cdot w \quad (12)$$

The penetration force (vertical component) is:

$$F_p = F_{RV} = 2 \cdot \sigma_z \cdot h \cdot \frac{sin\left(\beta_E + \delta\right)}{1 - sin\left(\beta_E + \delta\right)} \cdot \frac{sin\theta}{sin\left(\theta - \alpha\right)} \cdot sin\alpha \cdot w \quad (13)$$

In terms of the type of the material being excavated and the form of its breakage, digging by bucket chain excavators can vary widely between highly ductile failure of soft rock materials such as clay and loam to brittle failure of very brittle materials such as coal and rocks of different composition. If the problem is viewed from the standpoint of rock material strain, the following is observed: in rock materials such as clay and lignite, the cutting edge of the bucket blade serves for cutting purposes in the plastic fracture mechanics; in hard rocks, bucket teeth serve for facilitating the penetration process i.e. for ensuring that normal and tangential stresses are large enough for the initial fracture of the rock material to occur. This very fact justifies the use of the Evans model in designing bucket teeth. When designing bucket teeth, loads potentially leading to their critical state (failure and deformation) during the exploitation process should be taken into consideration. These loads are short-time and mostly generated during the interaction with the rock material of substantial hardness. The Evans model is appropriate for load description and force determination.

Table 1. Physical and mechanical characteristics of the rock material at the Tamnava West Field Open Cast Mine in Serbia

Lithological constituents	Moisture [%]	Bulk density [kN/m³]	Angle of internal friction ϕ [°]	Cohesion c [kN/m²]
Quaternary clay	25.0	19.9	25°	16.0
Alluvial sand	22.0	18.1	26°	1.0
Alluvial gravels	30.0	19.0	28°	0.0
Alluvial gravels and sand	29.0	18.6	30°	2.0
Pontian clay	31.0	18.6	25°	20.0
Coal	-	11.5	39°	30.0
Pontian sand	20.0	17.1	28°	4.0
Coaley clay	58.0	16.4	16°	15.0

Table 1. gives an overview of average physical and mechanical characteristics of the rock material at the Tamnava-West Field Open Cast Mine in Serbia. These characteristics apply to average operating conditions of the existing ERS 1000 bucket chain excavator teeth, which are analysed below.

Table 2. Values of parameters for existing excavating conditions used in tooth load calculations by the Evans model

Parameter		Designation	Value
Width of the cutting tooth (new-partially worn)		w[mm]	60÷120
Depth of the cut (cutting engagement of the bucket tooth)		d[mm]	40÷80
Wedge angle		$\beta=2\beta_E$[°]	22÷30
Uniaxial compressive strength of the rock material		σ_p[N/m^2]	5÷10
Uniaxial tensile strength of the rock material		$\sigma_z= (0.1)\cdot\sigma_c$	0.5÷1
Coefficient of external friction		μ	0.4÷0.5
Angle of external friction		δ= arctg(μ) [°]	21.8÷26.6°
Calculated value of force	Cutting	F_C[kN]	4.2÷75.0
	Penetration	F_P [kN]	0.8÷20.0
	TOTAL	F_{uk}[kN]	4.2÷77.0

Table 2. presents the values of parameters applicable to current excavating conditions and used in tooth load calculations. The analysis of the results in Table 2. shows a large dispersion of the load values. Due to the complexity of the problem of defining cutting tooth load, the adoption of a large number of starting assumptions and the inability to ensure the exactness of calculations, the obtained values should not be decisive in making engineering decisions. As already highlighted, the maximum calculated load values should be used as a guideline in the design process, as well as in the sizing and shaping of the cutting tooth.

4. ANALYSIS OF MAXIMUM LOAD

In addition to the computational analysis based on the FEM (finite element method) using the calculated load values, the design process should also involve an analysis using the maximum possible load (behaviour, stress and strain) – the load sustained at tooth failure. Such an analysis is not complicated, and it can be performed by laboratory tests.

The analysis comprises two stages. The first stage takes place as part of laboratory testing, involving loading of the cutting tooth until failure. Both the force being generated and the cutting tooth strain are monitored. Here, the direction and course of action of the external load are designed to be identical to those under actual field conditions, whereas the load intensity is increased until the cutting tooth fails. The second stage involves a computational analysis using maximum force readings before the failure of the physical prototype, taking into consideration all laboratory testing conditions. The comparison of the results from these two stages actually provides verification of the established computational model, while at the same time resulting in the maximum static force that the cutting tooth can withstand before failure. The verified computational model is a virtual prototype [16],[17], which is further used in the analysis incorporating the load calculations given in Table 2.

This approach should be employed at the initial design stage and later on before testing the physical prototype. Virtual prototypes are used at the early stage of development to simulate and check the properties of the cutting tooth before the fabrication of the physical prototype, thus achieving substantial savings or eliminating both the costs and the time needed to fabricate and modify the physical prototype. Unlike physical prototypes, virtual models make use of all advantages of the modern computational technique, with the focus of the engineering process shifted from the physical to the virtual environment. This shift offers a great advantage in solving problems in excavators operating in open-pit mines, given that testing of any physical prototype has significant limitations, and is a difficult costly process.

These considerations are particularly important in view of the tendency towards one-off production in the design of cutting teeth for bucket chain excavators. This entails the optimisation of cutting teeth for every single excavator and operation technology used, and rock material being excavated. In such cases, a flexible approach must be ensured not only in the engineering process but also in the fabrication and testing of prototypes.

The paragraphs below present the laboratory testing of two types of cutting teeth for the ERS 1000 bucket chain excavator [18]: a) the existing one-piece cutting tooth and b) the new modular cutting tooth developed to reduce production costs and improve the cutting performance.

Table 3 Mechanical characteristics of the bucket and cutting tooth material [19]

Characteristic	Designation of the material	Yield strength [N/mm^2]	Tensile strength [N/mm^2]
Existing cutting tooth	42CrMo4	710	1.100
Modular tooth (cutting portion)	42CrMo4	710	1.100
Modular tooth (holder)	CK45	530	650
Bucket	EN S355J2G3	300	580
Lifting eyes on the bucket	EN C35E	170	580
Bolt (M20, 10.9)	34Cr4	900	1.000

In contrast to field testing, laboratory testing is strictly controlled and manageable, and as such directly controllable and comparable with the computational analysis. Importantly, in this way, the verification of the virtual prototype design is made significantly easier. In accordance with laboratory testing, a successful virtual prototype also allows incorporation and modelling of the currently used test equipment, that is, the boundary conditions.

Figure 3. show the basic setup for the laboratory testing. The cutting teeth are mounted on the bucket in exactly the same position as on the excavator during the excavation process. Through the hydraulic system and the hydraulic cylinder, the hydraulic generator automatically exerts force. The position, orientation and point of application of the hydraulic cylinder on the bucket tooth are adjusted to portray the action of the external forces acting on the bucket tooth during the excavating operation.

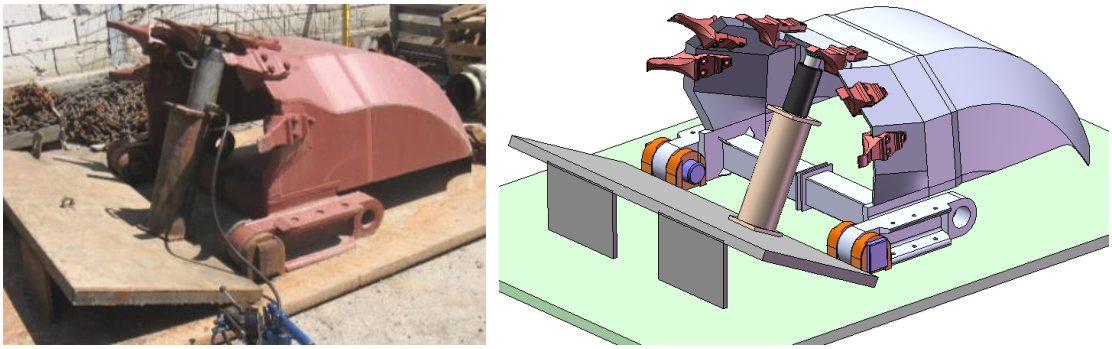
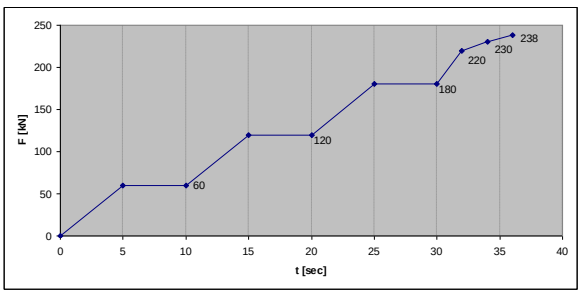


Figure 3. *Laboratory testing for maximum bucket tooth load and virtual prototype.*

During the laboratory experiment, loads are exerted through a hydraulic fixture with force gauge showing readings of the instantaneous force value. Loads are gradually applied to avoid dynamic effects that may occur due to a rapid increase in force. During loading, force and strain values were measured for both types of bucket teeth. The force diagram and the average strain diagram for one of the existing bucket teeth tested are presented in figure 4.

a)



b)

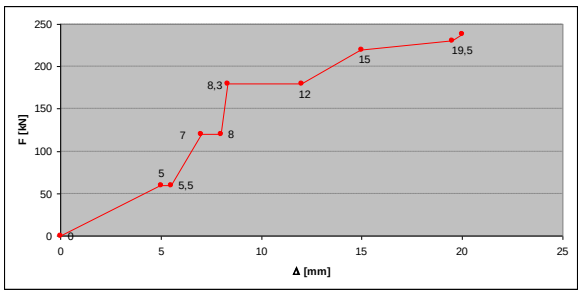


Figure 4. *a) Load diagram (the force created by the hydraulic cylinder) and b) Value of strain at the tip of the bucket tooth.*

When determining the direction, intensity and location of the point of application of the force acting on the physical prototype, two important facts were considered [20], [21], [22]. The force direction was determined to approximate the most unfavourable rock scooping case in which the excavator bucket is rotated around the external chain wheel to start interacting with the rock material. The force direction in the physical

prototype was adjusted by setting the position and orientation of the hydraulic cylinder and its support.

As the experiment focused on bucket tooth fracture, the force applied was gradually increased until failure. The measured value of the force at failure of the physical prototype was taken as the load for the computational analysis using the FEM.

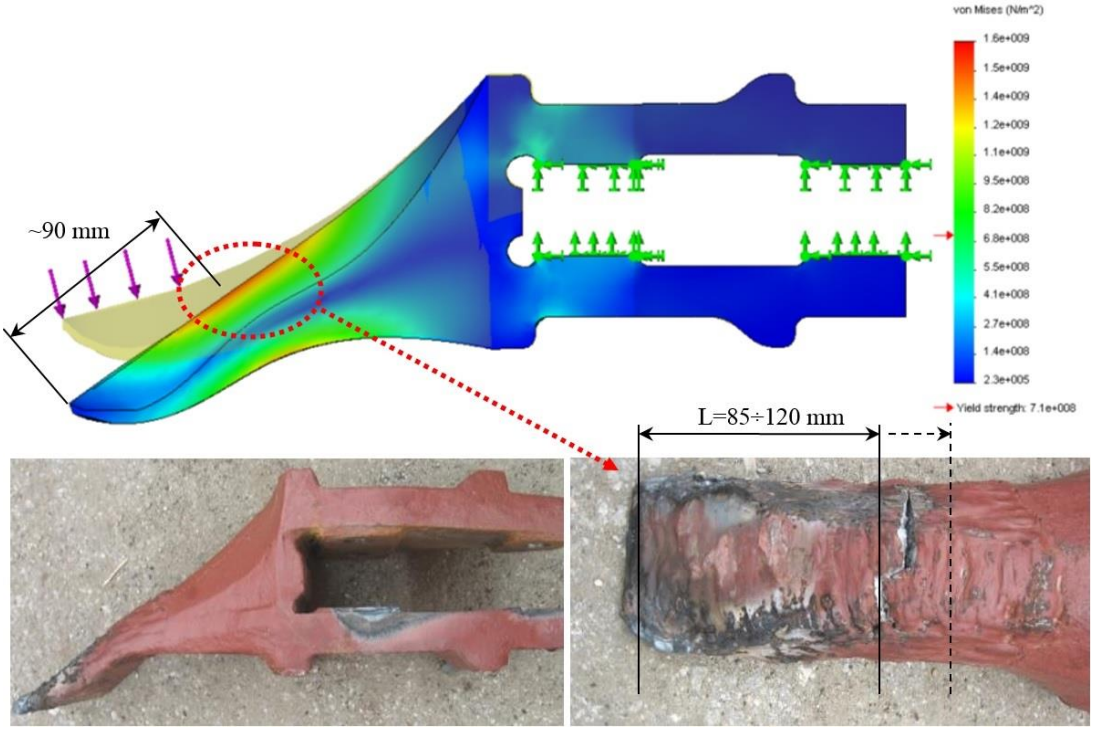


Figure 5. *A stress pattern of the bucket tooth after being subjected to maximum load, and the fractured bucket tooth after being subjected to maximum load under laboratory conditions.*

Figure 5 presents the results of failure of the one-piece bucket tooth during the laboratory testing. The figure also shows the stress distribution resulting from the computational analysis. The value of force at failure during the laboratory testing ranged from 210÷250 kN. This range was used when exerting force during the virtual experiment, with the average of 240 kN (for 10 tested cutting teeth) adopted. Computer-assisted analysis (the virtual experiment) was performed in the same manner as during the laboratory investigation. The stress distribution (figure 5) at a given load of 240kN indicates that the stress value in the critical area (red zone) exceeds the tensile strength value of the tooth material. The marked area indicates the location of a possible fracture. The measured values of maximum strain at the tip of the cutting tooth ranged from 15÷20 mm, whereas the computed value was approximately 16 mm.

During the testing of the physical prototype of the modular cutting tooth, the value of force at fracture was 180÷210 kN. Based on the experimental testing of a substantial number of modular bucket teeth, the average force before fracture was 190 kN. The exertion of this load during the computational analysis of the modular cutting tooth resulted in the stress pattern presented in figure 6.

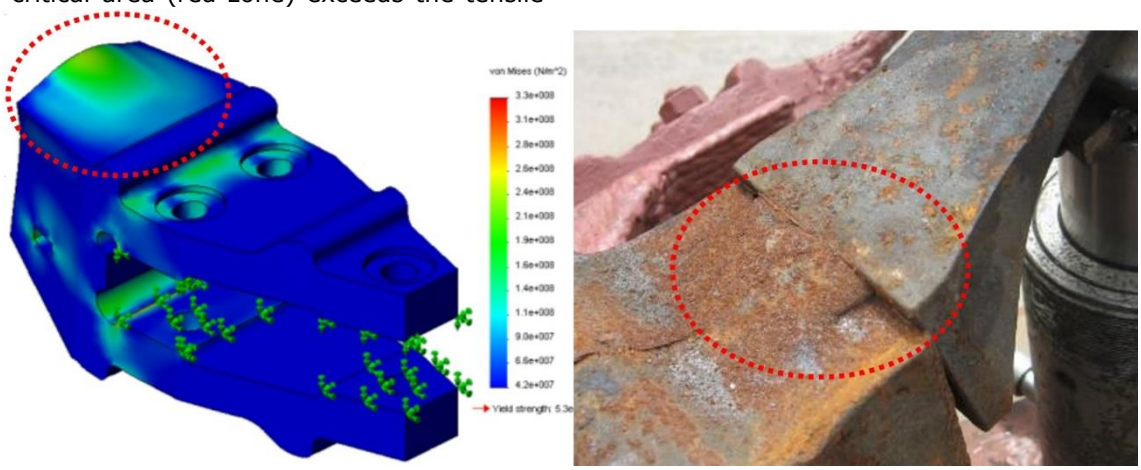


Figure 6. *Stress distribution in the modular tooth holder, and the fractured physical prototype.*

The figure provides an example of the most common type of fracture of the bucket tooth holder during the laboratory experiment. This fracture is due to overstrain in the tooth holder, causing the cutting portion of the tooth to drop out. A very high degree of compliance was found between the location and form of fracture of the tested bucket teeth, and the stress pattern and stress levels in the computational model.

5. CONCLUSION

Chapter 3. provides bucket tooth load calculations for the existing excavating conditions in the Tamnava-West Field Open Cast Mine in Serbia. Loads were calculated for the existing one-piece cutting tooth using the Evans two-dimensional model. In Chapter 4, the maximum static load that the existing one-piece tooth and the newly developed modular cutting tooth can endure were calculated. Models used in the finite element analysis of the maximum load capacity were established and verified.

During the first step of optimisation, the newly developed modular cutting tooth retained the geometrical characteristics and mode of attachment of the existing one-piece tooth. Therefore, the load value calculated in Chapter 3. is also applicable to the analysis of the modular cutting tooth. Part of the results of the finite element analysis of the modular cutting tooth are presented in figure 7. The aim of the analysis was to observe the influence of the assumed direction and distribution of external loads (cutting force FC and penetration force FP) on stresses inside the cutting tooth. When designing a cutting tooth, it is important to identify the most unfavourable stress pattern for the same intensity of penetration and cutting forces.

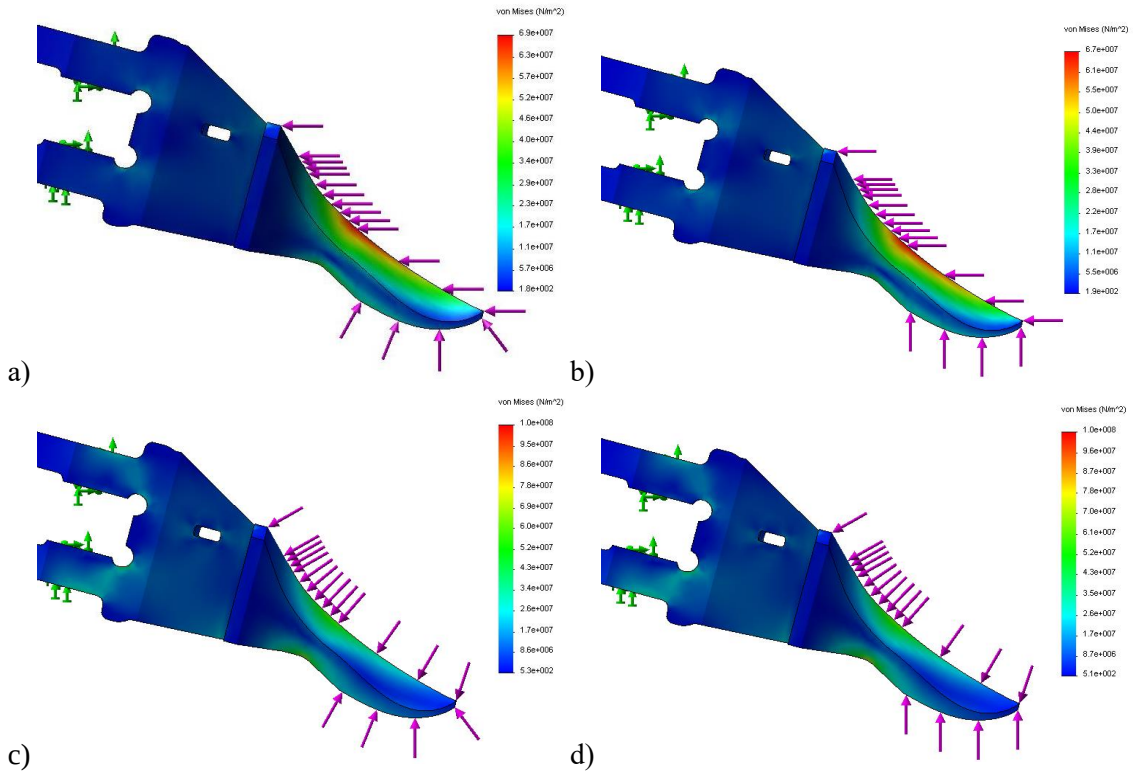


Figure 7. *Stress distribution in the modular cutting tooth for the same support conditions and the same intensity of forces, but for different assumed directions of cutting and penetration forces.*

Maximum values of the calculated cutting resistance FC=75kN and penetration resistance FP=20kN were used in the analysis. The material for the modular cutting tooth was characterised in accordance with Table 3.

The entire analysis (model parameters, attachment to the bucket, number of finite elements, etc.) was based on the verified FEM model for the analysis of maximum loads

Four different cases were discussed, each featuring forces of steady intensity, an identical mode of support for securing the tooth to the bucket, and variations in the direction of cutting and penetration forces. Figures 7. a, b, c and d present the following 4 cases, respectively:

a) The direction of the force FR coincides with the direction of motion; The force FP acts in a direction normal to each point on the back,

b) The direction of the force FR coincides with the direction of motion; The force FP acts in a vertical direction,

c) The force FR acts in a direction normal to each point on the face; The force FP acts in a direction normal to each point on the back,

d) The force FR acts in a direction normal to each point on the face; The force FP acts in a vertical direction.

