



**University of Kragujevac  
Faculty of Technical Sciences Čačak**



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## Preface

Seventh international scientific conference Technics and Informatics in Education – TIE 2018 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 72 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, 64 papers have been accepted for the current edition of Book of abstracts in the form of plenary lectures and original scientific papers.

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

Articles in the *Proceedings TIE 2018* are organized by the following topics:

- Plenary lectures
- Technics, Technology and Informatics in Education
- IT Education and Practice
- Engineering Education and Practice

Special activities within the Conference are the following:

- Round Table – University education of the professors of technics and IT in the region
- The Day of Computing – 20 years of Computer engineering studies at the Faculty of technical sciences Čačak
- Poster Session: Research project in the field of technical sciences and teaching at the Faculty of technical sciences

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

Faculty of Technical Sciences Čačak, University of Kragujevac, has the honour to organize the seventh international scientific conference 'Technics and Informatics in Education – TIE 2018'.

The Conference continues the tradition of gathering scientific associates and professionals in technical, technological and IT education in primary and secondary schools in Serbia. For the last 50 years this assembly has been organized in various forms (scientific and professional conferences and consultations on technical education, information technologies, technical seminars, etc.). These scientific and professional gatherings have had a huge impact on the development of technical education, mostly in primary and secondary education. The impact is also noticeable in both higher and university education. Six conferences titled Technics and Informatics in Education were held in 2006, 2008, 2010, 2012, 2014 and 2016. Still, the necessity for continuous, organized scientific assembly related to technics and informatics in new surroundings has increased.

The aim of the conference TIE 2018 is to improve the exchange of knowledge and experience between experts, scientific associates and professionals from Serbia, neighbouring countries and Europe, engaged in the subject matter. The conference will provide an analytical review of technical (technological) and IT education, as well as education regarding technical (technological) and IT achievements including assistive technology, teaching aids, student books, etc. Teacher training is considered highly significant for research and development in education in this field.

The Conference includes technical (technological) education at all levels: from preschool institutions, primary and secondary schools over higher and university education, to various forms of lifelong learning.

Furthermore, the special emphasis will be given to the place, importance, and role of informatics and IT in technical and professional education, as well as correlation with other natural, social and education science.

A comprehensive analytical review will be given on the state of education in the fields of technics and informatics, as well as the contribution of technical and IT education to other fields.

The conference results are expected to provide the basis for planning the development of education in Serbia, especially in the fields of technical (technological) education, engineering, IT and informatics. The results are also expected to support and contribute to the exchange of educational patterns in the region and coordination with European trends in this field.

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

*Danijela Milošević*  
*Željko M. Papić*  
Co-Chairs

## Organization

The 7<sup>th</sup> International Scientific Conference Technics and Informatics in Education – TIE 2018 is organized by the Faculty of Technical Sciences Čačak, University of Kragujevac, Serbia.

The Conference is held under the patronage of:

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

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Faculty of Technical Sciences, Čačak, Serbia, 25-27<sup>th</sup> May 2018

# **Plenary Session: Keynotes**

**Notes:**



# Conceptualization of Technology as a Curriculum Framework of Technology Education

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**Abstract:** *Technical (technological) and engineering knowledge is characterized by constant variability and unpredictable dynamics of development. Therefore, the system of technological knowledge can't be compared to the content base of most other subjects or areas. While the knowledge of other areas is relatively stable, technological knowledge is subject to constant upgrading and alignment with the dynamics of technology development. Due to the tremendous growth and pervasiveness of knowledge, the technology and engineering is faced with the problem of appropriate systematization, while the technology education faces the problem of conceptualizing, selecting and elaborating such knowledge for learning and teaching purposes. In this light, experts and teachers face the problem of conceptualizing technical knowledge in order to achieve the desired learning goals in a very limited time. Thus the openness of the curriculum is becoming more a serious alternative to the today's content-limited curriculum. Therefore, this paper presents an overview of selected concepts of technological knowledge as an attempt to facilitate the future development of the technology education curriculum. In this connection, conceptualization of technology is proposed, as a unique model that takes into account different ways of conceptualizing technology in an individual's mind. Such conceptualization can become a universal framework for the development of the curriculum of technology education.*