The results indicate that the maximum stress acting on the cutting tooth varied from 70÷100 N/mm2, for the same load intensity and the same adopted tooth material, but for different load directions. This shows that stress distribution is influenced not only by load intensity but also by the mode of load determination in the finite element analysis. From the point of view of certainty, a less favourable case should be adopted in the load capacity analysis; accordingly, the force acting on the tooth face should be modelled as in the case of c) and d). The assessment of only these two cases suggests that variations in the direction of the force FP have no substantial effect on total stress.

The advantage of the approach presented in this paper is that it reduces the time required to develop and test the cutting teeth of bucket chain excavators. This is of particular importance given the need for uniform optimised cutting tooth designs. Virtual prototyping allows the fabrication of a physical prototype at the very end of the process i.e. after the correction of most of the errors and after optimisation of the cutting tooth design.

The simplified mechanical model provides a rough approximation to the excavating process, while substantially departing from the inclusion of all impact factors associated with the total load value. In particular, load values obtained by direct measurement [23] (e.g. using strain gauges) on the cutting tooth during the excavation operation contribute to the design of more appropriate, more accurate simulation models. However, in general, there is no comprehensive solution to the problem due to a range of non-measurable effects (such as determination of the exact load direction, number of surfaces on cutting teeth across which loads are transferred, characteristics of the scooped rock material, dynamic effects etc.). The design of cutting teeth for bucket chain excavators is mostly based on empirical knowledge. Therefore, the authors believe that, towards a systemic approach to cutting teeth engineering, the approach presented in this paper is the optimal solution among all possible solutions entailing either simplification of the load defining process or inclusion of as many parameters affecting bucket tooth load as possible.

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Appendix A:

Symposium "Technics and Informatics in Education: School Teachers for Teachers"

Notes:

Simpozijum *"Tehnika i informatika u obrazovanju: Nastavnici za nastavnike"*

Stručni rad
UDC: 37.015.3

Samovrednovanje oblasti „Nastava i učenje" u nastavi izbornih programa

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Rezime: *Rad prikazuje rezultate samovrednovanja rada škole u ključnoj oblasti „Nastava i učenje" sprovedenog u Gimnaziji u Čačku u junu 2019.g. Primenjena je metodologija samovrednovanja na osnovu Pravilnika o standardima kvaliteta rada ustanove. Ispitano je 233 učenika koji su procenjivali rad 9 nastavnika u 4 izborna programa: Jezik, mediji i kultura, Pojedinac grupa i društvo, Umetnost i dizajn, Obrazovanje za održivi razvoj, sa kojima se i jedni i drugi susreću prvi put. Rezultati pokazuju da su u nastavi izbornih programa u većoj meri prisutni pokazatelji (nivo 3) koji opisuju pet standarda kvaliteta rada ustanove u oblasti Nastava i učenje. Učenici različito ocenjuju nastavnike različitih predmeta.*

Ključne reči: *samovrednovanje; Nastava i učenje; izborni programi.*

Self-Evaluation in the Field "Teaching and Learning" in Teaching of Elective Courses

Abstract: *This work features the results of the school self-evaluation in the key field „Teaching and learning" conducted in Gimnazija in Čačak in June 2019. The methodology of self-evaluation was applied according to the Rule book on quality standards of the institution. 233 interviewed students evaluated the work of 9 teachers in 4 elective courses: Language, media, culture, Individual, group and society, Art and design and Education for sustainable development, and for both the students and the teachers it was the first contact with the courses. The results show that in the teaching of the elective courses there are the indicators present (level 3), which describe the five quality standards of the institution in the field Teaching and learning. The students evaluate differently the teachers of different subjects.*

Keywords: *self-evaluation, teaching and learning, elective courses.*

1. UVOD

Od 2005.g. u obrazovni sistem Republike Srbije uveden je proces samovrednovanja kao jedan od značajnih mehanizama u cilju obezbeđivanja kvaliteta rada obrazovno-vaspitnih ustanova. Određen kao postupak kojim se vrednuje sopstvena praksa i sopstveni rad [1], predstavlja osnovu za planiranje, razvoj i unapredjenje kvaliteta rada škole. Primenom samovrednovanja postiže se veća transparentnost rada u školi i aktivnija uloga svih učesnika obrazovno-vaspitnog procesa u njoj: učenika, roditelja, nastavnog i nenanstavnog osoblja. Samovrednovanje nije samo obična procena sopstvenog kvaliteta, već predstavlja proces koji se odvija kroz više faza i aktivnosti: analiza stanja u školi; izbor i sagledavanje postojećeg stanja u izabranim ključnim oblastima; uočavanje jakih i slabih strana; izrada plana za otklanjanje uočenih slabosti [1]. Cilj samovrednovanja nije u kontroli, nego u uočavanju postojećih teškoća i izrada plana za njihovo prevazilaženje. U tom kontekstu, samovrednovanje kao veština koja doprinosi unapredjenju kvaliteta života i rada škole sada i u budućnosti ima razvojnu funkciju jer traga za odgovorima na pitanja: kakvi smo sada, kako to znamo i šta možemo učiniti da budemo bolji i kvalitetniji [2]. U procesu samovrednovanja, kao najvažnijem sredstvu za osiguranje kvaliteta rada škole, primenjuju se propisani standardi kvaliteta rada ustanove [3]. U tom smislu je sprevedeno samovrednovanje rada Gimnazije u Čačku u ključnoj oblasti: Nastava i učenje, u okviru realizacije novih nastavnih programa – izbornih programa. Značaj istraživanja leži u činjenici da su prvi put učenici škole procenjivali rad nastavnika, u ovom slučaju izbornih programa, sa kojima se i jedni i drugi susreću prvi put. Naime, od 2018-2019. šk.g. Program nastave i učenja za prvi razred gimnazije

[4], pored programa nastave i učenja obaveznih predmeta sadrži i listu izbornih programa sa fondom od jednog časa nedeljno. Programi su iz različitih oblasti: prirodne i društvene nauke, umetnost, zdravlje i svi su interdisciplinarni, ishodovno i tematski kreirani. Njihova svrha je u ostvarivanju opštih ishoda obrazovanja i vaspitanja, razvijanju ključnih kompetencija i opštih međupredmetnih kompetencija učenika kroz povezivanje školskog i vanškolskog učenja primenom istraživačkog i projektnog učenja. Interdisciplinarni karakter programa daje okvir unutar koga učenici i nastavnici određuju konkretne sadržaje kojima će se baviti vodeći računa o ishodima koje treba ostvariti i kompetencijama koje treba razviti. U pojedinačnim programima su navedeni samo ishodi po temama i na nivou programa. U zavisnosti od izbornog programa broj tema je različit. Teme su zaokružene celine sa više ishoda učenja. Svaka tema se obrađuje na istraživački i projektni način što znači da ne postoji unapred definisan scenario aktivnosti, već se on planira i razvija pre i tokom nastavnog procesa. Na osnovu datih ishoda i sadržaja, nastavnik kreira svoj godišnji plan rada, operacionalizuje operativne planove, priprema čas koji vodi ka razvijanju kompetencija i ostvarivanju ishoda propisanih programom. Planiranje, ostvarivanje, praćenje, vrednovanje i ocenjivanje nastave i učenja izbornih predmeta, postavljaju pred nastavnika izazove, dajući im veliku autonomiju, angažovanje različitih kompetencija među kojima značajno mesto zauzimaju fleksibilnost i organizovanost. Da bi ostvario postavljene ciljeve i ishode programa, podstakao radoznalost, kreativnost, istrajnost, argumentovanje, refleksivnost, odgovornost i samostalnost učenika, nastavnik mora unapred da osmisli svoje aktivnosti i pripremi odgovarajući materijal. Složenost planiranja polustruktuiranih izbornih programa, ogleda se i u činjenici da se isti program na različite načine ostvaruje u različitim grupama učenika.

U nedostatku referentnih naučnih istraživanja oblasti samovrednovanja „Nastava u učenje" u nastavi izbornih programa, rezultati ovog istraživanja su uporedjivani sa rezultatima spoljašnjeg vrednovanja kvaliteta rada Gimnazije u Čačku iz 2017.g.

2. METODOLOGIJA ISTRAŽIVANJA

U čačanskoj Gimnaziji je sprovedeno istraživanje u cilju samovrednovanja rada škole u ključnoj oblasti: Nastava i učenje, u okviru realizacije novih nastavnih programa – izbornih programa. Značaj istraživanja leži u činjenici da su prvi put učenici škole procenjivali rad svojih nastavnika, u ovom slučaju izbornih programa, sa kojima se i jedni i drugi susreću prvi put. Predmet samovrednovanja: aktivnosti i rad nastavnika u obrazovno-vaspitnom procesu. Cilj istraživanja: ispitivanje stavova i mišljenja učenika i nastavnika o različitim aspektima nastave izbornih programa nakon prve godine primene u Gimnaziji u Čačku.

Primenom Pravilnika o standardima kvaliteta rada ustanove [3] i preporuka Školske uprave u Čačku [5] sprovedeno je samovrednovanje oblasti Nastava i učenje i vrednovanje ostvarenosti ishoda (očekivanih efekata) u nastavi izbornih programa, nakon prve godine primene u Gimnaziji u Čačku. Istraživanje je realizovano na osnovu učeničkih percepcija i procena aktivnosti nastavnika u procesu nastave/učenja. Učenici su procenjivali u kojoj meri su prisutni pokazatelji koji opisuju definisane standarde na skali 1 do 4 (od 1- uopšte se ne slažem do 4 - u potpunosti se slažem). Nivo ostvarenosti standarda je izražen na osnovu prosečnih vrednosti pokazatelja u okviru istog standarda i oni su iskazani na skali od 1 do 4, pri čemu 4 označava najviši nivo ostvarenosti. *Nivo 4* označava da je u potpunosti ostvaren standard (vrednost aritmetičke sredine mere prisutnosti pokazatelja od 3,51 i 4,00). *Nivo 3* označava da je standard ostvaren u većoj meri i (vrednost aritmetičke sredine mere prisutnosti pokazatelja od 2,51 do 3,50). *Nivo 2* označava da je standard ostvaren u manjoj meri (vrednost aritmetičke sredine mere prisutnosti pokazatelja od 1,51 do 2,50). *Nivo 1* označava da standard nije ostvaren (vrednost aritmetičke sredine mere prisutnosti pokazatelja od 1,00 do 1,50).

Kvalitet rada u nastavi četiri izborna programa: Jezik, mediji i kultura (u daljem tekstu JMK), Pojedinac, grupa i društvo (u daljem tekstu PGD), Obrazovanje za održivi razvoj (u daljem tekstu OOR) i Umetnost i dizajn (u daljem tekstu UID), nakon prve godine realizacije programa, učenici su procenjivali na osnovu 5 standarda kvaliteta oblasti samovrednovanja Nastava i učenje: 2.1. Nastavnik efikasno upravlja procesom učenja na času; 2.2. Nastavnik prilagođava rad na času obrazovno-vaspitnim potrebama učenika; 2.3. Učenici stiču znanja, usvajaju vrednosti, razvijaju veštine i kompetencije na času; 2.4. Postupci vrednovanja su u funkciji daljeg učenja; 2.5. Svaki učenik ima priliku da bude uspešan. Svaki standard predstavljen je kroz određeni broj izabranih pokazatelja kvaliteta (od 3 do 6), što ukupno iznosi 29 pokazatelja kvaliteta.

U procesu samovrednovanja učenici su na osnovu ličnog iskustva izražavali stepen slaganja sa izvedenim aktivnostima u realizaciji izbornih predmeta na skali od 1 (uopšte se ne slažem) do 4 (u potpunosti se slažem). Na osnovu učeničkih procena dobijene su informacije o značajnim aspektima nastave: koliko efikasno nastavnik upravlja procesom učenja na času, da li i na koji način nastavnik prilagođava rad na času obrazovno-vaspitnim potrebama učenika, o procesu i rezultatima učenja na časovima, ocenjivanju koje je u funkciji učenja kao i atmosferi

za učenje na času. Učenici su imali zadatak i da procene sopstveni napredak u dostizanju propisanih ishoda čime je dobijen uvid o ostvarenosti ishoda u nastavi izbornih programa.

2.1. Varijable

Nezavisne varijable: pol; smer u gimnaziji; način donošenja odluke o izboru predmeta; reizbor predmeta; ispunjenost očekivanja; kvalitet izbornih programa; opšti uspeh na kraju I polugodišta; izborni programi; predmetni nastavnik.

Zavisne varijable: Indikatori 5 standarda kvaliteta oblasti „Nastava i učenje": Nastavnik efikasno upravlja procesom učenja na času; Nastavnik prilagođava rad na času obrazovno-vaspitnim potrebama učenika; Učenici stiču znanja, usvajaju vrednosti, razvijaju veštine i kompetencije na času; Postupci vrednovanja su u funkciji daljeg učenja; Svaki učenik ima priliku da bude uspešan. Ostvarenost ishoda u nastavi izbornih programa.

2.2. Postupak ispitivanja

Onlajn ispitivanje je sprovedeno u junu 2019.g. korišćenjem upitnika za učenike i nastavnike posebno konstruisanih za ovo istraživanje. Onlajn ispitivanje učenika prvog razreda sproveli su nastavnici računarstva i informatike Gimnazije, jer je bilo važno da obezbedimo objektivne i ujednačene uslove ispitivanja. Onlajn upitnike za nastavnike su popunjavali samo nastavnici koji realizuju programe izbornih predmeta u I razredu.

Upitnik za učenike izrađen je u nameri da ispita stavove i mišljenja učenika o različitim aspektima nastave izbornih programa.

Prvi deo upitnika za učenike je sadržao osnovne podatke: pol, odeljenje, smer, način donošenja odluke za pohađanje nastave izbornog programa, izborni program, opšti uspeh na kraju prvog polugodišta, ocena iz izbornog programa na kraju školske godine.

U drugom delu upitnika učenici su se opredeljivali za ponuđene odgovore u vezi sa kvalitetom izbornih programa u odnosu na aspekte koji se prepoznaju kao relevantni u definisanim ciljevima i ishodima; (ne)ispunjenim očekivanjima i ponovnim izborom izbornih programa (pitanja zatvorenog i otvorenog oblika).

Treći deo je predstavljen kroz četvorostepenu skalu kojom su procenjivali rad nastavnika na času (na osnovu izabranih indikatora oblasti Nastava i učenje).

Četvrti deo upitnika čini četvorostepena skala u kojoj su navedeni mogući efekti nastave koju učenik pohađa u I razredu.

Zadatak učenika bio je da na skali od 1 (uopšte se ne slažem) do 4 (u potpunosti se slažem) proceni koliko su izvedene aktivnosti i sadržaji u nastavi izbornog predmeta njima lično odgovarali i koliko su od njih imali koristi (na osnovu propisanih ishoda predmeta određivali su šta i koliko znaju, razumeju i umeju da urade po završetku programa).

Upitnik za nastavnike je sadržao pitanja o: radnom stažu u nastavi, stručnom usavršavanju, proceni kvaliteta izbornog programa koji su realizovali i procenu materijalno-tehničkih, prostornih i drugih uslova i vidova podrške, koji mogu bitno uticati na kvalitet rada nastavnika i učenika.

Preporuke i predloge za unapređivanje rada u nastavi izbornih programa nastavnici su zapisivali kao odgovore na pitanja otvorenog tipa.

Za obradu podataka korišćene su deskriptivne i komparativne statističke procedure statističkog softvera SPSS.

2.3. Uzorak

Uzorak u istraživanju čine učenici I razreda koji su obrazovanje u Gimnaziji stekli prema Programu nastave i učenja za prvi razred gimnazije [4] i nastavnici koji su realizovali nastavu izbornih programa u prvom razredu gimnazije.

Istraživanje je realizovano u junu 2019. U to vreme nastavu je pohađalo 295 učenika prvog razreda Gimnazije. Ispitivanjem je obuhvaćeno 233 učenika (79% od ukupnog broja učenika I razreda): 99 učenika (42,5%) sa društveno-jezičkog smera (u daljem tekstu DJ smera) i 134 učenika (57,5%) sa prirodno-matematičkog smera (u daljem tekstu PM smera); 135 devojaka (57,9%) i 100 mladića (42,1%). Opšti uspeh isptanih učenika na kraju prvog polugodišta prvog razreda: odličan (111; 47,6%); vrlo dobar (109; 46,8%); dobar (5; 2,1%); nedovoljan (8; 3,4%). Od 233 učenika koji su učestvovali u istraživanju, 44,3% je pohađalo nastavu predmeta Jezik, mediji i kultura, 24,2% Pojedinac, grupa i društvo, 13,3% Obrazovanje za održivi razvoj i 18,2% Umetnost i dizajn.

U školskoj 2018/2019. nastavu izbornih programa u prvom razredu Gimnazije realizovalo je devet nastavnika. Jedna nastavnica je realizovala dva izborna programa, a svi ostali po jedan. Nastavu izbornog programa Jezik, mediji i kultura je izvodilo 4 nastavnika, kao i nastavni program Pojedinac, grupa i društvo. Nastavu predmeta Obrazovanje za održivi razvoj i Umetnost i dizajn je izvodio po jedan nastavnik.

3. REZULTATI ISTRAŽIVANJA

Na osnovu rezultata samovrednovanja oblasti Obrazovna postignuća (tabela 1) i pregleda odabranih pokazatelja školskog rada u periodu od 2006-2019. u Prosvetnom kartonu Gimnazije, Dunjić Mandić [7,8] je utvrdila da su na kraju drugog polugodišta 2018-2019. učenici I razreda postigli bolji opšti uspeh (4,42) u odnosu na vršnjake prethodnih generacija. Utvrđene razlike opšteg uspeha učenika prvog razreda različitih generacija nisu statistički značajne.

Tabela 1. *Opšti uspeh učenika prvog razreda (2012/2019.)*

I razred	N	Opšti uspeh
2018-2019.	295	4,42
2017-2018.	279	4.30
2016-2017.	298	4.16
2015-2016.	282	4,32
2014-2015.	242	4,25
2013-2014.	249	4.41
2012/2013.	287	4.22
2011-2012.	296	4.20

Prosečne ocene učenika I razreda Gimnazije iz izbornih programa na kraju drugog polugodišta kreću se u rasponu od 4,91 do 4,98. Analizom je utvrđeno da su prosečne ocene iz izbornih programa nešto više od prosečnih ocena iz drugih nastavnih predmeta, što rezultira većim opštim uspehom prvaka na kraju 2018/2019. u odnosu na prethodne godine. Raspon prosečnih ocena po izbornom predmetu: JMK (4,75–5,00); PGD (4.71–5.00); OOR (4.82–5.00); UID (4.82–5.00).

3.1. Način izbora predmeta

Prema Ružičiću [6] 78% učenika odluku o izboru predmeta donelo je samostalno, na predlog drugova/drugarica 10,3%, uz pomoć roditelja 9%. Pri ponovnom opredeljivanju za izabrani izborni program najveći broj učenika bi izabrao isti (Tabela 2).

Tabela 2. *Ponovni izbor izbornog programa*

Izborni predmet	Ponovo bi birao	Ne bi izabrao	Nisam siguran
JMK	47.9%	21.6%	30.4%
PGD	43.1%	34,9%	22%
OOR	65.5%	16,4%	18.2%
UID	85%	2,5%	12,5%
Ukupno	55.7%	20.8%	23.5%

Utvrđena razlika u spremnosti učenika izbornih programa koji bi ponovo izbrali isti predmet i onih koji to ne bi uradili: značajno je više učenika koji bi ponovo birali isti predmet (55.7%) u odnosu na one koji to ne bi uradili (20,8%) ili su neodlučni (23,5%). U situaciji da ponovo bira izborni program JMK skoro svaki drugi učenik bi ponovo izabrao program (47,9%), dok svaki peti ne bi (21,6%). Neodlučna je trećina ispitanih učenika (30.4%). Program PGD ponovo bi izabralo 43,1%, a ne bi 34,9% ispitanih učenika. Neodlučan je svaki peti učenik (22%). Program OOR ponovo bi biralo 65,5%, ne bi 16,4%, a nije sigurno (ne može da se izjasni) 18,2% ispitanih učenika. Program UID ponovo bi izabralo 85% učenika, ne bi ga biralo 2,5%, a nije sigurno/ne može da se izjasni o tome 12,5% ispitanih učenika.