**Keywords:** *conceptualization of technology, curriculum framework, technical education, technology education, technology and engineering education.*

## 1. INTRODUCTION

Technical and engineering knowledge, from the beginnings of systematic development to the present day, are characterized by exponential growth, constant change of technological reality, and the highly unpredictable dynamics of development. Such dynamics greatly influences and directs the course of development of the economy and society, but also the life of every individual, whereby the education of an individual for such a society is no exception. As a result, the overall technology education faces the problem of growing technological knowledge and alignment with such growth, with the problem of technical and engineering training, but also with the problem of personal advancement and excellence in technology and production [1]. The lack of appropriate and generally accepted terminology [2], [3], but also the taxonomy of technological knowledge and mechanisms that should allow for dynamic changes in the curriculum of technology education, further complicate these problems. Namely, the system of technological knowledge, as the content and cognitive (epistemological) basis of a particular curriculum, can't be compared

to the content base of most other subjects or areas. While the knowledge of most other subjects is characterized by relative durability, technological knowledge is subject to constant expansion and alignment with the dynamics of technology and engineering development. The aforementioned growth and changes of the technological knowledge, repeatedly puts in the first place the problem of appropriate system of technological knowledge, while the technology (and technical) teaching area is faced with the problem of conceptualization of technology, but also the choice and transformation of technological knowledge for learning and teaching purposes. Therefore, the openness of the curriculum continues to be imposed as a serious alternative to the traditional and content-limited curriculum. In such light, the issue of exemplars (What to choose?), but also the concept of technological knowledge, is imposed on experts and teachers so as to achieve the desired learning goals in a very limited time that allows the curriculum. Solutions to the problem of proper conceptualization and systematization of technological knowledge will certainly affect the

teachers training, without which the successful realisation of the curriculum is not feasible.

Conceptualisation term refers to the formation of ideas or principles about something, especially in the human mind [4]. In this paper conceptualization primarily refers to setting up technological ideas and principles in a certain system that comes from the human mind and should be understandable to the mind of another person. In that sense, technological knowledge is usually conceptualized, and conceptualization itself may depend on purposes or reasons. Thus technological knowledge can be conceptualized because of the systematic differentiation from the other knowledge, due to the development of the epistemological basis of the technology education, due to the more successful conceptualization of the technology in the mind of the individual, and to the easier structuring of the curriculum. When it comes to education, conceptualisation seeks to identify those factors that functionally and independently of time ensure a successful life and work in a technological (technical) environment, embody culture and encourage the development of civilization [5]. When it comes to curriculum development, conceptualization can be meta-orientation, i.e., educational philosophy, dominant psychology of learning and teaching, respect for the social context, as well as theoretical and practical principles of curriculum development [6]. Therefore, if conceptualization is to be carried out to suit the educational needs, which will have a lasting value and be universally applicable, it is necessary to take into account the conceptual frameworks (systematization) of technological knowledge and the conceptual framework for curriculum development.

Based on the aforementioned starting points, this paper provides a review and analysis of the conceptual frameworks of the technological knowledge and the performance link in the teaching, which aims to establish the optimal conceptualization of technology appropriate to each technology education. At the same time, conceptualization of technology is presented as a curriculum framework, which could serve as a starting point for the development and further elaboration of the curriculum of technology education.

## **2. PROBLEM OF CURRICULUM CONCEPT**

The conceptualization of technological knowledge in the curriculum of the technological (technical) teaching area has long been based solely on the technological contents. Thus, in the Croatian educational system, since the introduction of technical education in the 50s of the last century, the curriculum of general technical education was based on the content derived from the fundamental branches of technology and