3.2. Ispunjenost očekivanja

Nastava izbornih programa je u većoj meri ispunila očekivanja učenika koji su ih samostalno birali. U proseku, izborni programi su ispunili očekivanja 67% učenika prvog razreda. Sa najviše ispunjenih očekivanja su učenici koji su pohađali nastavu izbornih programa UID (77%) i OOR (76%), a nešto manje JMK (60,5%) i PGD (54,3%). Najčešći odgovori učenika kojima je nastava izbornih programa ispunila očekivanja vezani su za određene sadržaje programa i način rada koji uključuje više prakse, rada na terenu i grupnog rada, komunikacije između svih aktera obrazovno vaspitnog rada. Prema [6] svakom trećem učeniku izborni programi nisu ispunili očekivanja jer su oni za njih: *opterećenje, oduzimaju im puno vremena za učenje (mislili da će biti lakše i opuštenije jer su teži „od pravih, ozbiljnih predmeta*"). Mogući razlozi leže u činjenici da su učenici u osnovnoj školi imali jedan od dva ponuđena izborna predmeta (građansko vaspitanje i verska nastava), koji se potpuno drugačije realizuju, ne ocenjuju brojčano i ne ulaze u opšti uspeh.

3.3. Kvalitet izbornih programa

Kvalitet izbornih programa procenjivan je na osnovu pitanja: (a) zatvorenog oblika u kome je ponuđeno 5 aspekata nastave i na osnovu (b) pitanja otvorenog oblika u kome su učenici i nastavnici navodili svoje mišljenje o tome koji su najveći kvaliteti nastave izbornih predmeta.

U osnovi izbornih programa, između ostalog je i *spajanje učenika sličnih interesovanja iz različitih odeljenja*, što doprinosi unapređenju školske klime i boljem upoznavanju i saradnji učenika i samih nastavnika međusobno. Ovim istraživanjem je taj kvalitet i utvrđen. Naime, svaki treći ispitani učenik je izdvojio kao najveći kvalitet izbornih programa *Spajanje učenika sličnih znanja i interesovanja* i *Odnose između učenika* (po 29%). *Sadržaj izbornih programa* je za svakog petog učenika njihov najveći kvalitet (19%), dok su *Odnos nastavnika prema učenicima* (14%) i *Rad nastavnika na času* (9%) najlošije procenjeni. Obradom dobijenih podataka je utvrđeno da su pri određivanju kvaliteta izbornih programa, učenicima koji su pohađali nastavu JMK i PGD (za razliku od učenika sa OOR i UID) bitniji *odnosi između učenika*, a učenicima koji su pohađali nastavu UID i OOR najveći kvalitet je *spajanje učenika različitih znanja i interesovanja* (za razliku od učenika sa JMK i PGD).

I nastavnici izbornih programa su izrazili svoj vrednosni stav o konkretnim aspektima programa koji se prepoznaju kao relevantni u definisanim ciljevima i ishodima. Prema frekvencijama odgovora nastavnika izdvojili su se *Sadržaj nastavnih predmeta* (77,7%) i *Spajanje učenika sličnih znanja i interesovanja* (33,3%) kao najveći kvaliteti izbornih programa. Zanimljivo je da nijedan nastavnik ne smatra *Odnos nastavnika prema učenicima* kao poseban kvalitet izbornih programa, za razliku od 14% učenika koji naglašavaju ovaj aspekt nastave.

3.4. Nastava i učenje

Procenjujući rad nastavnika izbornih programa u školskoj 2018/2019. učenici su svaki dati iskaz upoređivali sa ličnim iskustvom i izražavali stepen slaganja na skali od 1 (uopšte se ne slažem) do 4 (u potpunosti se slažem). Kvalitet rada u nastavi izbornih programa, procenjivali su na osnovu 5 standarda predstavljenih kroz 29 pokazatelja kvaliteta koji se odnose na ključnu oblast samovrednovanja „Nastava i učenje".

Raspodelu odgovora učenika (prosečne ocene) po indikatorima standarda **Nastavnik efikasno upravlja procesom nastave na času** prikazuje tabela 3. Utvrđena prosečna ocena ovog standarda je 3,04. Procenjujući nastavnikovu efikasnost da upravlja procesom učenja na času učenici su (u proseku) od 9 indikatora na 5 dali ocenu jednaku ili veću od 3, a za 4 pokazatelja ocenu manju od 3. Najviše ocene su dobili indikatori: *Na časovima radimo u malim grupama na zajedničkom zadatku* (3,56), *Na časovima diskutujemo o temama kojima se bavimo* (3,38), *Nastavnik daje učenicima jasna uputstva i instrukcije za rad* (3,18) i *Nastavnik usmerava saradnju i komunikaciju među učenicima* (3,19). Nižim ocenama su procenjeni indikatori: *Nastavnik na interesantan način predaje gradivo* (2,67) i *Nastavnik koristi računar i druga savremena nastavna sredstva za rad na času* (2,78).

Analizom su utvrđene statistički značajne razlike u odgovorima sledećih grupa ispitanika:

- Devojke (3,47) su bolje ocenile indikator *Na časovima diskutujemo o temama kojima se bavimo* u odnosu na mladiće (3,21), dok mladići u većoj meri smatraju da *Nastavnik na interesantan način predaje gradivo* (2,68) za razliku od devojaka (2,44);
- Učenici sa PM smera (3,05) su bolje ocenili indikator *Nastavnik koristi različite metode (oblike) rada na času* u odnosu na učenike sa DJ smera (2.85);
- Učenici koji su pohađali nastavu izbornog programa UID su pozitivnije ocenili svog nastavnika jer *efikasno upravlja procesom učenja na času, daje učenicima jasna uputstva i instrukcije za rad, koristi različite metode (oblike) rada na času, koristi računar i druga savremena nastavna sredstva za rad na času* u odnosu na učenike koji su pohađali nastavu predmeta PGD.
- Utvrđene su značajne razlike u ocenama između nastavnika po skoro svim indikatorima;
- Naknadna (post-hoc) poređenja su utvrdila značajne razlike u okviru izbornih programa po skoro svim ispitivanim varijablama (najčešće na nivou odeljenja).
- Učenici koji bi ponovo birali izabrani predmet su značajno višim ocenama procenili sve indikatore ovog standarda u odnosu na učenike koji ne bi ponovo birali isti izborni program ili su neodlučni.

Tabela 3. *Nastavnik efikasno upravlja procesom nastave na času*

		N	M	F	Sig
N. efikasno upravlja procesom učenja na času.	JMK	194	3.05	4.554	.004
	PGD	109	2.70		
	OOR	55	3.00		
	UID	80	3.26		
	SVI	438	3.00		
N. daje učenicima jasna uputstva i instrukcije za rad	JMK	194	3.32	6.180	.000
	PGD	109	2.85		
	OOR	55	3.15		
	UID	80	3.40		
	SVI	438	3.18		
N. koristi različite metode (oblike) rada na času	JMK	194	3.02	4.430	.004
	PGD	109	2.66		
	OOR	55	3.07		
	UID	80	3.18		
	SVI	438	2.98		
Na časovima radimo u malim grupama na zajedničkom zadatku.	JMK	194	3.73	3.663	.012
	PGD	109	3.42		
	OOR	55	3.56		
	UID	80	3.51		
	SVI	438	3.56		
N. na interesantan način predaje gradivo.	JMK	194	2.26	11.043	.000
	PGD	109	2.49		
	OOR	55	2.84		
	UID	80	3.09		
	SVI	438	2.67		
N. koristi računar i druga savremena nastavna sredstva za rad na času	JMK	194	2.60	6.802	.000
	PGD	109	2.50		
	OOR	55	2.80		
	UID	80	3.21		
	SVI	438	2.78		

Min (1) Max (4)

Utvrđena prosečna ocena standarda **Nastavnik prilagođava rad na času obrazovno-vaspitnim potrebama učenika** je 2,81 (Tabela 4). U celini gledano sva tri izabrana indikatora ovog standarda su dobili prosečen ocene manje od 3. Učenici oba smera gimnazije, prirodno-matematičkog i društveno–jezičkog, na sličan način procenjuju izabrane indikatore standarda *Nastavnik prilagođava rad na času obrazovno-vaspitnim potrebama učenika* (nema značajne razlike).

Tabela 4. *Nastavnik prilagođava rad na času obrazovno-vaspitnim potrebama učenika*

Indikator	**Pred**	N	M	F	Sig
N. prilagođ. rad na času obrazovno-vaspitnim potrebama učenika	JMK	194	2.85	3.428	.017
	PGD	109	2.70		
	OOR	55	3.09		
	UID	80	3.14		
	SVI	438	2.95		
N. prilagođava način rada i nastavni materijal individual. karakteristikama učenika	JMK	194	2.52	6.352	.000
	PGD	109	2.55		
	OOR	55	2.65		
	UID	80	3.14		
	SVI	438	2.72		
N. posvećuje vreme i pažnju svakom učeniku u skladu sa njegovim obraz. i vaspitn. potrebama	JMK	194	2.57	4.944	.002
	PGD	109	2.54		
	OOR	55	2.98		
	UID	80	3.03		
	SVI	438	2.78		

Min (1) Max (4)

Utvrđene su statistički značajne razlike u odgovorima učenika različitih odeljenja u zavisnosti

od toga koji su izborni predmet pohađali i ko im je predavao. Najviše prosečne ocene su dobili predmeti UID i OOR. Statistički značajno višim ocenama su procenjeni indikatori za predmet UID: *Nastavnik prilagođava način rada i nastavni materijal individualnim karakteristikama svakog učenika* (3,14), *Nastavnik prilagođava rad na času obrazovno-vaspitnim potrebama učenika* (3,14), *Nastavnik posvećuje vreme i pažnju svakom učeniku u skladu sa njegovim obrazovnim i vaspitnim potrebama* (3,03).

Učenici koji su pohađali nastavu predmeta UID su pozitivnije ocenili indikatore i svog nastavnika jer *prilagođava način rada i nastavni materijal individualnim karakteristikama svakog učenika* (3,14) u odnosu na učenike koji su slušali nastavu PGD (2,55) i JMK (2,52). Značajno veće ocene je dobio nastavnik predmeta UiD i za posvećenost vremena i pažnje svakom učeniku u skladu sa njegovim obrazovnim i vaspitnim potrebama (3,03) u odnosu na nastavnike predmeta JMK (2,57) i PGD (2,54). Učenici koji bi ponovo birali izabrani predmet su značajno višim ocenama procenili sve indikatore standarda *„Nastavnik prilagođava rad na času obrazovno-vaspitnim potrebama učenika"* u odnosu na učenike koji ne bi ponovo birali isti izborni program ili su neodlučni.

Prosečna ocena standarda **Učenici stiču znanja, usvajaju vrednosti, razvijaju veštine i kompetencije na času** je 2,95. Više prosečne ocene su dobili predmeti UID i OOR. Utvrđena je značajna razlika u odgovorima 4 grupe učenika: učenici UID (3.28) su pozitivnije ocenili indikator kvaliteta rada svog nastavnika *Učenici stiču znanja, usvajaju vrednosti, razvijaju veštine i kompetencije na času* u odnosu na procene učenika sa JMK (2,85) i PGD (2,63).

Tabela 5. *Učenici stiču znanja, usvajaju vrednosti, razvijaju veštine/komp. na času*

		N	M	F	Sig
Učenici stiču znanja, usvajaju vrednosti, razvijaju veštine i kompetencije na času.	JMK	194	2.85	5.374	.001
	PGD	109	2.63		
	OOR	55	3.02		
	UID	80	3.28		
	SVI	438	2.95		
N. podstiče učenike da primene naučeno i obrazlože kako su došli do rešenja	JMK	194	3.03	2.972	.032
	PGD	109	2.72		
	OOR	55	3.13		
	UID	80	3.10		
	SVI	438	3.00		
N. nas uči kako da prethodno naučeno povez. sa različitim oblastima i primenimo u svakodn. životu.	JMK	194	2.86	2.357	.071
	PGD	109	2.69		
	OOR	55	3.02		
	UID	80	3.10		
	Svi	438	2.92		

in (1) Max (4)

Utvrđena prosečna ocena standarda **Postupci vrednovanja su u funkciji daljeg učenja** je 2,92. Tabela 6 prikazuje prosečne ocene standarda po izabranim pokazateljima (statistički značajne razlike). Nisu utvrđene razlike obzirom na pol i smer učenika; utvrđene su značajne razlike izmedju odeljenja i predmetnih nastavnika. Učenici koji bi ponovo birali izabrani predmet značajno višim ocenama procenili sve indikatore ovog standarda u odnosu na učenike koji ne bi ponovo birali isti izborni program ili su neodlučni. Ocenama većim od 3 ocenjeni indikatori rada u nastavi OOR i UID.

Tabela 6. *Postupci vrednovanja su u funkciji daljeg učenja*

		N	M	F	Sig
Postupci vrednovanja su u funkciji daljeg učenja.	JMK	194	2.61	5.461	.001
	PGD	109	2.75		
	OOR	55	3.11		
	UID	80	3.11		
	SVI	438	2.90		
Nastavnik nas ocenjuje na svakom času.	JMK	194	2.28	7.003	.000
	PGD	109	2.35		
	OOR	55	2.89		
	UID	80	2.85		
	SVI	438	2.59		
Nastavnikovi kriterijumi ocenjivanja su jasni	JMK	194	2.87	5.444	.001
	PGD	109	2.72		
	OOR	55	3.11		
	UID	80	3.34		
	SVI	438	3.01		
N. daje potpunu i razumljivu povratnu infor. učenic. o radu i jasne preporuke narednim koracima.	JMK	194	3.09	2.747	.043
	PGD	109	2.84		
	OOR	55	3.11		
	UID	80	3.29		
	SVI	438	3.08		
N. nas uči kako da procenimo svoj i napr ostalih učenika.	JMK	194	2.70	5.735	.001
	PGD	109	2.67		
	OOR	55	3.02		
	UID	80	3.24		
	SVI	438	2.91		

Min (1) Max (4)

Utvrđene su značajne razlike u odgovorima učenika koji su pohađali neki od 4 izborna programa: učenici koji su pohađali nastavu izbornog programa JMK su značajno nižim ocenama procenili indikatore: *Postupci vrednovanja su u funkciji daljeg učenja i Nastavnik nas ocenjuje na svakom času* u odnosu na učenike koji su pohađali nastavu OOR i UID. Da su Nastavnikovi kriterijumi ocenjivanja jasni značajno više odgovora i pozitivnije ocene je dobio nastavnik UID (3,34) u odnosu nastavnike JMK (2,87) i PGD (2,72); Učenici koji su pohađali nastavu predmeta UID su dali najviše ocene indikatorima *Nastavnik daje potpunu i razumljivu povratnu informaciju učenicima o njihovom radu, uključujući i jasne preporuke o narednim koracima* (M=3,29) i *Nastavnik nas uči kako da procenimo svoj napredak i napredak ostalih učenika* (M=3,24) u odnosu na učenike sa PGD.

Utvrđena prosečna ocena standarda **Svaki učenik ima priliku da bude uspešan** je 3,03. Procenjujući indikatore ovog standarda učenici su, u proseku, od 8 indikatora na 5 dali ocenu jednaku ili veću od 3, a za 3 pokazatelja ocenu manju od 3 (tabela 5). Na skali od 1 do 4 učenici su višim ocenama od 3 ocenili nastavnike izbornih programa koji često ili vrlo često stvaraju uslove za rad na času u kojoj svaki učenik ima priliku da bude

uspešan (M=3,31), podstiču učenike na međusobno uvažavanje i na konstruktivan način uspostavljaju i održavaju discisplinu u skladu sa dogovorenim pravilima (M=3,04), podstiču intelektualnu radoznalost i slobodno iznošenje mišljenja učenika (M=3,04), daju učenicima mogućnost izbora u vezi sa načinom obrade teme (M=3,08) i koju su spremni na razgovor sa učenicima i posle nastave (M=3,16). Tabela 7 prikazuje indikatore kod kojih su utvrđene statistički značajne razlike između predmeta.

Tabela 7: *Svaki učenik ima priliku da bude uspešan*

		N	M	F	Sig.
Svaki učenik ima priliku da bude uspešan	JMK	194	3.34	3.053	.028
	PGD	109	3.05		
	OOR	55	3.35		
	UID	80	3.48		
	Svi	438	3.31		
N. motiviše učenike na rad uvažavajući njihove različitosti i prethodna postignuća	JMK	194	2.75	2.760	.042
	PGD	109	2.74		
	OOR	55	3.00		
	UID	80	3.13		
	Svi	438	2.91		
N. podstiču intelekt. radoznalost i slobodno iznošenje mišljenja učenika.	JMK	194	2.92	4.850	.002
	PGD	109	2.75		
	OOR	55	3.15		
	UiD	80	3.33		
	Svi	438	3.04		
N. postavlja pitanja koja pobuđuju radoznalost učenika	JMK	194	2.52	7.118	.000
	PGD	109	2.71		
	OOR	55	3.05		
	UiD	80	3.14		
	Svi	438	2.86		
N. daje učenicima mogućnost izbora u vezi sa načinom obrade teme.	JMK	194	2.97	2.770	.041
	PGD	109	2.90		
	OOR	55	3.16		
	UiD	80	3.30		
	Svi	438	3.08		
Nastavnik stvar prijatnu atmosferu za rad na času	JMK	194	2.55	8.101	.000
	PGD	109	2.68		
	OOR	55	3.09		
	UiD	80	3.23		
	Svi	438	2.89		

U celini gledano, prosečna ocena kvaliteta rada oblasti samovrednovanja „Nastava i učenje" u nastavi četiri izborna programa (Jezik, mediji i kultura; Pojedinac, grupa i društvo; Obrazovanje za održivi razvoj; Umetnost i dizajn) iznosi 2,95 (novo 3). Nivo ostvarenosti standarda izražen na osnovu prosečnih vrednosti pokazatelja na skali od 1 do 4 prikazan je u tabeli 8.

Tabela 8: *Nivo ostvarenosti standarda*

Standard	M	Nivo
Nastavnik efikasno upravlja procesom učenja na času	3.04	3
Nastavnik prilagođava rad na času obraz.-vaspitnim potrebama učenika	2.81	3
Učenici stiču znanja, usvajaju vrednosti, razv. veštine, kompetenc. na času	2.95	3
Postupci vrednovanja su u funkciji daljeg učenja	2.92	3
Svaki učenik ima priliku da bude uspešan	3.03	3

U poredjenju sa rezultatima vrednovanja rada Gimnazije iz 2017.g. primetna je razlika u ocenama standarda *Nastavnik prilagođava rad na času obraz.-vaspitnim potrebama učenika i Postupci vrednovanja su u funkciji daljeg učenja.* Ocene ovih standarda, koje su dali eksterni evaluatori bile su na nivou 2, a ocene koje su dali ispitani učenici su na nivou 3.

4. DISKUSIJA REZULTATA

Rezultati istraživanja su omogućili sagledavanje različitih aspekata nastave novih izbornih programa nakon prve godine primene u Gimnaziji. Rezultati su pokazali da učenici, uglavnom, samostalno donose odluku o pohađanju izbornog programa, a nešto manje pod uticajem i na predlog druga/drugarice i uz pomoć roditelja. Nakon prve godine, u zavisnosti od predmeta koji su pohađali, svaki drugi učenik bi ponovo birao isti predmet, a svaki peti ne bi. S tim u vezi je podatak da je nastava izbornih programa u većoj meri ispunila očekivanja učenika koji su ih samostalno birali (izborni programi su ispunili očekivanja 67% učenika I razreda). Ispunjena su očekivanja vezana za određene *sadržaje programa i način rada koji uključuje više prakse, grupnog i rada na terenu rada, komunikacije između svih aktera obrazovno vaspitnog rada.* Neispunjenih očekivanja je svaki treći učenik jer su im oni *„dodatno opterećenje", „imaju manje vremena za učenje obaveznih predmeta, jer su oni „značajniji za njihovo dalje obrazovanje"*.

Polazne osnove za uvođenje izbornih programa (njihov interdisciplinarni karakter; povezivanje sadržaja iz različitih oblasti; spajanje učenika sličnih znanja i interesovanja iz različitih odeljenja), ovim istraživanjem su izdvojeni kao poseban kvalitet.

U celini gledano, prosečna ocena kvaliteta rada oblasti samovrednovanja „Nastava i učenje" u nastavi 4 izborna programa: Jezik, mediji i kultura; Pojedinac, grupa i društvo; Obrazovanje za održivi razvoj; Umetnost i dizajn, iznosi 2,95, što u metodologiji samovrednovanja odgovara nivou 3 (situacija koju karakteriše više jakih nego slabih strana; postojeće slabosti treba otkloniti jer umanjuju kvalitet rada ustanove).

Prosečna ocena standarda *Nastavnik efikasno upravlja procesom učenja na času* je 3,04 (nivo 3). Procenjujući nastavnikovu efikasnost da upravlja procesom učenja na času učenici su od 9 indikatora na 5 dali ocenu jednaku ili veću od 3, a za 4 pokazatelja ocenu manju od 3. Najviše ocene su dobili indikatori u kojima se naglašava nastavnikov način rada na času: *rad u malim grupama na zajedničkom zadatku, dikusija o temama kojima se bave, nastavnik daje učenicima jasna uputstva i instrukcije za rad i usmerava saradnju i komunikaciju među učenicima*. Slabosti koje treba otkloniti tiču se načina na koji nastavnik predaje gradivo i preporuka da više koristi računar i druga savremena nastavna sredstva za rad na času. Utvrđena prosečna ocena (2,81) standarda *Nastavnik prilagođava rad na času obrazovno-*

vaspitnim potrebama učenika, implicira češće prilagođavanje načina rada i izbor nastavnih materijala obrazovno-vaspitnim potrebama i karakteristikama svakog učenika, uz posvećenost vremena i pažnje svakom učeniku u skladu sa njegovim obrazovnim i vaspitnim potrebama. Za sticanje znanja, usvajanje vrednosti, razvijanje veština i kompetencija na času potrebno je da nastavnici podstiču učenike na primenu naučenog i obrazloženje kako su došli do rešenja. Nastavnik stvara uslove i uči učenike kako da naučeno povezuju sa različitim oblastima i kako da to primene u svakodnevnom životu. Da bi postupci vrednovanja bili u funkciji daljeg učenja potrebno je da nastavnici ocenjuju učenike na svakom času, primenjujući jasne kriterijume ocenjivanja. U tu svrhu je najbolje koristiti formativno ocenjivanje kojim se obezbedjuje kvalitetna, potpuna i razumljiva povratna informaciju o radu učenika, uključujući i jasne preporuke o narednim koracima. Poželjno je da nastavnici uče svoje učenike kako da procene svoj napredak i napredak ostalih učenika. Da bi se ovo postiglo potrebno je da nastavnici u procesu planiranja nastave posebnu pažnju posvete pitanjima „Zašto ga ovo pitam, šta želim time postići"? Da ocenjivanje ne bi bilo impresionističko potrebni su Pravilnik o ocenjivanju, različite taksonomije (Blum, Solo), program i ishodi predmeta, koji će nastavniku pomoći da najpre prepozna učenikov napredak, i odredi na koji način će vrednovati rezultate učenja i aktivnosti.

Obzirom da je istraživanjem utvrđeno da su višim ocenama ocenili nastavnike izbornih programa koji: stvaraju uslove za rad na času u kojoj svaki učenik ima priliku da bude uspešan, podstiču učenike na međusobno uvažavanje i na konstruktivan način uspostavljaju i održavaju discisplinu u skladu sa dogovorenim pravilima, podstiču intelektualnu radoznalost i slobodno iznošenje mišljenja učenika, daju učenicima mogućnost izbora u vezi sa načinom obrade teme i koju su spremni na razgovor sa učenicima i posle nastave, poželjno je da se ovi principi svakodnevno primenjuju u nastavi.

Rezultati istraživanja su pokazali da učenici različito ocenjuju nastavnike različitih predmeta. Utvrđene značajne razlike između predmetnih nastavnika po skoro svim indikatorima ispitivanih standarda, nagoveštava dosta prostora za unapredjenje rada u nastavi izbornih programa i samih nastavnika.

5. ZAKLJUČCI

Samovrednovanje rada škole je proces. Njegovom primenom škole dobijaju značajne smernice u kom pravcu i na koji način mogu unaprediti sopstvenu pedagošku praksu. Koristeći rezultate ovog istraživanja, Gimnazija je preduzela neophodne korake i formativno delovala povratnim informacijama u individualnom pedagoško-instruktivnom radu direktora i stručnih saradnica sa predmetnim nastavnicima izbornih programa. U individualnom savetodavnom radu nastavnicima je predočena potvrda onoga u čemu su dobri (šta dobro rade), ali i koje su im slabosti i čemu treba da posvete veću pažnju i kako da unaprede svoj rad. Imajući u vidu da su nastavnici nosioci promena u reformi gimnazija pred njih su postavljeni novi i viši zahtevi, a ovo istraživanje, između ostalog, pokazuje puteve i načine promena pristupa u radu sa učenicima koji bi doveli do tog cilja.

Utvrđene jake strane i slabosti koje treba otkloniti mogu biti korisne svim nastavnicima, stručnim saradnicima i direktorima, kako naše tako i drugih škola, za unapredjenje realizacije izbornih programa.

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Simpozijum *"Tehnika i informatika u obrazovanju: Nastavnici za nastavnike"*

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Upotreba IKT alata u nastavi na daljinu

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Rezime: *Pojavom novih tehnologija u nastavnom procesu su se nametnule brojne promene. Savremena nastava se ne može zamisliti bez upotrebe IKT alata kako bi se učenici što više zainteresovali, motivisali i podstakli na usvajanje novih znanja. U procesu nastave na daljinu do izražaja je došlo nastavnikovo umeće, kao i njegovo usavršavanje u korišćenju multimedijalne nastave. Internet i IKT alati su neophodni u razmeni i usvajanju novih znanja i veština. U radu su, na osnovu neposrednog iskustva nastavnika-praktičara, prikazani IKT alati korišćeni u nastavi u toku pandemije.*

Ključne reči: *IKT alati, internet učionica, onlajn okruženje, savremena nastava, multimedijalna nastava*

The Use of ICT Tools for Teaching at a Distance

Abstract: *With the appearance of new technologies in the teaching process, numerous changes have been imposed. Modern teaching cannot be imagined without the use of ICT tools in order to interest, motivate and encourage students to acquire new knowledge. In the process of distance teaching, the teacher's skills came to the fore, as well as his improvement in the use of multimedia teaching. Internet and ICT tools are necessary in the exchange and adoption of new knowledge and skills. Based on the direct experience of teachers-practitioners, the paper presents ICT tools used in teaching during a pandemic.*

Keywords: *ICT tools, internet classroom, online environment, modern teaching, multimedia teaching*

1. UVOD

Integrisati tehnologiju u nastavu, nije lako, ali nije ni nemoguće. Potrebno je mnogo iskustva, ali i želje da se adaptiramo u tekovine novog doba. Cilj predavača jeste naučiti učenike da uče. Nastavnik mora biti sposoban da ide u korak sa vremenom. Multimedijalna nastava je zaživela u našem obrazovanju. Elektronsko učenje je novi vid učenja koje prati ovo vreme. Biće potrebno još mnogo vremena za njegovu najbolju primenu u nekim oblastima školovanja, ali ga ne treba nigde ni suzbijati, posebno tamo gde se pokazuje kao efikasno. Svedoci smo da već dugi niz godina nastava ne može da funkcioniše samo primenom tradicionalnih metoda. Kao što očekujemo od svojih učenika rad i napredak, tako je došlo vreme da nastavnik ne može da se osloni samo na znanje koje je stekao u toku svog školovanja, već postoji potreba za celoživotnim učenjem i obrazovanjem i u drugim oblastima koje u svom primarnom obrazovanju nije imao priliku da upozna. U današnjem obrazovnom sistemu akcenat se stavlja na učenika, njegovu aktivnost. Nastavnik ne može više da bude samo predavač, već mora da prati, usmerava, podstiče učenika i koristi informaciono-komunikacionu tehnologiju u cilju obrazovanja.

Informaciono-komunikaciona tehnologija uveliko ima primenu u školama i nastava se ne može zamisliti bez nje. Uglavnom se IKT nastava u učionici kombinovala sa tradicionalnom nastavom, što je imalo za cilj bolju motivaciju učenika, njihovo veće angažovanje i misaonu aktivnost.

U vreme KOVID pandemije, kada je redovna nastava prestala sa radom, nastavniku je ostalo samo da se osloni na svoja informatička znanja i organizuje nastavni proces. Među brojnim IKT alatima koji su dostupni, nastavnik je bio primoran da sam napravi selekciju u odabiru i načinu primene istih. Primenom IKT alata u nastavi veoma je važno da se ne zanemari pedagoški aspekt učenja i na pravi način integriše tehnologija u cilju promovisanja učenja [1]. Nastavnik, pri kreiranju obrazovnih materijala i osmišljavanju aktivnosti za učenike, mora da ima na umu kako da ih motiviše, kako da im pruži povratnu informaciju, kako da pospeši interakciju i kako da učeniku da podršku. IKT alati su sredstvo u rukama dobrog nastavnika. Treba ih koristiti svrsishodno, bezbedno i u cilju svrsishodnog učenja, proširivanja funkcionalnog znanja, saradnje među učenicima, razvoja kritičkog mišljenja.

2. INTERNET UČIONICA

Komunikacija u doba pandemije podrazumevala je upotrebu različitih veb aplikacija (internet učionice) u kojima učenici uče i jedni od drugih, a ne samo od nastavnika. U okolnostima u kojima je internet sa veb alatima bio jedini način komunikacije, velika odgovornost je bila na samom učeniku. On je morao sam da traga za različitim izvorima znanja, kreira sadržaje, preuzima odgovornost, sarađuje sa drugima. Najlakša učionica za uspostavljanje komunikacije i rad sa učenicima jeste Google učionica, koja već postoji i nije je potrebno dodatno instalirati i pokretati. Ona je vrlo jednostavna za upotrebu i učenici se preko kodova, koje im nastavnik da, jednostavno uloguju na nju. Okruženje je bezbedno i garantovana je privatnost učenika jer je nastavnik taj koji ih poziva u okruženje, kontroliše i vodi učenje. S obzirom na socijalnu distancu, veoma je važno da alati koji se koriste pospešuju saradničko učenje, timski rad, svakodnevnu komunikaciju među učenicima.

Multimedijalni programi kreirani za personalne računare nude mogućnost kreiranja elektronskih udžbenika sa tekstom, slikama, zvučnim animacijama, filmovima, tako da učenici mogu samostalno da napreduju u ovladavanju nastavnih sadržaja, da se vrate na sadržaje koji im nisu dovoljno jasni, da dobiju povratne i dodatne informacije u skladu sa svojim mogućnostima i interesovanjima. Interaktivnost i kvalitet prezentovanih materijala uz korišćenje multimedije i hiperteksta daje znatno bogatije sadržaje u poređenju sa nastavom koja se odvija u tradicionalnim učionicama [2].

Nastavnik vrlo lako komunicira sa svima i jednako je svima dostupan za dodatna pitanja i podršku. Učenici vrlo lako dobijaju povratne informacije za svoje radove, bilo da su to emotikoni, komentari, bodovi, vršnjačke procene. Na javnom zidu nastavnik postavlja obaveštenja koja se odnose na sve učenike, a prednost ove učionice jeste što nastavnik može učeniku u okviru privatnih komentara sugerisati nešto, što bi inače rekao nasamo u učionici. Upotreba IKT alata u internet učionici ne svodi se samo na proveru toga da li učenik ume da koristi neki alat, već se koriste tako da od učenika traže pun misaoni angažman i pospešuju razvoj znanja i sposobnosti.

U internet učionici, ukoliko nastavnik koristi IKT alate metodički utemeljeno, postignuća učenika mogu odgovarati nivoima Blumove taksonomije. Nastavnik je taj koji, kada kreira nove sadržaje, mora da motiviše i aktivira učenike različitih sklonosti i sposobnosti [3]. Sadržaje mogu kreirati i učenici, pa će od toga zavisiti koji od alata i na kom nivou će biti upotrebljeni.

3. IKT ALATI ZA OBRADU GRADIVA

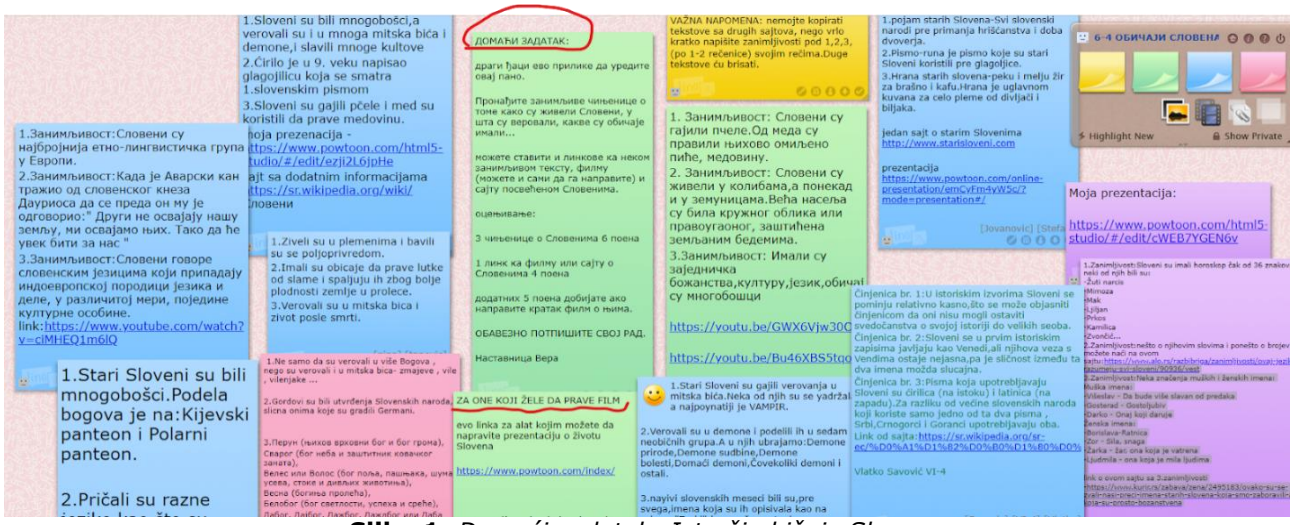
Veliki izazov je savladati nove nastavne sadržaje u onlajn okruženju [4]. Treba pronaći prave internet alate pomoću kojih će učenici sa lakoćom savladati novo i nepoznato gradivo. Svaki od alata može se koristiti kako za obradu nastavne jedinice, tako i za utvrđivanje, sistematizaciju, analizu. Izbor je na samom nastavniku i njegovoj organizaciji.

***Linoit* tabla** [5] je tabla sa stikerima i mogućnošću korišćenja drugih datoteka. Spada u najpovoljnije alate ove vrste zbog jednostavnosti primene, potpune analogije sa realnom tablom i udobnog korisničkog okruženja bez ograničenja u pogledu privatnosti, broja korisnika i tipova dokumenata. Nastavnik je može koristiti za postavljanje novog sadržaja, ili učenici za prezentovanje nekih svojih radova, koji mogu biti individualno ili grupno rađeni, čime se podstiče interakcija među učenicima i saradničko učenje. Njena primena je vrlo široka. Na tabli se mogu ređati raznobojni papirići promenljive veličine, slike, video-prilozi i druge datoteke. Dizajn table je prilagodljiv: menja se boja i veličina papirića, slova i same table. Popunjena ili tek započeta tabla može se ugraditi u veb-mesto i mogu se prezentovati rezultati saradnje, ili pozvati posetioci da postave priloge i komentare. Table mogu da budu privatne i javne, sa mogućnošću da drugi korisnici samo vide ili sami postavljaju stikere. Uz pomoć ove table mogu da se prikupljaju različite ideje, razvijaju debate ili diskusije na određenu temu, a u prilog se može dodati link ili zvučni zapis. Takođe, učenici mogu da naprave i veb poster.

Posebna vrednost ovog alata je što može da bude korišćen na različite načine:

- može se napraviti transparentan zadatak za učenike
- za grupni rad učenika
- za individualni istraživački rad

Primeri nekih takvih zadataka se mogu videti i na sledećim fotografijama:



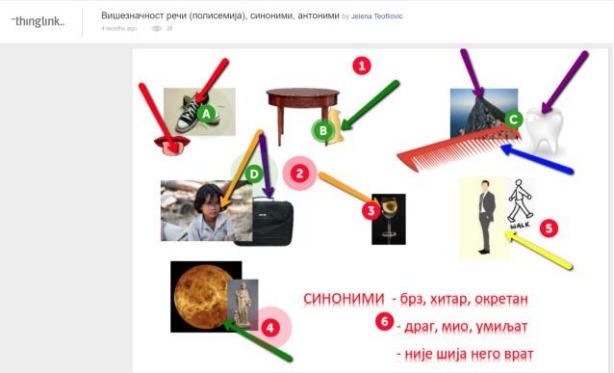
Slika 1: *Domaći zadatak: Istraži običaje Slovena*

Slika 2: *Domaći zadatak: napravi rad - zanimljivosti o Vikinzima*

Zadatke su radili učenici 6.razreda

Zadaci su bili istraživačkog karaktera i veoma je važno da učenici imaju jasno precizirane kriterijume ocenjivanja radova. Kriterijumi podstiču motivaciju učenika kao i samostalno vrednovanje svog rada.

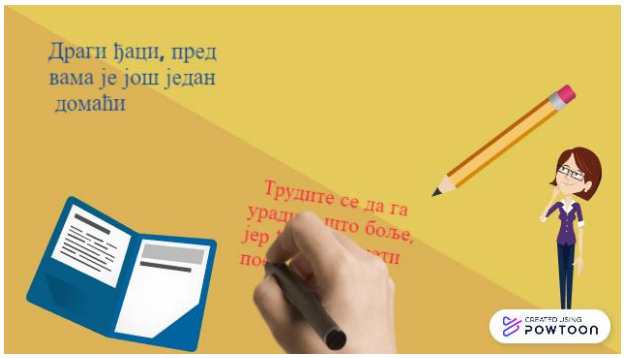
Thinglink [6] je alat u koji se može uvesti slika i na nju postaviti multimedijalne oznake. Slika postaje interaktivna kada nastavnik postavi informativnu sliku i na njoj svaki deo slike obogati dodatnim sadržajem. Na ovaj način učenici dobijaju rezime lekcije, pojašnjenje nekog problema, kao i najbitnije činjenice koje treba zapamtiti. Ovakvim sadržajem učenje postaje efikasnije i zanimljivije (slika 3) [4].



Slika 3: *Primer zadatka za vežbanje sinonima, koji je nastavnica dala učenicima, gde svaki broj otkriva novi zahtev ili neko dodatno objašnjenje za učenike*

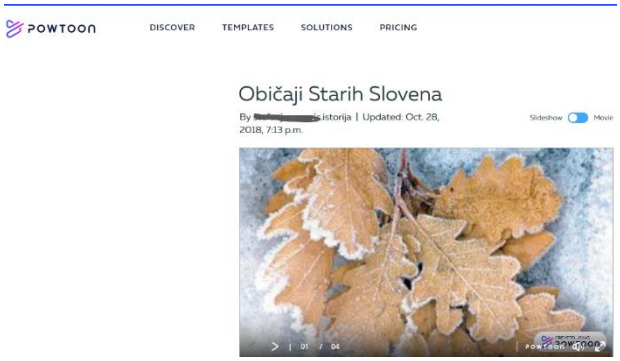
PowToon [7] je veoma lak alat kojim se mogu kreirati dinamične digitalne priče pomoću grafičkih objekata, teksta i muzike. Ovaj alat može biti koristan u obradi novog gradiva, jer se učenicima

kroz priču od nekoliko minuta prezentuju, uz pomoć slajdova ili kao video zapis, novi nastavni sadržaji.



Slika 4: *PowToon - Primer nastavničke prezentacije*

Ovaj alat je veoma pogodan za učeničke zadatke za pravljenje zanimljivih prezentacija. Primer učeničkog rada može se videti na sledećoj slici.



Slika 5: *PowToon - Primer učeničke prezentacije*

4. METODA IZOKRENUTA UČIONICA (*Flipped learning*)

Izokrenuta učionica je metod koji se sve češće pominje kao novi način rada u kojem se kombinuju prednosti tehnologije, ali se ne zanemaruje ni rad sa učenicima u učionici.

Suština ove metode je da se sadržaj, osnovne informacije koje je nastavnik do sada pričom na času prenosio učenicima (*ex cathedra*) više nije neophodan. Učenici kroz film do 10-tak minuta treba da saznaju sve osnovne činjenice o temi koja se obrađuje. Domaći zadatak podrazumeva gledanje filma i odgovaranje na pitanja iz upitnika i kreiranje mape uma kao sažetak naučenog. Ovakav način rada nije samo od koristi u nastavi na daljinu, već se vrlo efikasno može primeniti i u redovnoj nastavi. Čas onda može da se koristi za vežbu, rad u grupama na istu temu, vršnjačko učenje i sl. Čas služi da tema koja je rađena kroz domaći zadatak treba da bude provežbana na času. Učenici imaju prilike da budu aktivni učesnici u savladavanju gradiva, jer im je tema bar u osnovnom delu poznata.