engineering. This education included areas such as construction, electrical engineering, graphic communications, agriculture, transport, engineering, and information technology. Knowledge of these areas was the basis for the transformation of technological knowledge into educational contents. The advocates of such a concept was argued that these areas constitute a permanent basis for the technical culture of modern man and are the starting point for determining the content of general technical (technology) education [7]. Instead, the contents became a limiting factor of the curriculum, which often did not track social development and the context in which education was realized. In addition, the nature of technological knowledge was neglected, as an important epistemological basis, which turned the realization of the curriculum into direct teaching of dictated contents. Therefore, considerations of technological knowledge, contents and activities was pointed to the need to look at those declarative and procedural knowledge and practical skills that are common to all fields of technology [8], [9]. In this way, they tried to include in the curriculum only those contents and knowledge that are directly applicable in everyday life as well as those who anticipate social needs and have an educational function [9]. Nevertheless, conceptualization based on technical contents has so far remained the main approach and starting point for curriculum development of any technology (technical) and engineering education in the Croatian education system. In this sense, the epistemological foundations that technological knowledge does not validated in relation to "truth", but to a successful "function" [10], [11] are most often ignored. Thus, technological knowledge is subject to constant review and assessment of adequacy with regard to the social and economic context. It can be said that such conceptualization involves only the knowledge derived from the philosophy that Mitcham [2] calls the engineering philosophy of technology, while the humanistic philosophy of technology is present only declaratively but not in reality. Such a strictly determining and structuring of technological (technical) contents, without looking at their applicative, futurological and sociological dimensions, is in fact the limitation of education and training to the measurable amount of information that is useless in the life's reality [5]. Such a concept has for years shown its weaknesses in all areas of education, and has had a particularly negative impact on technology education. Namely, by applying existing conceptualization, it is not possible to keep up with the growth of technological knowledge and make a suitable choice and didactic transformation of content that will have sense and meaning for students. For this reason it is

necessary to change the approach for conceptualization and structuring of technological knowledge, but also the concept on which the traditional and content-oriented curriculum of technology education is based. Due to the finding of an acceptable concept of curriculum, it is important to carry out an analysis of the existing conceptualisations (classification) of technological knowledge, as well as the analysis of the taxonomy of knowledge, relevant to the point of view of technology education.

### 3. CLASSIFICATION OF KNOWLEDGE AND TECHNOLOGY EDUCATION

Knowledge, as an important category in the education process, is the subject of many scientific and expert discussions that tried to define and classify knowledge from different perspectives. When it comes to education, it is important to note that knowledge can't be treated as an absolute category that exists independently of human being, but is a category that is part of an individual but also of social groups with the same epistemological beliefs [12]. With regard to classifications, this work will be limited to those which are generally accepted and may be linked to the technology education. Scientists generally agree that there are two basic categories of knowledge, explicit and tacit or implicit knowledge [11]. Explicit knowledge can be explained as knowledge that exists in the available and conscious form and as such can be articulated [11] or as knowledge that can be expressed in words and other symbolic representations [12]. Tacit knowledge can be explained as knowledge that is not articulated (can't be described), but also as knowledge that is implicit and can be articulated but with some difficulties [12]. This is actually the trait of the one who knows more than he can say [13], or as knowledge that can only be developed through practice and can only be validated in practice [11]. In this, explicit and tacit knowledge should be seen as a spectrum rather than as definitive points, because in practice all knowledge is a mixture of tacit and explicit elements [14]. From the aspect of technology education, explicit knowledge is knowledge contained in documents and artefacts [14], which an individual can verbalize or express through abstract symbolism. Tacit knowledge includes *know-how* and cultural knowledge [14] and is expressed through the practical application of knowledge and can be validated during and after that process. Despite such a general classification, it is important to note that researchers increasingly distinguish the above types from the "embedded knowledge" category [14], [15]. Embedded knowledge is the knowledge that is encountered in business rules, processes, manuals, organization culture, code of conduct

and ethics [14], but also contextual issues related to processes, products, objects, structures, and customary practice, legislative and political aspects [15]. This knowledge is important from the aspect of technology education, because many standards, rules, procedures, experience indicators, customary practice etc. are present in this area. In cases where embedded knowledge is important for an individual's professional performance, it can become part of explicit knowledge, and in cases where is important practical application, and part of the tacit knowledge. However, in technology education, this knowledge is often found in many standards, rules and empirical coefficients that are not learn "by memorizing" but are used "as needed". Such knowledge is sometimes a product of experiential knowledge (without explanation as to how it has come about), sometimes lacked explanations and are often part of traditions and conventions that are local or regional and are not globally applicable.