Prednost ovakvog rada je što i učenici kod kuće mogu svojim tempom i u vreme koje njima odgovara da savladaju lekciju, koja nije duga, a često ni mnogo zahtevna.

Prednosti ovakvog načina rada su mnogostruki. Pokazalo se da je ovakav način rada vrlo uspešan i kod učenika sa slabijim postignućima, koji su nesigurni ili imaju smanjenu pažnju. Dodatna motivacija za njih je i to što mogu da se uključe u aktivnosti na času (debate, kvizove, grupne projekte).

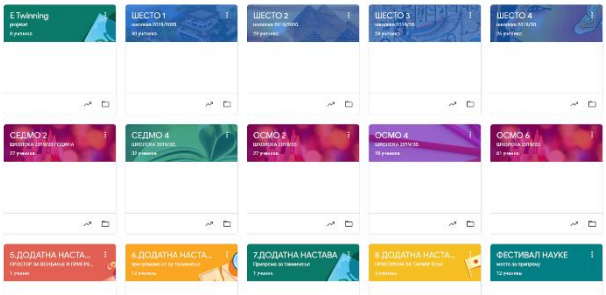
Metod izokrenute učionice međutim, od nastavnika zahteva poseban napor pripreme materijala koji će učenici proučavati kod kuće, sa specifičnim zadacima, ali takođe i pripremu scenarija za čas koji je po pravilu mnogo zahtevniji u organizacionom smislu, ali naravno i mnogo dinamičniji, jer se u toku časa može smenjivati više aktivnosti.

Osnovni koraci u kreiranju izokrenute učionice su:

1. Napraviti onlajn platformu za rad sa učenicima.

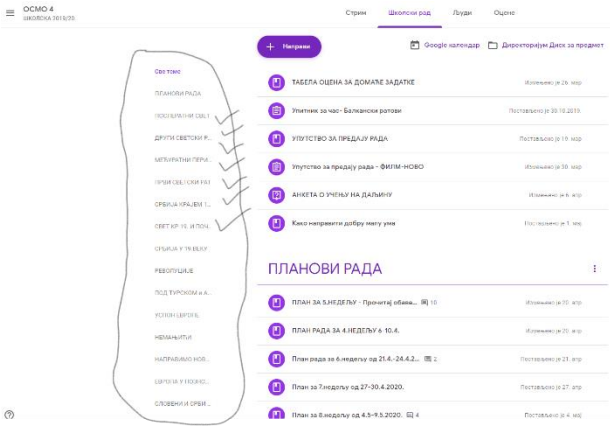
Na primer, korišćenjem Gugl učionice:

Svako odeljenje ima svoju učionicu koja je dostupna samo učenicima sa određenim kodom. Učionice se mogu koristiti za redovnu nastavu, dodatnu, sekcije i sl. (slika 6).



Slika 6: *Gugl učionice*

Tokom školovanja odeljenje ima samo jedan prostor, slika 7, gde se sa leve strane mogu videti teme koje su obrađivane tokom tri školske godine, a štiklirane su teme koje su obrađivane tekuće školske godine.

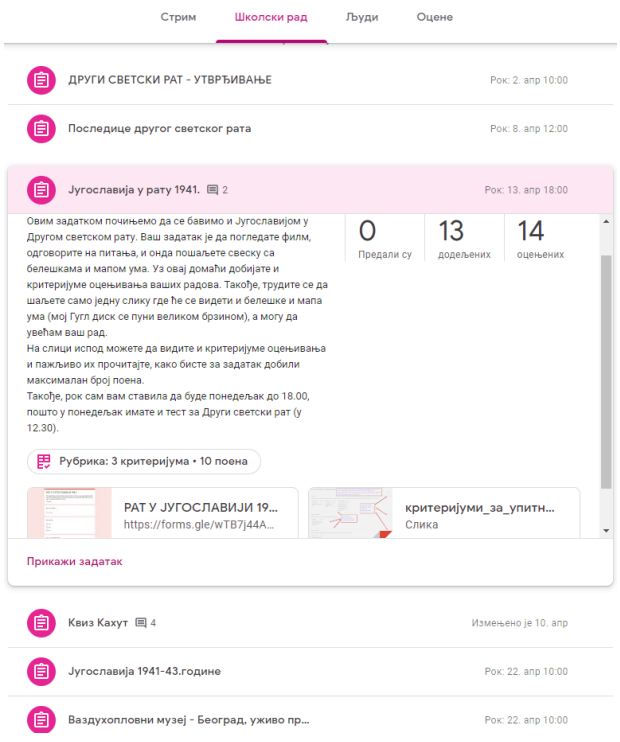


Slika 7: *Primer Gugl učionice jednog odeljenja*

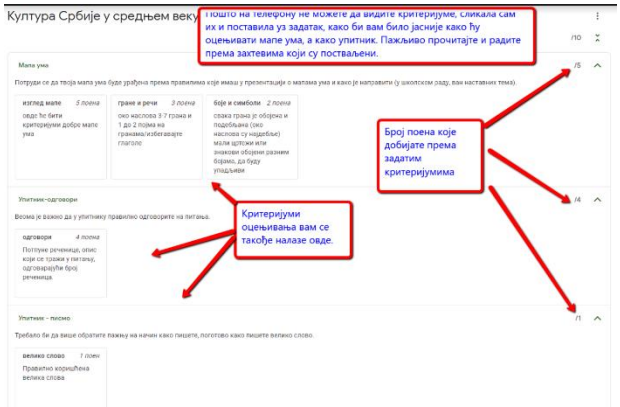
2. Napraviti zadatak za učenike (to može biti na primer kratak film sa pitanjima i beleškama u svesci).

Na slici 1.8. može se videti primer jednog zadatka sa uputstvom i obrazloženjem. Većina zadataka za obradu su slične sadržine: imaju kriterijume

ocenjivanja (slika 1.9) i Gugl upitnik u kojem se nalazi film koji je nastavnica snimila i nalazi se na njenom JuTjub kanalu sa три pitanja [8].

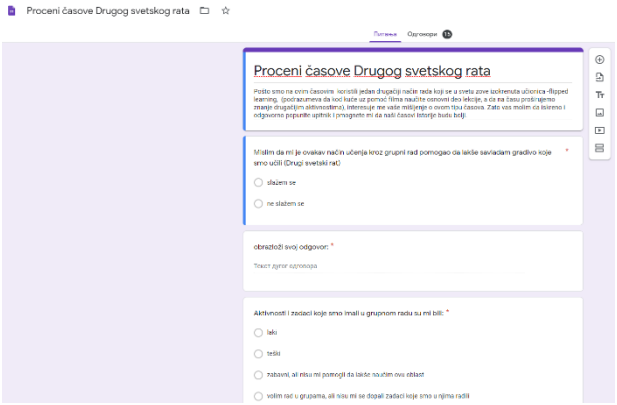


Slika 8: *Primer zadatka sa uputstvom i obrazloženjem*



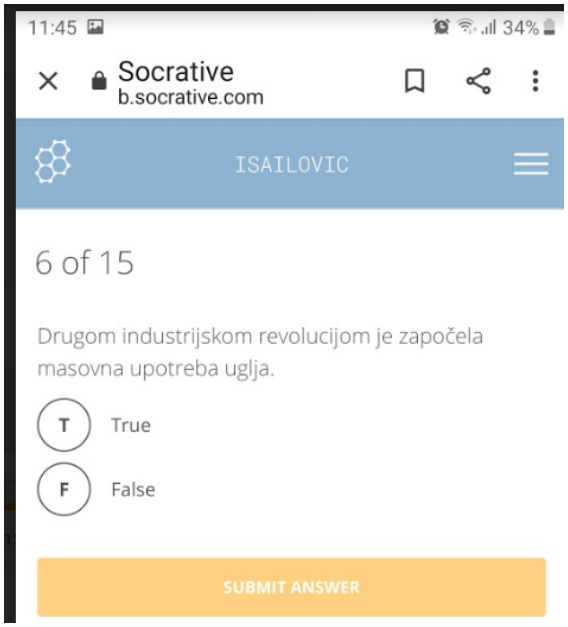
Slika 9: *Kriterijum ocenjivanja*

3. Pripremiti aktivnosti za čas (debata, kviz, proučavanje tekstova, igranje uloga i sl.)
4. Pripremiti evaluaciju tako organizovanih aktivnosti uz pomoć upitnika (slika 1.10).



Slika 10: *Evaluacija*

5. Proveriti znanje učenika nekim od onlajn alata (Sokrativ [9] je veoma jednostavan i koristan jer u svakom trenutku nastavnik na svom ekranu ima pregled šta učenici rade i koja pitanja rešavaju; pitanja su kod učenika različitim redom sortirana što smanjuje mogućnost prepisivanja) (slika 1.11)

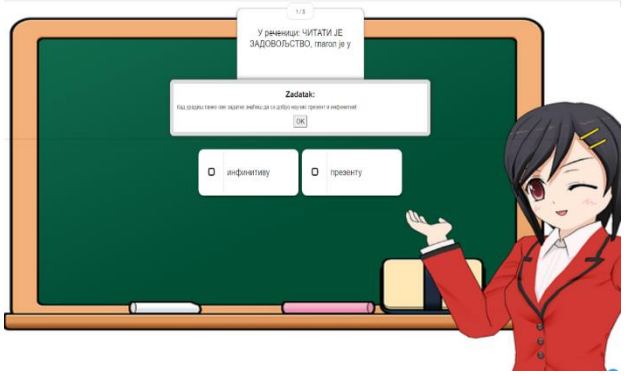


Slika 11: *Sokrativ alat za onlajn proveru znanja*

5. IKT ALATI ZA UTVRĐIVANJE I PROVERU ZNANJA

U onlajn nastavi pred nastavnicima je vrlo težak zadatak. Nije potrebno učenicima samo pomoći u savladavanju novog gradiva, već proveriti i vrednovati naučeno. Brojni su veb alati koji nastavnicima mogu biti od velike pomoći i u mnogome olakšati posao.

Learningapps [10] je alat koji u velikoj meri nastavnicima pomaže da na kreativan način sa svojim učenicima provežbaju obrađeno gradivo kroz razne kvizove poput Milionera, ukrštenih reči, povezivanja parova, linije vremena. Učenik vrlo lako i kroz igru sam proveri koliko je savladao naučeno i sam uviđa na kojoj oblasti bi morao više da radi. Na slici 12 je primer jednog vežbanja iz srpskog jezika.



Slika 12: *Learningapps - primer vežbanja iz srpskog jezika*

Wordwall [11] je još jedan veoma lak i dostupan alat koji pruža mogućnost da kroz igru (kviz, ukrštenica, vešala, bušenja balona, anagrama) učenik provežba naučeno. Prednost ovog alata jeste što nastavnik ima povratnu informaciju ko je, za koje vreme i koliko tačnih odgovora dao u postavljenom zadatku. U onlajn nastavi korišćenjem ovog alata nastavnik itekako ima povratnu informaciju o savladanosti gradiva. Jedna od mogućnosti provere u ovom alatu je kroz video-igricu. Naime, u zadatku učenici na balonima treba da pronađu sinonime, a zatim probuše balon (slika 13). U ovakvom radu pored znanja bitna je brzina, spretnost, koordinacija. Nastavnik dobija povratnu informaciju o broju tačnih odgovor, kao i vremenu koje je učenik uložio kako bi rešio zadatak.

Slika 13: *Wordwall – primer provere znanja kroz igricu*

Mindmaps [12] je elektronska mapa uma koja učenicima može poslužiti da naprave kratak rezime naučenog, a za nastavnika je to dodatna informacija da li učenik razume lekciju za koju je morao sam da istražuje i da se dodatno angažuje. Njihova primena je veoma široka, a najviše efekta ima kada treba ponoviti obrađeno gradivo.

Ocenjivanje učenika u nastavi na daljinu nije bio lak proces. Uglavnom se, pored znanja, vrednovala učenička aktivnost, angažovanje, kreativnost, ažurnost. Čini se da su sada te stvari došle više do izražaja, nego u redovnoj nastavi kada je korišćenje veb alata sporadično.

Za vrednovanje znanja korišćeni su **kvizovi kahoot, tricider, quizlet, sokrativ, gugl testovi, onlajn časopisi, linoit tabla kao poster, prezentacije**, što učenicima daje različite mogućnosti da ispolje svoje znanje. I na ovaj način nastava je mogla biti izvođena u timovima ili parovima što je bilo jako važno za samu saradnju i komunikaciju među učenicima, a čime je obezbeđena trenutno neophodna socijalna distanca.

6. ZAKLJUČAK

Neosporno je da je nastavnik nezamenljiv, ne samo za nastavu i vannastavne aktivnosti, već i za saradnju škole i društvene sredine, porodice i škole. Ovakvim načinom rada on se sve više oslobađa predavanja, a više se bavi planiranjem, pripremanjem, organizovanjem, vaspitanjem [2].

Nastava na daljinu uz pomoć različitih IKT alata i alata za e-učenje je bila test za svakog prosvetnog radnika da preispita svoje obrazovanje, usavršavanje i vidi da li može da ide u korak sa vremenom, da li je kadar da ispuni zahteve koji se pred njega stavljaju. Ne postavlja se pitanje da li škola može da funkcioniše bez nastavnika, on je važna figura u obrazovanju učenika, ali u savremenom svetu on nije dovoljan. Učenik je prevazišao nastavnika u pogledu informatičke pismenosti i zato nastavnici moraju biti dosledniji u pogledu ličnog usavršavanja u oblasti IKT nastave. Sve manjkavosti u vreme nastave na daljinu došle su do izražaja i zato su pojedini učenici ostali uskraćeni za znanje na koje su imali pravo. Nekoliko IKT alata prethodno navedenih u ovom radu su pre svega besplatni i veoma laki za upotrebu. Na nastavniku je da pokaže samo malo volje, želje i angažovanja da ovlada njima i tako u velikoj meri oplemeni nastavni proces i učini ga interesantnijim za svoje učenike.

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[11] https://wordwall.net/play/2280/731/193

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Simpozijum *"Tehnika i informatika u obrazovanju: Nastavnici za nastavnike"*
Stručni rad
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Upis učenika u srednje škole za vreme epidemije COVID 19

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Rezime: *U ovom radu je prezentovano istraživanje koje je imalo za cilj da utvrdi kakva je raspodela učenika u srednje škole za vreme pandemije Covid 19 u zavisnosti od iskazane liste želja. U grupi za istraživanje bilo je 236 učenika iz dve osnovne škole. Podaci su dobijeni sa tehničkog sajta Ministarstva prosvete.Rezultati ovog istraživanja daju značajne podatke srednjim školama za dalje planiranje upisa učenika i drugih neophodnih aktivnosti koje treba da podrže proces integracije obrazovnih profila u srednje stručno obrazovnje.*

Ključne reči: *upis učenika; srednje škole;obrazovni profili.*

Enrollment of Students in High Schools During the Epidemic COVID 19

Abstract: *This paper presents a research that aimed to determine the distribution of students in high schools during the Covid 19 pandemic, depending on the expressed wish list. There were 236 students from two primary schools in the research group. The data were obtained from the Technical website of the Ministry of Education. The results of this research provide significant data to secondary schools for further planning of student enrollment and other necessary activities that should support the process of integrating educational profiles into secondary vocational education.*

Keywords: *student enrollment; high school, educational profile.*

1. UVOD

Svi učenici koji završe osnovnu školu i polože završni ispit mogu da nastave školovanje kroz srednjoškolsko obrazovanje. Pored srednjih stručnih škola postoje još i Gimnazija i umetničke škole. Svi učenici stariji od 17 godina mogu da obave upis u srednju školu i kao vanredni učenici, dok mlađi od 17 godina upisuju srednju školu kao redovni učenici. Srednja škola nije obavezna.

Rangiranje učenika prilikom upisa u srednju školu vrši se na osnovu bodova ostvarenih uspehom tokom školovanja (maksimalno 60) i bodova stečenih na maloj maturi (maksimalno 40). Za upis u specijalizovane srednje škole prilikom rangiranja uzimaju se i bodovi koje su učenici stekli učestvovanjem i osvajanjem nagrada na nekom od takmičenja na državnom ili međunarodnom nivou [1].

Ukupan broj bodova koji se razmatra prilikom upisa u srednju školu ostvaruje se na osnovu uspeha u školi i bodova koje nosi mala matura. Na osnovu uspeha u školi moguće je ostvariti ukupno 60 bodova, dok mala matura nosi maksimalno 40 bodova.

Bodovi koji se dobijaju za uspeh računaju se na sledeći način:

- uspeh iz šestog, sedmog i osmog razreda množi se sa četiri,
- sabiranjem ova tri broja dobija se iznos bodova za uspeh u školi.

Procedura upisa u srednje škole

Nakon objavljenih rezultata završnog ispita, svaki učenik izračunava broj bodova sa kojima konkuriše za upis u neku od škola. Naredni korak je sastavljanje liste želja gde svaki učenik upisuje školu i profil za koji je pokazao najviše interesovanja. Kao prvu želju učenici unose profil za koji imaju najviše interesovanja, druga želja je profil za koji su manje zainteresovani, treći još manje itd. Redosled napisanih škola je bitan, jer će

učenik biti raspoređen u prvu školu za koju bude imao dovoljno bodova.

2. ORGANIZACIJA ISRAŽIVANJA

Predmet ovog istraživanja su želje učenika osnovnih škola i njihova raspodela u srednje škole.

U cilju prikupljanja podataka korišćen je sajt Ministarstva prosvete nauke i tehnološkog razvoja. Istraživanje je obavljeno u junu 2020. godine. Istraživanjem su obuhvaćene dve osnovne škole u opštini Ivanjica (236 učenika). Analiza istraživanja sastoji se iz dva dela: iskazane želje učenika i njihova raspodela po obrazovnim profilima i smerovima Gimnazija. [2]

3. REZULTATI ISTRAŽIVANJA

U cilju boljeg sagledavanja upisa učenika u srednje škole urađena je osnovna statistička analiza, gde je u prvom koraku sprovedena statistička analiza po iskazanim željama učenika zatim alaniza prema njihovoj raspodeli po određenim profilima i smerovima.

Posmatrani uzorak čine učenici dve osnovne škole u opštini Ivanjica. Ukupan broj učenika u obe škole je 236. U OŠ "Milinko Kušić" 136 učenika i OŠ "Kirilo Savić" 100 učenika.

Nakon objavljenih rezultata završnog ispita, usledilo je sastavljanje liste želja gde svaki učenik upisuje školu i profil za koji je pokazao najviše interesovanja. Kao prvu želju učenici unose profil za koji imaju najviše interesovanja, druga želja je profil za koji su manje zainteresovani, treći još manje itd. Redosled napisanih škola je bitan, jer će učenik biti raspoređen u prvu školu za koju bude imao dovoljno bodova.

Opština Ivanjica ima dve srednje škole: Tehničku školu i Gimnaziju. Tehnička škola Ivanjica ima pet obrazovnih profila:

- Ekonomski tehničar (IV stepen-30 učenika),
- Mašinski tehničar za kompjutersko konstruisanje (IV stepen-30 učenika),
- Tehničar za oblikovanje nameštaja I enterijera (IV stepen-30 učenika),
- Modni krojač (III stepen-30 učenika),
- Konobar – kuvar (III stepen-30 učenika) [3].

Gimnazija ima dva smera: opšti tip i smer za učenike sa posebnim sposobnostima za računarstvo i informatiku.

3.1 Analiza liste želja učenika osnovnih škola po obrazovnim profilima i smerovima

Analizirajući iskazane liste zelja učenika može se zaključiti da je najveći broj učenika pokazao interesovanje za Gimnaziju opšti tip. Na drugom mestu je profil Ekonomski tehničar u Tehničkoj školi u opštini Ivanjica. Zatim sledi smer IT u Gimnaziji. Na četvrtom mestu je profil Mašinski tehničar za kompjutersko konstruisanje, a potom Tehničar za oblikovanje nameštaja i enterijera. Nešto manje iskazanih želja odnosi se na profile sa trećim stepenom.

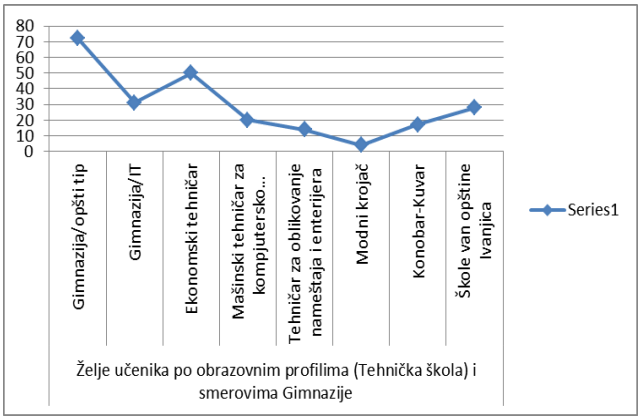
Takođe je bitan podatak da je skoro ceo jedan razred učenika iskazao želju za školovanjem van opštine Ivanjica.

Kako se upis učenika odvija za vreme epidemije Covid 19 odliv učenika u ovom broju nije očekivan. Tabela 1., daje prikaz liste želja učenika osnovne škole.

Tabela 1. *Prikaz liste želja učenika osnovne škole*

Želje učenika po obrazovnim profilima (Tehnička škola) i smerovima Gimnazije								
Gimnazija/opšti tip	Gimnazija/IT	Ekonomski tehničar	Mašinski tehničar za kompjutersko konstruisanje	Tehničar za oblikovanje nameštaja i enterijera	Modni krojač	Konobar-Kuvar	Škole van opštine Ivanjica	Ukupan broj učenika
72	*31*	*50*	*20*	*14*	*4*	*17*	*28*	236

Analiza liste želja učenika osnovnih škola po obrazovnim profilima i smerovima urađena je na osnovu iskazane prve želje. Na Slici 1., dat je grafički prikaz liste želja učenika ocnovne školi.



Slika 1. *Grafički prikaz liste želja učenika ocnovne škole*

3.2. Analiza rapodele učenika osnovnih škola po obrazovnim profilima i smerovima

Nakon predavanja liste želja, učenici se raspoređuju u srednje škole.

Analizirajući raspodelu učenika prema ostvarenom broju bodova i predviđenim kvotama za upis u srednje škole došlo se do sledećih podataka.

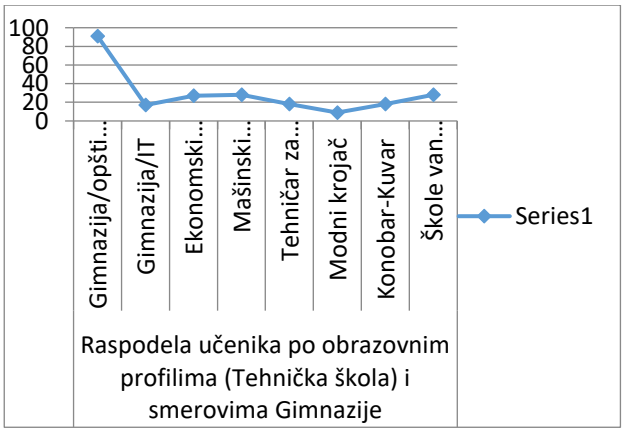
Prema podacima o raspodeli učenika u srednje škole može se videti da je najveći broj učenika upisao opšti smer Gimnazija. Smer IT u Gimnaziji upisao je manji broj učenika u odnosu na iskazane želje. Obrazovni profil Ekonomski tehničar i Mašinski tehničar za kompjutersko konstruisanje upisali su maksimalan broj učenika. Tehničar za oblikovanje nameštaja i entrijera nalazi se na trećem mestu izabranih profila. Kada se govori o obrazovnim profilima trećeg stepena vidi se da veoma malo interesovanje učenici pokazuju za profil Modni krojač. Nešto veće interesovanje pokazali su za profil Konobar-Kuvar.

Kao što je već navedeno veliki broj učenika nastaviće školovanje van Ivanjice [4].Prikaz raspodele učenika po obrazovnim profilima i smerovima prikazan je sledećom tabelom (Tabela 2.).

Tabela 2. *Prikaz raspodele učenika u srednje škole*

Raspodela učenika po obrazovnim profilima (Tehnička škola) i smerovima Gimnazije								
Gimnazija/opšti tip	Gimnazija/IT	Ekonomski tehničar	Mašinski tehničar za kompjutersko konstruisanje	Tehničar za oblikovanje nameštaja i enterijera	Modni krojač	Konobar-Kuvar	Škole van opštine Ivanjica	Ukupan broj učenika
91	*17*	*28*	*27*	*18*	*9*	*18*	*28*	236

Na slici 2. je dat prikaz raspodele učenika po obrazovnim profilima i smerovima



Slika 2. *Grafički prikaz raspodele učenika po obrazovnim profilima i smerovima*

3.3 Uporedna analiza liste želja i raspodele učenika u srednje škole

Analizirajajući listu želja i raspodelu učenika po obrazovnim profilima i smerovima došlo se sledećih podataka.

Gimnaziju/opšti tip upisalo je 12 učenika više nego što se izjasnilo na listi želja. Gimnaziju/ IT upisalo je 14 učenika manje u odnosu na njihovu iskazanu želju. Smer Ekonomski tehničar upisalo je 22 učenika manje. Prikazom liste želja 50 učenika se izjasnilo za ovaj profil.

Profil Mašinski tehničar za kompjutersko konstruisanje upisalo je 27 učenika a na listi želja bilo je njih 20.Ovde se misli da je 7 učenika upisano sa drugom željom.

Tri učenika više u odnosu na listu želja upisalo je smer Tehničar za oblikovanje nameštaja i enterijera. Takođe ovim učenicima ovo je bila druga želja.

Obarzovni profil Modni krojač upisalo je 5 učenika više u odnosu na iskazanu listu želja. Obrazovni profil Konobar-Kuvar upisalo je jedan učenik više u odnosu na iskazanu listu želja.

Može se zaključiti da je kod većeg broja obrazovnih profila i smerova učenicima ispunjena prva zelja. Za profil Ekonomski tehničar situacija je nešto drugačija. Veliko interesovanje i velika konkirencija kod učenika dovelo je do toga da 22 učenika ne budu rasporedjena u ovaj profil. Oni su kao drugu želju uglavnom naveli Gimanziju opšti tip i Profil Mašinski tehničar za kompjutersko konstruisanje gde su i rasporedjeni.

Svi učenici koji su iskazali interesovanje za školovanje van opštine Ivanjica na listi zelja tako su i rasporedjeni. Uglavnom se odnosi na prvu želju.

Kada analiziramo odliv učenika sa teritorije opštine Ivanjica mođemo zaključiti da je najveće interesovanje za profilima u Medincinskim školama, Saobraćajnim školama kao i Turističko-hotelijerskim školama.

S'toga je veoma bitno da se u narednoj školskoj godini Tehničkoj školi u Ivanjici odobri profil Turistički tehničar, kako bi se smanjio odliv učenika sa teritorije opštine ivanjica.

Kao srednja stručna škola Tehnička škola okrenuta je osposobljavanju učenika za rad. Praktične veštine neophodne za obavljanje poslova, učenici stiču u virtuelnim preduzećima. U virtuelnim preduzećima se simuliraju poslovi stvarnih preduzeća, a obavljajući ove poslove učenici stiču praktična znanja i veštine neophodne za njihovo buduće zanimanje. Kroz simulaciju poslovanja učenici imaju priliku da povežu znanja stečena u okviru pre svega stručnih, ali i opšteobrazovnih predmeta i na taj način dobiju celovitu sliku o svom profilu i budućem zanimanju [5].

Takođe učenici obrazovnog profila Turistički tehničar u okviru stručnih predmeta imaju veliki broj časova praktične nastave i blok nastave gde se osposobljavaju da obavljaju poslove u turističkim agencijama i na poslovima recepcije. Takođe, učenici imaju mogućnost da usavrše stečena znanja i dobro se pripreme za buduće poslove u svom zanimanju. Sve gore navedeno govori nam da je opštini Ivanjica i Tehničkoj školi profil Turističi tehničar ili Turističko hotelijerski tehničar od veoma velikog značaja [6].

4. ZAKLJUČAK

Rezultati istraživanja predstavljeni u ovom radu treba da pruže dodatne informacije, koje bi doprinele unapređenju i poboljšanju upisa učenika u srednje škole. Ovde se prevashodno misli na obrazovne profile u Tehničkoj školi.

Kada se izvrši uporedna analiza iskazane liste želja za profil Ekonomski tehničar u odnosu na raspodelu učenika može se zaključiti da je duplo više učenika bilo zaintereovano za navedeni profil u odnosu na predviđenu upisnu kvotu.

Kako bi se samnjio odliv učenika predlog je vratiti neka zanimanja u srednju stručnu školu. To se pre svega odnosi na profil Turistički tehničar ili Turističko–hotelijerski tehničar. Prema ranijim istraživanjima interesovanje za ovim profilom je veliko. Kako je Ivanjica turističko mesto potreba za navedenim profilom je zaista opravdana. Takođe može se zaključiti da su drvna i teksilna industrija veoma značajne za opštinu Ivanjica, stoga je veoma bitno da se upis učenika za navedena područja rada znatno poboljša.

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Simpozijum *"Tehnika i informatika u obrazovanju: Nastavnici za nastavnike"*

Stručni rad
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Onlajn nastava u mlađim razredima osnovne škole

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Rezime: *Globalni problemi u svetu izazvani pandemijom virusa KOVID-19, izmestili su nastavni proces iz učionica u onlajn okruženje. U ovom radu će biti prikazana organizacija nastave u mlađim razredima osnovne škole upotrebom video konferencijske platforme. Kvalitet onlajn nastave u velikoj meri zavisi od tehničke opremljenosti nastavnika i učenika, digitalnih kompetencija nastavnika i pružanja podrške roditelja. Cilj rada je da se podstakne što kvalitetnija digitalna uključenost učitelja kroz upotrebu video konferencijske tehnologije u nastavnom procesu.*

Ključne reči: *onlajn nastava, nastavnik, učenik, roditelj.*

Online Teaching in the Younger Grades of Primary School

Abstract: *Global problems in the world caused by the KOVID-19 virus pandemic have shifted the teaching process from classrooms to the online environment. This paper will present the organization of teaching in the younger grades of primary school using a video conferencing platform. The quality of online teaching largely depends on the technical equipment of teachers and students, digital competencies of teachers and the provision of parental support. The aim of this paper is to encourage the highest quality digital involvement of teachers through the use of video conferencing technology in the teaching process.*

Keywords: *online teaching, teacher, student, parents.*

„Teaching should be such that what is offered is perceived as a valuable gift and not as hard duty. "

Albert Einstein

„Poučavanje treba biti takvo da ono što je ponuđeno učini vrednim darom, a ne napornom dužnošću."

Albert Ajnštajn

1. UVOD

Elektronsko učenje podrazumeva proces pružanja podrške učeniku, i zajedno sa tradicionalnom nastavom ima za cilj postizanje određenog ličnog napretka učenika kao pojedinca ili čitave određene grupe. Sam proces učenja na daljinu može se ostvariti u neposrednom kontaktu, telefonskim putem kao i upotrebom internet tehnologija.

U mlađim razredima osnovne škole u našem sistemu školovanja učenje na daljinu se retko koristi, iako se u nekim državama ta ideja, zasnovana još 70-tih godina prošlog veka, uveliko primenjuje. Proces digitalizacije škola u Srbiji je u toku, ali pojava pandemije Korona virusa isključila je tradicionalnu školu i nastava je ostala da se realizuje samo na daljinu, što je izazvalo niz problema koji se najvećim delom ogledaju u neposedovanju učenika sa odgovarajućim hardverskim uređajima i internet konekcijom. Pri tome, takav vid nastave je stavio pred prosvetne radnike veliku dilemu - šta i kako raditi u nastaloj situaciji? Većina nastavnika je svesna da nema dovoljno razvijene digitalne kompetencije, da za potrebe nastave učenja na daljinu mora koristiti svoje lične IT uređaje, a pre svega najveći problem je kako organizovati nastavu i kako komunicirati sa učenicima i roditeljima. Veoma brzo se shvata da je uloga nastavnika mentorska, a da uloga roditelja u obrazovanju njihove dece postaje nezaobilazna i veoma važna.

Ako se polazi od pretpostavke da je učenicima u mlađim razredima najpristupačniji metod koji daje

najbolje rezultate rada metod žive reči, otuda se dolazi do zaključka da je nastava koja je organizovana putem video konferencije bila najbolje rešenje u situaciji kada je bila isključena mogućnost realizacije nastave kroz uobičajeni nastavni proces u školi.

2. ONLINE NASTAVA

Danas kada imamo ubrzan napredak i upotrebu modernih tehnologija u svim sferama života kao i u obrazovnim tehnologijama, konkretno razvoj virtuelnih tehnologija, nudi nove mogućnosti u komuniciranju među učesnicima u obrazovanju, ali i potrebu brze implementacije u pedagošku praksu.

Hronološki, razvojni put učenja na daljinu, prema Tejlorovoj paradigmi modela obrazovanja na daljinu, [1] kreće se kroz pet generacija:

Model dopisivanja - Predstavlja najstariji model učenja na daljinu i koristi se od druge polovine devetnaestog veka. Razvoj poštanskog sistema i štampane reči omogućio je i razvoj učenja na daljinu.

Multimedijalni model - Pojavom radija, televizije i audio traka, računarskih disketa, didaktičkih programa krajem šezdesetih i početkom sedamdesetih godina prošlog veka, omogućeno je kombinovanje više medija istovremeno (slika, zvuk, animacija, video itd.). Predavač i učenik su i na taj način bili u mogućnosti da komuniciraju.

Telekomunikacioni model - Karakteriše ga mogućnost interakcije među polaznicima, koji su fizički udaljeni i odvija se dvosmerno ili jednosmerno. Najpopularniji oblik ovakvog vida obrazovanja na daljinu je video konferencija.

Model fleksibilnog učenja - Razvoj interneta, prvenstveno veba, polaznicima omogućava komunikaciju na različite načine, jer postoji mogućnost da se koriste dostupni multimedijalni resursi, a ovakav vid nastave omogućava interaktivnost, kolaboraciju i nelinearnost u samom procesu učenja, jer postoji širok spektar resursa koji su dostupni i laki za korišćenje.

Model inteligentnog fleksibilnog učenja - U korišćenju ovog modela, postoji mogućnost da se putem interneta koriste inteligentni sistemi koji olakšavaju proces učenja na daljinu.

Sam proces razvoja učenja na daljinu obuhvata 4 nivoa:

Prvi nivo podrazumeva elementarnu digitalnu pismenost nastavnika i učenika, kako bi mogli da korenspondiraju putem e-pošte, društvenih mreža, ili da čitaju štampane materijale.

Drugi nivo obuhvata razvijen hardver i programe kako bi učenici mogli da uče individualno na neumreženim računarima, ili pak da preko umreženih računara koriste veb alate i sisteme za učenje na daljinu.

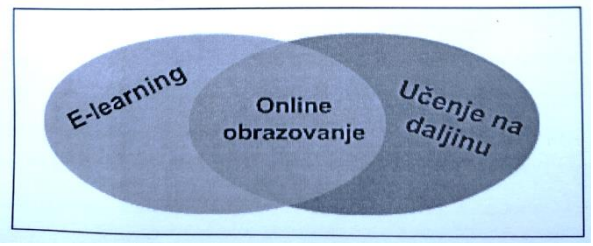
Treći nivo podrazumeva osavremenjavanje postojećih alata koji se koriste u nastavi za uvežbavanje gradiva i upotrebu alata kojima se obezbeđuje društveno umrežavanje i samousmereno učenje.

Četvrti nivo omogućava mogućnost da se preuzimaju edukativni materijali kao i mogućnost da se kreiraju sadržaji za učenje, interakciju i diskusiju među polaznicima.

Kraj dvadesetog veka donosi promene u učenju uz pomoć računara, pa se na taj način pojavljuje i termin elektronsko učenje ili e-učenje (eng. *e-learning*) koje nudi širok spektar mogućnosti i neograničene resurse koji se koriste za izradu multimedijalnih obrazovnih sadržaja. Postojanjem mogućnosti da internet bude svima dostupan, učenik je pomoću računara i interneta u svom obrazovanju na jednostavan način mogao da pristupi resursima za učenje. Tradicionalan način obrazovanja je upotpunjen upotrebom savremenih tehnologija. Shodno tome, nije neophodno da postoji direktan kontakt između nastavnika i učenika kako bi se taj proces odvijao, već je postojala mogućnost da se proces učenja odvija i u indirektnom kontaktu, odnosno upotrebom savremenih IT tehnologija.

Iz tog razloga, postoji potreba da se sve češće koristi termin „udaljeno" obrazovanje (eng. „*Distance Education*") ili „učenje na daljinu", a osim ovih, koriste se i termini *Distance Learning*, *Distance Training*, *Distance Education*, *Online Education*, *Virtual Instruction*, *Virtual Education*.

Svi ovi termini imaju zajedničku karakteristiku jer su zasnovani na činjenici da su izvori znanja i primaoci znanja fizički razdvojeni, a na sam kvalitet procesa učenja utiče način na koji se koriste savremene tehnologije, kao i mogućnost da svi korisnici imaju pristup internetu. U tom slučaju je reč o onlajn učenju (*sl. 1*). Osim toga, nije nužno da nastavnik i učenik moraju da budu fizički razdvojeni da bi se proces učenja na daljinu ostvario, jer postoji i mogućnost da budu u istoj prostoriji i da se koristi neki od interaktivnih programa.



Slika 1: *Učenje na daljinu*

2.1. Onlajn nastava u mlađim razredima

Sve do uvođenja sistema video konferencija, zajednička karakteristika svih prethodnih sistema jeste da su bili jednosmerni i asinhroni. Učenici, slušaju ili gledaju obrazovne materijale, ali ni na koji način nisu bili u mogućnosti da direktno

postave pitanje nastavniku ili da razmene mišljenja sa učesnicima koji na drugom mestu prate isto predavanje.

Obrazovanje na daljinu u Srbiji kasni u odnosu na neke druge zemlje u Evropi i svetu. Započelo je kroz mogućnost podrške na projektima *Tempus* ili *WUS*. Ministarstvo spoljnih poslova Republike Austrije pružilo je značajnu stručnu i finansijsku podršku programu za razvoj e-učenja u Srbiji. Najpre su fakulteti i kompanije uvele neke od tehnologija e-učenja. Srednje i osnovne škole u Srbiji doživljavaju proces digitalizacije infrastrukturnim projektima, umrežavanjem škola, primenom novih tehnologija u nastavi i uvođenjem koncepata rada na sopstvenom uređaju.

Učenje na daljinu je propisano Zakonom o osnovama sistema obrazovanja i vaspitanja [2] i shodno tome učenici koji nisu u mogućnosti da pohađaju redovnu nastavu, tu mogućnost, koju nudi zakonski okvir, mogu da iskoriste. Takav uslov se stekao usled pandemije virusa COVID-19 pri čemu se u Republici Srbiji prešlo na onlajn nastavu. U takvim okolnostima, osim nastave koju su učenici pratili preko TV-a, korišćene su i određene platforme i aplikacije.

Koronavirus i vanredno stanje izmestili su nastavu iz učionice na TV i u domove učenika.

Nastavnici su komunicirali sa njima, držali časove i slali domaće zadatke. Tako je nova adresa obrazovanja u Srbiji postala - Virtuelni svet, a u svemu tome značajnu kariku u procesu obrazovanja činili su i roditelji.

Odluke o načinu realizacije nastave i rada nastavnika u vanrednim okolnostima zavise prvenstveno od preporuka Vlade Republike Srbije, resornog ministarstva (MPNTR), a zatim i od tehničkih mogućnosti da se ovakav vid nastave realizuje. Sam proces realizacije i prilagođavanja, uslovljen je tehničkom opremljenošću nastavnika i učenika potrebnim uređajima, uzrastom učenika i pružanjem podrške roditelja. Akteri u obrazovanju (učenik, nastavnik, roditelj) ubrzo su uvideli da tehnologija može da pomogne u procesu učenja i podučavanja. U onim školama u kojima je nastava bila organizovana putem sajta, bloga, *Viber* grupe, *Google Classroom*-a, mejla i sl, izostali su vizuelni i auditivni kontakti, interakcija učenika i nastavnika kao i međusobna interakcija učenika tipična za učioničku nastavu. Još jedan nedostatak ovakvog načina komuniciranja sa učenicima jeste i izostanak povratne informacije koje nastavnik šalje učenicima o stepenu napredovanja. Pojavile su se i poteškoće u ocenjivanju, kako u formativnom, tako i sumativnom smislu.