During the development of technology education, various subcategories of knowledge have been introduced. Compton [11] refers to these subcategories as: procedural knowledge (knowing how to do it), conceptual knowledge (understanding the relationship between knowledge), device knowledge (knowledge of devices or systems), descriptive knowledge (descriptions based on valid criteria), prescriptive knowledge (knowledge about function as validity criteria) and evaluative knowledge (as a integration of descriptive and prescriptive knowledge). Since this classification is a product of several different authors with different views and starting points, the inconsistency of this approach is noticed. In education, the dimensions of knowledge [16], [17], or the quality of knowledge may be more appropriate in place of the subcategories mentioned above. Thus Krathwohl [17] presents four dimensions of knowledge: factual (declarative), conceptual, procedural and metacognitive knowledge. Factual knowledge is the basic element that students must know to learn about discipline or solve problems. Conceptual knowledge represents the knowledge of the interrelationships between the basic elements within a larger structure that enable them to function together. Procedural knowledge is knowledge of how to do or investigate something, the criteria for using skills, algorithms, techniques and methods. Metacognitive knowledge represents knowledge of cognition in general, as well as awareness and knowledge of one's own cognition [17]. In technical education, the goals are often focused on achieving the level of application of knowledge in the cognitive domain, which is necessarily accompanied by the corresponding skills at the level of precision in the psychomotor domain, and

the adoption of certain values in the affective domain. The level of application of knowledge involves the use of procedures for carrying out activities and is closely related to procedural knowledge [18]. Thus, procedural knowledge is the fundamental dimension of the level of application of knowledge that can not be achieved without performing practical activities. In other words, procedural knowledge is not a knowledge of how something is done but a unique cognitive dimension of an individual's ability to apply specific skills and algorithms, techniques and methods, and criteria for the use of particular procedures [16]. Although conceptual knowledge is often identified with explicit, and procedural with tacit, it does not always have to be so. Namely, linking knowledge into the meaningful concepts can have elements of tacit knowledge just as procedural knowledge can be transformed into a particular standard, rule, or "cookbook", thus ceasing to be tacit knowledge [11]. Achieving a metacognitive dimension of knowledge, whereby a learner adopts optimal ways of learning and progress, and develops self-confidence and self-consciousness, assumes many different experiences, i.e. a high level of procedural knowledge.

#### 4. CONCEPTUAL FRAMEWORK OF TECHNOLOGICAL KNOWLEDGE

Enormous growth of technological knowledge has caused a high complexity of the existing, content-based classifications of scientific-technological and engineering knowledge. Therefore, many more serious attempts to create taxonomies, classifications or conceptual frameworks of technological knowledge have been recorded over the past decades.

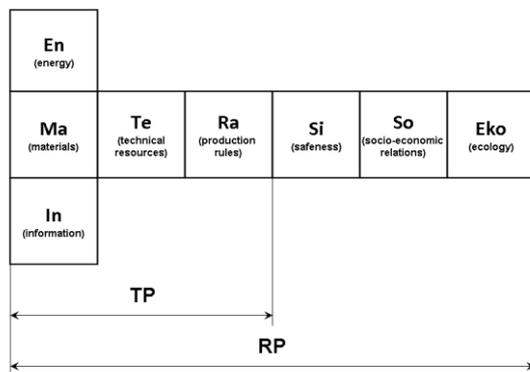
Among the first classifications (conceptualization) of technological knowledge is worth mentioning of the one developed by Staudenmaier [19], as a result of extensive study of sources in the area of philosophy of technology. Staudenmaier has structured all the technological knowledge according to their common features: *scientific concepts, problematic data, engineering theory and technical skills*. Scientific concepts make up the scientific foundations of technological knowledge, as well as the wide potential of applying scientific knowledge in technological activities and their development. In order to allow for the acquisition of knowledge, it is necessary to implement the specific requirements of theoretical concepts in specific situations. The problematic data refers to the development of a knowledge that can't be developed theoretically. This implies phenomena that are not demystified at the theoretical level or can't be demystified, thus contributing to the development of new practical technological knowledge. Engineering theory

includes crucial, experimentally verified and formally structured knowledge (knowledge in the narrow sense). This theory is a precondition for solving specific problems, but is not directly related to their solving. Technical skills are the basis for judgment, activity and work and enable real-world understanding of technology, development of skills and competencies. Experts criticize this concept because of the strict "technological" approach and the absence of the social and ecological component [5], which should provide the necessary authenticity and meaningfulness in the technological education.