Sa druge strane, škole i pojedini nastavnici koji su se opredelili za način uspostavljanje sistema onlajn nastave pomoću određenih platformi, a shodno razvojnim karakteristikama učenika mlađih razreda osnovne škole, imali su poteškoću u tehničkom pristupu video konferencijskoj nastavi. Kako učenici mlađeg školskog uzrasta ne poseduju informatičke i digitalne kompetencije na nivou koji je potreban za rad na pomenutim platformama i aplikacijama, neophodna je bila i pomoć roditelja jer je rad na takvim platformama podrazumevao da učenik/roditelj ume da se registruje, prijavi, instalira pristup platformi, preuzme materijal koji mu je nastavnik poslao i da ga koristi u svrhu učenja. Uprkos početnim poteškoćama koje su se pojavile usled tehničkih prepreka, učenici su se veoma brzo prilagodili i osamostalili u korišćenju računara, samom radu na platformi i bezbednom korišćenju interneta u obrazovne svrhe.

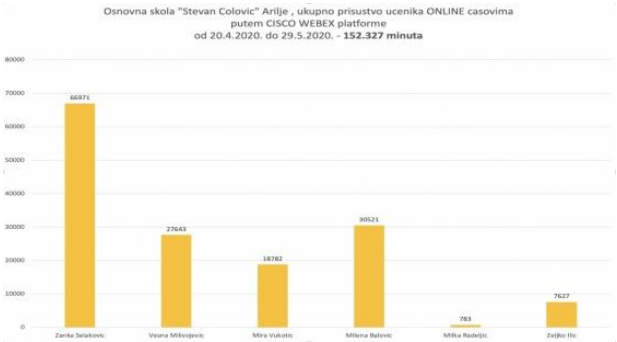
Razlika između ova dva pristupa realizacije nastave indiretknog (sajt, blog, mejl, viber…) i video konferencijske nastave jeste u tome što u drugom slučaju postoji direktna komunikacija sa učenicima na relaciji učenik-nastavnik i učenik-učenik, kao i mogućnost da se vrši kontinuirano praćenje napretka učenika i ocenjivanje. Jedna od takvih, efikasnih platformi, ne tako zahtevna za instalaciju i rad na njoj, jeste i platforma *Cisco Webex Meetings* [3].

Cisco Webex Meetings je praktična platforma koja omogućava direktnu komunikaciju i interakciju korisnika. Za njeno korišćenje neophodno je posedovanje računara/tableta/mobilnog telefona i interneta. Pruža mogućnost da se platformi pristupi sa bilo koje lokacije. Sam proces instaliranja aplikacije, iako je za učenike jednostavan, zahteva pomoć roditelja. Može da se instalira preko *Google Play* prodavnice. Potrebno je da nastavnik instalira na svom uređaju *Cisco Webex Meetings* i po dobijanju personalnog broja (ili *URL* adrese) deli dobijeni broj sa učenicima na osnovu kog oni prilikom instaliranja na svojim uređajima ukucavaju dobijeni broj kako bi pristupili virtuelnoj učionici (*personal room*) nastavnika. Uloga nastavnika se sastoji i u tome da pripremi materijal za rad koji će koristiti na samom času. (*pdf* dokumenta, *word* dokumenta, *ppt*, *youtube*, obrazovni digitalni alati za učenje na daljinu…). U toku držanja onlajn časa, koristi se kamera i mikrofon što, stvara atmosferu realne učionice, iako učenici i nastavnik nisu u istom prostoru (*sl. 2*).

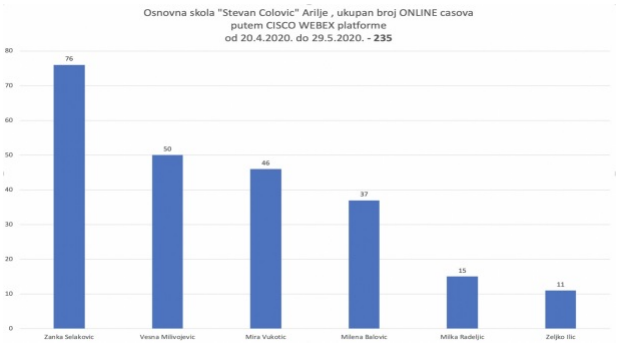
Slika 2: *Onlajn čas koji se održava preko Cisco Webex Meetings-a*

Jedna od karakteristika *Cisco Webex Meetings*-a je ta što je nastavnik na kraju svake nastavne nedelje dobija statističke podatke o realizovanim onlajn časovima – ukupno prisustvo učenika onlajn časovima (*sl. 3*), ukupan broj onlajn časova (*sl. 4*),

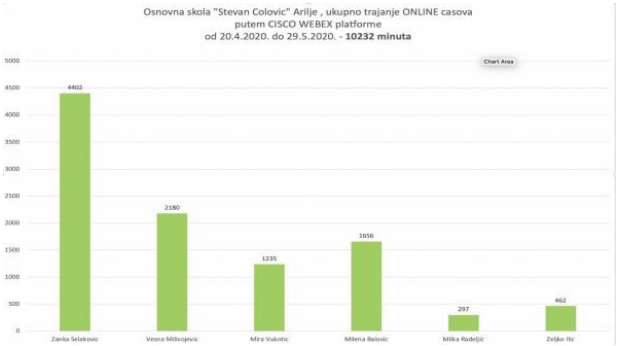
ukupno trajanje onlajn časova (*sl. 5*)... Na taj način se dobija kompletna slika o tome koliko su sami nastavnici, a i učenici bili aktivni na onlajn časovima.



Slika 3: *Ukupno prisustvo učenika onlajn časovima*



Slika 4: *Ukupan broj onlajn časova*



Slika 5: *Ukupno trajanje onlajn časova*

Još jedna od prednosti korišćenja *Cisco Webex Meetings*-a je i ta što je proces praćenja, napredovanja, vrednovanja i ocenjivanja učenika kontinuiran.

Jedan od načina da se učenici ocenjuju jeste i upotreba *Google* testova koje nastavnik kreira, a koji učenici rešavaju za vreme onlajn časa dok su kamere i mikrofoni uključeni, pa je obezbeđen i stepen validnosti i objektivnosti u proveri znanja. Po urađenom testu, učenici istog trenutka dobijaju povratnu informaciju kako su savladali određeno gradivo, a pomoću komentara nastavnika i kroz razrednu diskusiju o postignućima se obezbeđuje objektivno vrednovanje i prati se napredovanje učenika. Ponderi u testu se lako pretvaraju kroz procente u ocene i na taj način se ocenjuje u skladu sa važećim pravilnikom.

Iako na internetu postoji mnogo video konferencijskih platformi, *Cisco Webex Meetings* je platforma koju su učitelji u Srbiji imali mogućnost da koriste za vreme vanrednog stanja kad je bila doneta odluka da se obustavi redovna nastava i pređe na nastavu na daljinu. Predstavlja jedan od najsavremenijih modela komunikacije, planiranja, organizacije i realizacije nastave, i nudi mnoge mogućnosti da se uz direktnu video vezu sa učenicima koriste i mnogobrojni digitalni alati, a učenici su motivisani i angažovani za vreme onlajn časova. Još jedna od pogodnosti korišćenja ove platforme jeste i visok stepen bezbednosti dece na internetu, jer nije potrebno da deca mlađeg školskog uzrasta direktno koriste mejl (osim pri instaliranju, a i to rade uz pomoć i prisustvo roditelja). Nastavnik u svakom trenutku onlajn časa ima mogućnost da nadzire učenike, pa je stepen bezbednosti na visokom nivou, što predstavlja još jednu karakteristiku *Cisco Webex Meetings*-a i olakšava proces realizacije nastave na daljinu.

Učenici u bilo kom trenutku mogu uzeti učešće ili napustiti nastavu bez ometanja ostatka grupe. Takođe, mogu komunicirati i postavljati pitanja učitelju korišćenjem četa. Časovima mogu prisustvovati svi učenici, grupa učenika ili pojedinačno, što je velika prednost kada je u pitanju realizacija nastave i dostava materijala deci sa poteškoćama u razvoju.

U samom radu na platformi mogu nastati i izvesni organizacioni problemi koji se ogledaju u ograničenjima koja su uslovljena brzinom internet konekcije i tehničkih problema zbog velikog broja udaljenih lokacija (domova učenika) i okruženja u kome žive. Ako je na početku nastave na daljinu i bilo nekog nezadovoljstva učenika i roditelja zbog preopterećenosti dece, lošeg organizovanja vremena za rad i izradu zadataka, posle uspostavljanja platforme tih problema više nije bilo. Učenici su se veoma brzo navikli na ovakav vid rada i sa zadovoljstvom, svakog dana u određeno vreme, su prisustvovali časovima i na kraju časa se pozdravljali: „Vidimo se i sutra na *Webex*-u".

3. ZAKLJUČAK

Nastavnici su uspeli da sačuvaju obrazovni sistem, učenike na okupu, komunikaciju sa učenicima i roditeljima i realizuju nastavni program u onlajn okruženju. Ovladali su informacionim tehnologijama i naučili sve ono što godinama, a neki decenijama, nisu. Bili su nosioci najveće i najbrže reforme u obrazovanju ikada.

Dominantne individualne razlike u snalaženju među nastavnicima, razlog su što smo mišljenja da je mlađim razredima približnija realizacija nastave na platformama kod kojih su „živa" reč i direktna komunikacija sa učenicima najprihvatljivije. Zaključujemo da kvalitet onlajn nastave zavisi od broja onih koji nađu izgovor.

Nadamo se da će se onlajn obrazovanje mlađih razreda realizovati putem video konferencijskih platformi na teritoriji cele Republike Srbije.

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Simpozijum *"Tehnika i informatika u obrazovanju: Nastavnici za nastavnike"*

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Digitalne igre kao način učenja programiranja

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Rezime: *Programiranje je samo po sebi apstraktno i teško, posebno za početnike u osnovnoj školi gde se prilikom „klasičnog" učenja programiranja koriste tekstualni programski jezici, što vodi do problema usvajanja sintakse i dodatno smanjuje motivaciju učenika. Shodno tome, potrebno je pronaći nove načine usvajanja gradiva koji će približiti programiranje učenicima povezujući ga sa njihovim interesovanjima. Digitalne igre su sastavni deo dečije svakodnevnice, a uključivanjem njih u nastavni proces zadržava se pažnja učenika i podiže njihovo interesovanje za usvajanje gradiva. U radu je prikazan pregled literature koja za temu ima učenje programiranja baziranog na digitalnim igrama. Istraživanje je sprovedeno na uzorku od 26 radova preuzetih iz 9 repozitorijuma i elektronskih baza podataka, koji su analizirani kako bi se prikazao uticaj digitalnih igara na usvajanje osnovnih koncepata programiranja. Rezultati pokazuju porast broja radova u poslednjim godinama kao posledicu sve većeg interesovanja za ovu oblast, što potvrđuje pozitivan uticaj korišćenja digitalnih igara prilikom učenja programiranja.*

Ključne reči: *digitalne igre; programiranje; obrazovanje; učenje.*

Digital Games as a Way of Learning Programming

Abstract: *Programming itself is abstract and difficult, especially for elementary school beginners where textual programming languages are used during "classical" programming learning, which leads to syntax problems and further reduces student motivation. Accordingly, it is necessary to find new ways of adopting materials that will bring programming closer to students by connecting them with their interests. Digital games are an integral part of children's daily lives, and their inclusion in the teaching process keeps students' attention and raises their interest in learning the material. The paper provides an overview of the literature on the topic of learning programming based on digital games. The research was conducted on a sample of 26 papers taken from 9 repositories and electronic databases, which were analyzed to show the impact of digital games on the adoption of basic programming concepts. The results show an increase in the number of papers in recent years as a result of growing interest in this area, which confirms the positive impact of using digital games when learning programming.*

Key words: *digital games; programming; education; learning.*

1. UVOD

Početkom treće industrijske revolucije ili digitalne revolucije, kako je mnogi nazivaju, analogna tehnologija je skoro u potpunosti zamenjena digitalnom. Shodno promenama koje su se desile u okviru ove revolucije, programiranje je kao profesija sebe postavilo na vrh lestvice najtraženijih profesija današnjice. Zakonom o osnovnom obrazovanju i vaspitanju Republike Srbije informatika i računarstvo je postalo obavezan predmet u osnovnim školama [1], a učenici se već od prvog razreda susreću sa osnovama programiranja. U petom razredu učenici ozbiljnije izučavaju programiranje u odnosu na prvi obrazovni ciklus od prvog do četvrtog razreda. Najpre izučavaju programski jezik Scratch koji predstavlja temelj u učenju programskih jezika jer ne zahteva poznavanje sintakse i ispisivanje koda pa ga deca ovog uzrasta razumeju. U starijim razredima, počevši od šestog, učenici izučavaju rad u programskom jeziku Python kroz koji stiču znanje za pisanje tekstualnog koda.

Digitalna revolucija počinje znatno da se razvija od druge polovine 20. veka, a 1970. godine došlo je da popularizacije programiranja koje je tada predstavljalo mehaničko ispisivanje naredbi tj. kodova. Pedeset godina kasnije programiranje predstavlja mnogo više od pukog ispisivanja naredbi, a od programera se očekuje visok stepen kreativnosti i inovativnosti. Upravo velika

očekivanja koje je tržište nametnulo na globalnom nivou zahteva da se kod dece od najranije dobi razvije algoritamsko mišljenje. U početnoj fazi programiranja kod učenika veliki problem predstavlja apstraktna strana programiranja, jer deca u tom uzrastu najlakše razumeju ono što vide i upravo obrazovni plan treba prilagoditi tako da se programiranje izučava od konkretnog ka apstraktnom. Shodno navedenom, veliki preduslov za odabir programskih jezika jeste i uzrast učenika.

Programiranje, digitalne igre, uticaj igara na razvoj dece tema su mnogih radova. Autori koji istražuju tehničko – tehnološko područje često se u svojim radovima bave ovim temama pojedinačno, ali mali je broj radova koji ih dovode u vezu jednu sa drugom. Iako digitalne igre u nastavi nisu mnogo zastupljene, oblast u kojoj se nešto više koriste je programiranje, a pored toga što postoje igre koje su razvijene za učenje osnovnih koncepata programiranja one se i dalje ne primenjuju dovoljno. Samim tim nastavnici teže tome da se to promeni.

U ovom radu je sprovedena analiza na uzorku od 26 radova koji su preuzeti iz 9 repozirorijuma i elktronskih baza podataka. Radovi su zatim radi lakše obrade podataka grupisani prema različitim kriterijumima na osnovu kojih su dobijeni rezultati.

2. PROGRAMIRANJE

Intenzivno korišćenje računara, kako u svakodnevnom životu, tako i u školama, počinje krajem dvadesetog veka, dok su danas računari i obrazovni softveri postali nezaobilazni element u nastavnom procesu.

Od školske 2007/2008. godine predmet informatika i računarstvo uveden je kao izborni predmet u osnovnim školama na teritoriji Republike Srbije, od tada pa nadalje procenat dece koja su odabrala da pohađaju ovaj predmet je svake godine bio sve veći. Od 2017. godine pravnim aktima [1] je definisano da predmet informatika i računarstvo postaje obavezan predmet od petog razreda osnovne škole, a u okviru njega se izučava i programiranje. Kroz izučavanje programskog jezika Scratch, čija je osnovna prednost jednostavno okruženje, učenici petog razreda stiču osnovna znanja u učenju programskih jezika. Nakon toga, počevši od šestog razreda programiranje se izučava u programskom jeziku Python kroz koji učenici uče sintaksu i stiču znanje za pisanje tekstualnog koda. Jedan od razloga zbog kog se tek od šestog razreda izučava složeniji programski jezik jeste taj što učenici u petom razredu još uvek nemaju dovoljno razvijeno apstraktno razmišljanje.

Popularizacija programiranja počela je 70-tih godina prošlog veka i predstavljala je uglavnom mehaničko ispisivanje naredbi, tj. kodova. U današnje vreme programiranje se koristi za rešavanje problema pomoću računara, otklanjanje grešaka, razvijanje logičkog razmišljanja, što podrazumeva razvoj strategija za rešavanje problema koji mogu biti iz različitih oblasti [2]. Ranije je programiranje bilo veština u kojoj su programeri mogli da koriste linearno razmišljanje, dok se danas od programera očekuje kreativnost, a ne samo kreiranje algoritama i rešavanje problema na najjednostavniji način. Programiranje se ne uči samo u okviru nastavnog procesa (osnovna škola, srednja škola, visoko obrazovanje), sve je više kurseva i privatnih akademija za učenje programiranja. Takođe, programeri se obrazuju i samostalno pomoću literature koja je dostupna na internetu i u bibliotekama, pa je tako sve više samoukih stručnjaka iz ove oblasti. U ovom radu akcenat je stavljen na decu, od njihove najranije dobi, a prvenstveno na učenje programiranja kroz nastavni proces.

Veliki problem, u početnoj fazi programiranja, za učenike predstavlja apstraktna strana programiranja, jer oni mnogo lakše razumeju ono što vide i zbog toga bi trebalo ići od konkretnog prema apstraktnom. Programski jezici za početnike trebali bi imati jednostavnu sintaksu kako bi proces učenja bio lakši, a u isto vreme bi trebali biti dovoljno jak način za uvođenje programiranja [2].

Jezici koji se koriste za programiranje u industriji, kao što su Java, C++ ili C# nisu pogodni za početno učenje programiranja u školama jer je njihova sintaksa preteška za razumevanje. Programski jezici za početnike treba da imaju lakšu i jednostavniju sintaksu kako bi početnici mogli da je razumeju i razviju algoritamski način razmišljanja. Neki od tih jezika su Logo, Scratch i Python, od kojih prva dva pripadaju grupi vizuelnih programskih jezika, dok poslednji pripada tekstualnim programskim jezicima.

3. IGRE

Deca od najranijeg uzrasta provode sate igrajući se, iako vlada mišljenje da one imaju loš uticaj na razvoj deteta, zapravo svi sati provedeni u igri kod dece razvijaju mnoge pozitivne osobine. Pa tako deca kroz igre zapravo uče, a njihov karakter je u potpunosti zabavan i motivišući. Kako navodi [3] igrajući se, deca rešavaju određene zadatke, i tako obogaćuju svoje znanje i razvijaju inteligenciju [4].

Igre na više načina utiču na razvoj dece, imaju uticaj na kognitivni razvoj deteta, njegovo razmišljanje, svest, obradu informacija [5]. Pored toga utiču na socijalni, emocionalni i fizički razvoj dece, što se kasnije ogleda u njihovoj komunikaciji, moralnim vrednostima, empatiji, koordinaciji pokreta i veštinama koje lakše stiču.

Igra je najzabavniji oblik učenja, a znanje stečeno kroz igru je mnogo trajnije od onog stečenog na neki drugi način. Takozvana „digitalna generacija" najveći deo vremena provodi u virtuelnom svetu,

najčešće igrajući digitalne igre, što nas vodi do pitanja zašto to ne iskoristiti tako da to vreme provedu učeći? Jedan od načina da se digitalne igre primene u procesu učenja je prilikom usvajanja znanja iz oblasti programiranja.

Igrajući digitalne igre deca istovremeno izvršavaju više radnji odjednom. Koriste motoriku, vizuelno opažanje, logičko razmišljanje, samim tim razvijaju kreativno razmišljanje, a ne samo linearno. One omogućavaju učenje putem otkrića, a brojna istraživanja su pokazala da takvo učenje ima mnogo veći učinak u savladavanju gradiva nego tradicionalno učenje kroz nastavu. Najveća prednost je to što bi primena digitalnih igara u izvođenju nastave mogla da predstavlja most između tradicionalnog načina učenja iz knjiga i budućih pristupa učenju koji bi učenicima bili pristupačniji i zanimljiviji.

Neke od prednosti igre kao oblika učenja su sledeće [6, 7]:

- Vrlo je lako postići najveću moguću koncentraciju pažnje.
- Aktivnost dece u igri veća je nego u drugom obliku učenja.
- Igra povećava motivaciju, interes, izaziva pažnju, te učenje čini zanimljivijim nego drugi način rada.
- Naučene sadržaje u igri deca duže pamte i lakše primenjuju.
- Kao što postoje prednosti, tako postoje i rizici kod igranja digitalnih igara, a neki od njih kako navodi [8], prema [9] su:
- Nasilje koje je osnovna karakteristika velikog broja digitalnih igara.
- Opasnosti kretanja od umerenog igranja i preokupacije do patološkog igranja, gde igrač umereno igra digitalne igre što ga polako dovodi do preokupacije kada zanemaruje svoje obaveze, a kasnije do patološkog igranja kada mora igrati po svaku cenu, zanemarujući sve ostale potrebe.

Iako postoji opasnost od negativnih posledica koje su navedene ipak je više pozitivnih strana koje digitalne igre pružaju. Ukoliko se vodi računa o sadržaju digitalnih igara, kao i o vremenu koje deca provedu igrajući ih, može se uticati na njihov negativan uticaj, kako bi se što više iskoristile pozitivne strane digitalnih igara.