A somewhat more complex classification of technological knowledge is given by Vincenti [20], where knowledge is classified as: *Fundamental Design Concepts, Design Criteria and Specifications, Theoretical Tools, Quantitative data, Practical Considerations, and Design Instrumentalities*. Fundamental design concepts here consist of operational principles and normal configurations. The design criteria and specifications relate to the conditions, frameworks and rules under which the artefact is designed and constructed. The theoretical tools here include mathematical tools, explanations and scientific basis for the functioning of artefacts or technologies. Quantitative data refer to the standards, coefficients and experiential values required for the development of artefacts. Practical considerations include finite solutions, examples, cases, ways of customizing artefacts or technologies, while design instrumentalities are engineering tools and systems that help develop a product or technology. This concept offers a systematic approach to engineering knowledge, mostly theoretical and those related to design and construction, but without the practical problem solving and product or technology realization. This concept is criticized because certain categories (theoretical tools and quantitative data) are not exclusive areas of technological knowledge [11], but it is easy to find examples that fit into multiple categories and those that do not fit into any one [21]. The absence of social and ecological categories, this classification does not seem appropriate for technology education.

The next classification was offered by Rophol [22], which classifies technical knowledge as: *Technological Laws, Functional Rules, Structural Rules, Technical Know-How, and Socio-Technological Understandings*. Technological laws here represent the scientific foundations of technical knowledge, and include theoretical concepts of how something works and concrete situations-examples. Functional rules relate to the development of knowledge that is impossible to develop theoretical (basically, solving problems). Structural rules make the most important, verified and formally structured theoretical technical knowledge. Procedural knowledge refers here to

knowledge gained through practical activities, enabling understanding of technology and the development of skills and competencies. Social-technical understanding is knowledge of the relationships between technology, natural environment and society. This concept and its application is identical to Staudenmaier, with an important addition to acknowledging the knowledge about the interrelationships of technology, society and nature. In education this means that students need to gain insight into the social justification of a particular technology, but also to the consequences for the natural environment and human. Some experts criticize this concept because of insufficient breadth because some knowledge can't be classified into any category (e.g. standard components) but also because of the methodological inconsistency of taxonomy [21].



**Figure 1.** Framework of the technical knowledge [23], [24]

The conceptual framework, important from the point of view of the current general technical education in Croatia, was offered by Majetić [23], [24] (Figure 1). This concept is derived from traditional, content-based elements of technology. Majetić conceptualized technical knowledge into the underlying elements of the technological process (TP) and working process (RP). The technological process thus comprises: material (substance), energy, information, resources, and rules under which the process is performed. The working process includes: safety at work, socio-economic relations and ecology (this element is subsequently associated with the original concept). This concept is first developed for vocational education and then for general technological education, which is why it is mainly applicable to production activities. But in the curriculum there are no resources or time for such activities, so the concept has remained largely inapplicable according to the author's idea. Implementation in teaching was carried out by didactical transformation of selected content into the catalogue themes, thus transforming the concept into a dictated closed curriculum. All this

has prevented the implementation of many meaningful activities in teaching, and the systematization of technological knowledge in pupils' awareness.