Da bi se privukla pažnja učenika za neko gradivo potrebno je pronaći najbolji način kako ih zainteresovati i kako im to gradivo približiti. Potrebno je povezati školsko gradivo, u našem slučaju programiranje, sa interesovanjima učenika kako bi oni imali motivaciju da uče, u suprotnom se ostaje pri klasičnom učenju programiranja koje obeshrabruje učenike jer se većinom oslanja na rešavanje matematičkih problema. Shodno tome, sferu njihovog interesovanja za digitalne igre neko se dosetio da poveže sa programiranjem, što nas dovodi do ne tako velikog broja digitalnih igara za učenje programiranja, ali to ostavlja prostor za dalji razvoj ove oblasti.

Neke od digitalnih igara koje se koriste za učenje programiranja, kako u školama tako i van njih su: LightBot, RoboZZle i Waterbear koje koriste istu tehniku prilikom igranja, zatim Run Marco i Tynker koje u mnogo čemu podsećaju na programski jezik Scratch, a tu su i RoboMind i CodeCombat koje zahtevaju neko predznanje iz oblasti programiranja. Navedene igre se pretežno baziraju na vizuelnom programskom jeziku koji ne zahteva poznavanje sintakse. Namenjene su kako deci mlađeg uzrasta tako i starijima koji tek ulaze u svet programiranja. Za temu imaju uglavnom već poznate koncepte koji se koriste u komercijalnim igrama, tako da se korisnici lako snalaze od samog početka.

4. METODOLOGIJA

Kako bi se izvršila analiza literature koja je istraživana u ovom radu najpre su se morali odrediti koraci prema kojima će se odabrati određen broj radova:

- određivanje kriterijuma za odabir literature,
- prikupljanje podataka,
- odabir podataka,
- analiza podataka,
- rezultati.

4.1. Određivanje kriterijuma

U skladu sa temom rada, prilikom pretrage korišćeni su sledeći termini: „digitalne igre", „programiranje", „obrazovanje", „učenje", „game-based", „game", „programming", „learning", „education", „video", „digital".

Kako bi se rad uopšte mogao razmatrati u analizi, morao je ispuniti određene kriterijume:

- rad se morao odnositi na uticaj digitalnih igara na učenje programiranja,
- morao je biti objavljen u poslednjih 10 godina (od 2010. do 2020.),
- mogao se sa interneta preuzeti kao potpuni tekst,
- morao je imati sažetak.

Pretragom prema ključnim rečima pronađeno je 7326 radova, od kojih su nakon primene kriterijuma koji su korišćeni preuzeta 54 rada, a nakon čitanja apstrakta za analizu je odabrano 26 radova koji će biti korišćeni u daljoj analizi i predstavljaće uzorak na osnovu kog su izvođeni zaključci.

4.2. Prikupljanje podataka

Sprovedena je analiza literature na uzorku radova koji su prikupljeni iz 9 repozitorijuma i elktronskih

baza podataka koje su relevantne za preuzimanje literature:

- Nacionalni repozitorij završnih i diplomskih radova u Republici Hrvatskoj ZIR (https://zir.nsk.hr/),
- JSTOR (https://www.jstor.org/),
- Central and Easter European Online Library CEEOL (https://www.ceeol.com/),
- ResearchGate (https://www.researchgate.net/),
- IEEE Xplore Digital Library (https://ieeexplore.ieee.org/Xplore/home.jsp)
- COBISS (http://sr.cobiss.net/),
- ELSEVIER (https://www.elsevier.com/),
- Wiley Online Library (https://onlinelibrary.wiley.com/),
- Google Scholar (https://scholar.google.com/).

4.3. Analiza podataka

Kako bi se podaci lakše analizirali radovi su podeljeni prema tipu u četiri grupe:

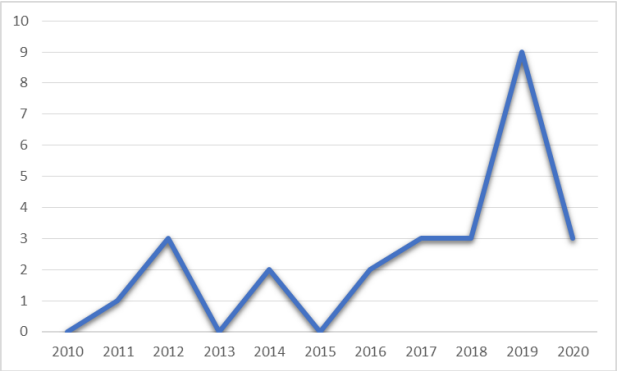
- istraživanje (radovi u kojima su autori došli do podataka koje su obrađivali kroz ankete i istraživanja koja su sproveli na određenom uzorku učenika, i na taj način došli do zaključaka kako digitalne igre utiču na učenje programiranja);
- teorijski prikaz (objašnjenje osnovnih pojmova vezanih za digitalne igre i učenje programiranja, prikaz igara koje se koriste u obrazovanju, njihov uticaj i značaj);
- pregledni rad (sinteza radova prema tačno određenoj metodologiji koji za temu imaju digitalne igre i učenje programiranja);
- razvojni projekat (radovi u kojima se razvijaju digitalne igre namenjene učenju početnog programiranja ili usavršavanju veština kod učenika i studenata sa osnovnim predznanjem).

Odabrani radovi su dalje analizirani i kategorizovani prema još nekoliko kriterijuma:

- uzrastu za koji je namenjena igra za učenje programiranja: učenici u osnovnoj školi ili studenti;
- predznanju učenika: početnici bez predznanja ili studenti sa osnovnim predznanjem (kojima igra služi za usavršavanje veština i bolje razumevanje osnovnih koncepata programiranja);
- jeziku koji autori smatraju dobrim za početak učenja programiranja: Logo, Scratch, Python, C++, C#, Java;
- relevantnosti za ovo istraživanje (0 – niska, 1 – srednja, 2 – visoka).

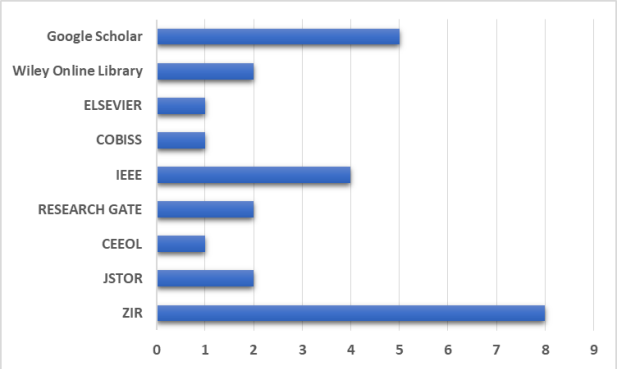
5. REZULTATI

Iako primena digitalnih igara kod učenja programiranja nije novina, već nešto što je prisutno godinama unazad, mali je broj radova koji se bave ovom temom. Slika 1 prikazuje porast broja radova objavljenih s obzirom na godinu. Tendencija porasta broja radova poslednjih godina javlja se iz razloga što je ovo još uvek nedovoljno istražena tema koja zaokuplja pažnju mnogih autora.



Slika 1. *Porast broja radova odabranih za analizu s obzirom na godinu publikovanja*

Radovi koji su odabrani za analizu preuzeti su iz 9 repozitorijuma. Slika 2 prikazuje broj preuzetih radova iz svakog repozitorijuma. Kao što se može videti najveći broj radova preuzet je iz Nacionalnalnog repozitorijuma završnih i diplomskih radova u Republici Hrvatskoj ZIR. Od 53 rada koji su preuzeti nakon primene kriterijuma za analizu je odabrano 26 radova. Razlog odbacivanja ostalih radova je najčešće bio taj što su se oni bavili uticajem digitalnih igara na učenje više predmeta, a ne samo programiranja. Još jedan od razloga što neki radovi nisu uključeni u analizu je taj što je u njima prikazivan razvoj digitalne igre za učenje programiranja, ali bez osvrta na njen značaj i uticaj na samo učenje istog.



Slika 2. *Broj preuzetih radova iz svakog repozitorijuma*

Radi lakše analize radovi su grupisani prema tipu: istraživanje, teorijski prikaz, pregledni rad i razvojni projekat. Najveći broj radova (31%) prikazuje istraživanja koja su se bavila uticajem

digitalnih igara na učenje programiranja, stavovima učenika i nastavnika, kao i pilot projektima koji su pokazali značaj korišćenja digitalnih igara u nastavi informatike. Razvojni projekat je bio tema istog broja radova (31%), gde su autori prikazali razvoj igara koje pomažu boljem razumevanju osnovnih koncepata programiranja i njegovom lakšem učenju. Nešto je manji broj radova teorijskog tipa (27%) u kom su dati osnovni pojmovi vezani za ovu temu, kao i primeri već postojećih igara koje se koriste, njihov uticaj i značaj. Pregledni rad zauzima najmanji procenat (11%) jer kao što je već pomenuto mali je broj radova koji se uopšte bave ovom temom, a posebno je mali broj radova koji se bave pregledom literature vezane za ovu oblast.

Autori nisu saglasni oko jezika koji je najbolji za učenje programiranja. Prema podacima koji su analizirani napravljene su tri grupe radova: oni u kojima se koriste vizuelni programski jezici (23%), oni u kojima se koriste tekstualni programski jezici (35%) i radovi u kojima nije definisano koji bi programski jezik bio najbolji (42%). Autori koji se zalažu za vizuelne programske jezike smatraju da su Scratch i Logo najbolji za početno učenje programiranja jer zahvaljujući nepostojanju sintakse usvajanje gradiva je olakšano, a to će kod učenika probuditi veću zainteresovanost za programiranje. Nasuprot tome, veći broj autora se zalaže za tekstualne programske jezike kao što je Python, smatrajući da će na taj način učenici kasnije lakše savladati više programske jezike poput C#, C++ i Java. Radovi u kojima nije definisan programski jezik su najčešće radovi u kojima se autori bave teorijskim okvirima bez definisanja određenog programskog jezika koji bi po njima bio najbolji. Ti autori većinom podržavaju učenje najpre vizuelnih, a zatim tekstualnih programskih jezika za učenje programiranja navodeći da bi se kombinacijom ova dva pristupa postigli najbolji rezultati.

Radovi su dalje analizirani prema uzrastu i predznanju učenika za koje su igre pravljene ili kojima su se autori bavili, tj. sprovodili istaživanja među učenicima. Od ukupnog broja analiziranih radova 73% se bavi učenicima koji tek počinju da uče programiranje i to su najčešće učenici u osnovnoj školi, dok se 27% radova odnosi na studente koji već imaju neko osnovno predznanje i kojima igra pomaže da na zabavan način usavrše svoje veštine programiranja.

Odabrani radovi koji su predstavljali uzorak na osnovu kog je izvršena analiza podataka su u većoj ili manjoj meri odgovarali istraživanju koje je sprovedeno. Kako bi se napravio dobar pregled literature radovi su ocenjeni prema relevantnosti za ovu temu rada. Ocene koje su korišćene su 0 – niska relevantnost, 1 – srednja i 2 – visoka. Radovi ocenjeni kao visoko relevantni ispunili su sve kriterijume, detaljno obrađujući sve aspekte učenja programiranja zasnovanog na digitalnim igrama i na taj način se izdvojili kao dominantniji i takvih radova je bilo 13. Ocenu srednje relevantnosti dobilo je 8 radova u kojima je postojao nedostatak informacija koje su se mogle pronaći u drugim radovima, što je radove iz ove grupe odmah okarakterisalo kao manje relevantne. Svega 5 radova dobilo je ocenu niske relevantnosti, a razlog niže ocene je taj što su to uglavnom radovi koji su prikazivali sprovedena istraživanja i ankete kroz raspravu i analizu rezultata vrlo sažeto, ne prikazujući samo istraživanje što je rezultiralo nedostatkom potrebnih informacija radi potpunog razumevanja istog.

6. ZAKLJUČAK

Obrazovni sistem kakav poznajemo ne odgovara u potpunosti vremenu u kom živimo, shodno tome potrebno je razvijati ga tako da prati savremene trendove iduću u korak s vremenom jer dolaze nove generacije koje odlikuje poznavanje i široka upotreba računara. Deca su od rođenja naviknuta da u svom okruženju imaju računar koji najčešće koriste za razne vidove zabave, samim tim digitalne igre postaju sastavni deo njihove svakodnevnice tokom odrastanja. Iz svega već pomenutog jasno je da treba iskoristiti sav potencijal koji im računar i digitalne igre mogu pružiti, ali na način da deci pomognu u obrazovanju, a ne da se koriste samo u svrhu zabave.

Školski sistem se godinama unazad nije znatno promenio, a škole su zadržale stare karakteristike gde se teži da učenici steknu što više znanja za kratko vreme i ne idu u korak sa interesovanjima učenika. Zadatak nastavnika je da to izmene, da prilagode nastavu njihovim potrebama i interesovanjima uključivanjem računara i digitalnih igara koje će obogatiti nastavu i učiniti je lakšom i zanimljivijom.

Tema ovog rada proizašla je iz ogromne zainteresovanosti za učenjem programiranja i samog problema na koji početnici nailaze, kao što su nedostatak motivacije usled tradicionalnog pristupa koji nastavnici imaju, a koji je učenicima u većini slučajeva težak za razumevanje. Iz tog razloga traže se novi načini putem kojih se gradivo može približiti učenicima, zbog čega se došlo do digitalnih igara. Programiranje samo po sebi može biti zanimljivo i lako ili potpuno strano i teško, to zavisi jednim delom od učenika, a drugim delom od nastavnika. Kod nekih učenika je apstraktno mišljenje više razvijeno i oni bolje razumeju koncepte programiranja, dok su neki učenici više vizuelno orijentisani i ne mogu u potpunosti razumeti ono što ne vide, tada nastavnici treba da preuzmu inicijativu i pronađu način da im olakšaju usvajanje gradiva.

Iako primena digitalnih igara nije velika u našim školama, ipak se mogu naći primeri gde se one koriste i treba težiti tome da se njihova upotreba

poveća. U radu su prikazane igre koje se koriste za početno učenje programiranja i čija je efikasnost već dokazana kroz primenu u nastavi, ali osim igre bitno je odabrati i odgovarajući programski jezik za početno učenje. Autori koji zagovaraju tradicionalne pristupe učenju zalažu se za tekstualne programske jezike, dok se autori koji zagovaraju savremene pristupe okreću vizuelnim programskim jezicima. Istražujući literaturu koja se bavi ovom temom dolazi se do zaključka da se kombinovanjem ova dva pristupa dolazi do najboljih rezultata. Učenici najpre uče osnovne koncepte programiranja putem vizuelnih programskih jezika, a kada to savladaju prelaze na učenje sintakse tekstualnih programskih jezika i usavršavanje veština koje su ranije stekli. Ovakva raspodela je primenjena iz razloga što je savladavanje osnova programiranja lakše putem vizuelnih programskih jezika gde učenici mogu da vide ceo proces nastanka programa, a tekstualni se kasnije primenjuju jer je profesionalno programiranje zasnovano na njima zbog većih mogućnosti koje pružaju.

Problem nedostatka literature vezane za ovo područje polako se prevazilazi usled povećanja broja radova poslednjih godina jer se javlja sve veća zainteresovanost za ovu temu. Veliki broj radova se bavi teorijskim okvirima i istarživanjem što nudi informacije o osnovnim pojmovima vezanim za programiranje i digitalne igre, kao i podatke o sprovedenim anketama iz kojih se na osnovu povratnih informacija učenika mogu poboljšati pristupi učenju programiranja. Nešto manji broj radova bavi se razvojem digitalnih igara za učenje programiranja što vodi do zaključka da se ova oblast tek razvija i shodno tome ostavlja prostor za kreiranje velikog broja igara koje će u budućnosti moći da se koriste kako u školama tako i van njih u svrhe početnog učenja programiranja.

Analizom radova nastavnicima i istraživačima dat je uvid u teme koje su u njima obrađivane, kao i sami rezultati koji mogu pomoći u daljem istraživanju ove oblasti. Takođe prikazuju smernice za preoblikovanje same organizacije nastave i novih metoda koje bi olakšale usvajanje gradiva.

Digitalne igre svakako nisu zamena za tradicionalno učenje programiranja, ali mogu biti podrška tom učenju i sredstvo da se učenicima približi čak i ono što im na prvi pogled izgleda preteško, potuno nepoznato i nezanimljivo.

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Appendix B:

Higher Education Development in the Realm of Technics and Technology

2017–2020

Notes:

Higher Education Development in the Realm of Technics and Technology

2017–2020

Project of Higher Education Development supported and financed by the Ministry of Education, Science and Technology Development of the Republic of Serbia in the period 2017 – 2020 and realized at the Faculty of Technical Sciences in Čačak:

2017–2018

1. **Innovation of University Courses in The Field of Manufacturing Technologies Based on The Implementation of Dual Education**
   Project manager: Nedeljko Dučić, PhD, assistant professor
   Project team: Radomir Slavković, PhD, full professor; Jelena Baralić, PhD, assistant professor.

2. **Modernization of the curriculum of the subject Fundamentals of Computer Engineering in the Study Program of OAS Information Technology**
   Project manager: Vanja Luković, PhD, assistant professor
   Project team member: Radojka Krneta, PhD, full professor

3. **Development of curricula and teaching competencies for subjects in basic academic studies of Information Technology accredited in 2017**
   Project manager: Danijela Milošević, PhD, full professor
   Project team: Nebojša Mitrović, PhD, full professor; Živadin Micić, PhD, full professor; Vladimir Mladenović, PhD, associate professor; Marija Blagojević, PhD, assistant professor; Olga Ristić, PhD, assistant professor; Marjan Milošević, PhD, assistant professor; Vesna Ružičić, PhD, assistant professor; Maja Radović, assistant; Katarina Mitrović, assistant.Jelena Orelj, MSc, asistant.

2018–2019

4. **Strengthening the competencies of students – master teachers of technics and informatics for entrepreneurial education and support for student professional development**
   Project manager: Veljko Aleksić, PhD, assistant professor
   Project team: Dragana Bjekić, PhD, full professor; Željko M. Papić, associate professor; Milica Stojković, PhD, assistant professor; Biljana Djorić, MSc, assistant.

5. **Digital transformation of the course Educational technology**
   Project manager. Veljko Aleksić, PhD, assistant professor

6. **The innovation of a group of professionally applied courses of the study program Undergraduate academic studies - module of Power engineering within the development of digital competencies and introduction of elements of the concept of industry 4.0**
   Project manager: Miroslav Bjekić, PhD, full professor
   Project team: Sanja Antić, PhD, assistant professor; Marko Rosić, PhD, assistant professor, Miloš Božić, assistant

7. **Innovation of the curricula and teaching competencies for the subject Advanced web programming in master's academic studies in Information Technology**
   Project manager: Vladimir Mladenović, PhD, associate professor

8. **Innovation of the curricula and teaching competencies for the subject Multimedia systems in basic academic studies of Information Technology accredited in 2017**
   Project manager: Vladimir Mladenović, PhD, associate professor
   Project team member: Nebojša Stanković, MR/MSc, assistant

9. **Adaptation and modernization of Computer Networks and Communications**
   Project manager: Marjan Milošević, PhD, assistant professor
   Project team member: Maja Radović, MSc, assistant

10. **Creating subject Introduction to Software Testing in undergraduate studies of IT**
    Project manager: Olga Ristić, PhD, assistant professor

11. **Development of Computer aided Design in Power Engineering subject curriculum aiming to enhance digital and entrepreneurial competences of the students**
    Project manager: Marko Rosić, PhD, assistant professor
    Project team member: Dragan Ćetenović, MSc, assistant

12. **Improving educational processes, teacher's, digital, and entrepreneurial competencies, and curriculums of the Web Technologies and Electronic Business courses (WEB-EBIZ)**
    Project manager: Nenad Stefanović, PhD, associate professor
    Project team: Mladen Janjić, MSc, assistant, Andrijana Jovičić, teaching assistant, Jelena Plašić, teaching assistant

2019–2020

13. **IT and knowledge and competence management, on a standardization platform**
    Project manager: Živadin Micić, PhD, full professor
    Project team member: Marija Blagojević, PhD, assistant professor

14. **Implementation of laboratory exercises and information technologies in the group of courses Electrical installations and lighting in order to develop professional and entrepreneurial competencies of students**
    Project manager: Momčilo Vujičić, PhD, associate professor
    Project team member: Marko Šućurović, MSc, assistant

15. **Improving and enhancing the professional, digital and entrepreneurial competencies of students by innovating the curriculum and accompanying practical activities of subjects in the field of electronics and telecommunications**
    Project manager: Predrag Petrović, PhD, full professor
    Project team: Ana Plazinić, MSc/PhD, assistant/assistant professor; Mihajlo Tatović, MSc, assistant

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