The next classification of technological knowledge was offered by de Vries [25], and is mainly based on technological practice and development, that is, artefact knowledge. So de Vries lists four categories of knowledge: *Physical Nature Knowledge*, *Functional Nature Knowledge*, *Means Ends Knowledge*, and *Action Knowledge*. Physical nature knowledge refers to operational explicit knowledge and understanding of the physical properties of the artefacts. Functional nature knowledge includes knowledge of the function that an artefact can fulfil or of rules that can ensure its functionality. Means ends knowledge refers to knowledge of the relationship between physical and functional, i.e. criteria and mechanisms for assessing the suitability of artefacts. Action knowledge refers to knowledge about the ways in which "actions" that lead to desired outcomes are performed. Although this classification is structured "broadly", limiting technology to the artefact knowledge only seems insufficient to apply to education.

Interesting conceptualization of technology is suggested by Barlex [26], as an *ideas about technology* and *ideas of technology*, which makes a certain curriculum frame of the technology education. Barlex states that *ideas about technology* would mainly inform the development of a perspective on technology while the *ideas of technology* would be essential for enabling technological capability [26]. The ideas about technology here relate to starting points that distinguish technology from other areas: used for development of technologies and products to intervene in the natural and made worlds; it uses knowledge, skills and understanding from a wide range of sources; in technology there are many possible and valid (better or worse) solutions to technological or manufacturing challenges; the worth of technologies or products is a matter of judgment; always have unintended consequences which cannot be fully predicted by creators. Ideas of technology are in fact technological knowledge (and skills). Technological knowledge here includes: *Knowledge of materials*, *Knowledge of manufacturing*, *Knowledge of functionality*, *Knowledge of design*, and *Knowledge of critique with regard to impact*. This concept may seem to be a good starting point for developing a curriculum of technology (technical) education, but with certain constraints. Namely, the classification of knowledge is based mainly on conceptualization from activities (on product development), which are a good basis for the development of knowledge, but not the only way for conceptualization of technology.

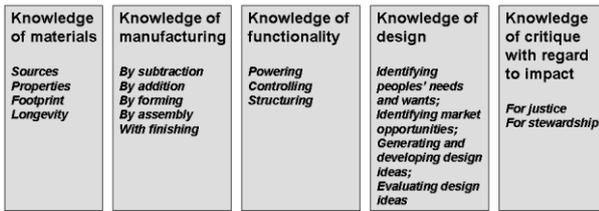


Figure 2. Ideas of technology [26]

Views of different classifications bring different concepts of technological knowledge, which are often not fully applicable in contemporary education. The reasons should be sought in the fact that taxonomy of knowledge is not a purpose for itself and that there is a big difference between the technological knowledge system outside the context of education and the way in which technological knowledge is acquired and developed. In this light Mitcham [2] in the extensive review of engineering and humanistic philosophy of technology, introduces a different ways of the conceptualizations of technology. Mitcham does this from the conceptual framework of the manifestations of technology (Figure 3), as a result of analysing various philosophical discussions. According to this framework, technology can be manifested through artefacts (objects), as activities, and as technological knowledge, which can't be observed outside the human volition aspect. Thus, knowledge does not exist outside of human being and his volition aspect, which is why this important manifestation of technology have to be taken into account.

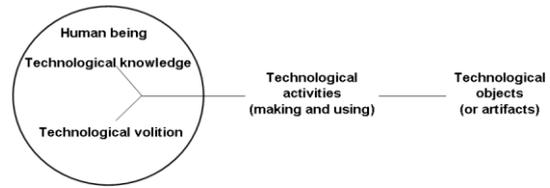


Figure 3. Modes of the manifestation of technology [2]

From such a framework, Mitcham [2] also elaborates different types of technology, i.e. ways of the conceptualizations of technology, such as: *Types of Technology as Object*, *Types of Technology as Knowledge*, *Types of Technology as Activity*, and *Types of Technology as Volition*. Therefore, technology can be manifested, and thus structured through various technological objects, as the most obvious evidence of such a structure. It can manifest through the structured technological knowledge, whose quality largely depends of the human volition aspect. Finally, technology can be manifested through the various activities, specific for this area. This conceptual framework can represent a sufficiently open foundation for adaptation for different purposes, as well as for the needs of education.

**5. CONCEPTUALIZATION OF TECHNOLOGY AS A CURRICULUM FRAMEWORK**

Any development of the curriculum framework of technology education presupposes the appreciation of different concepts, classification

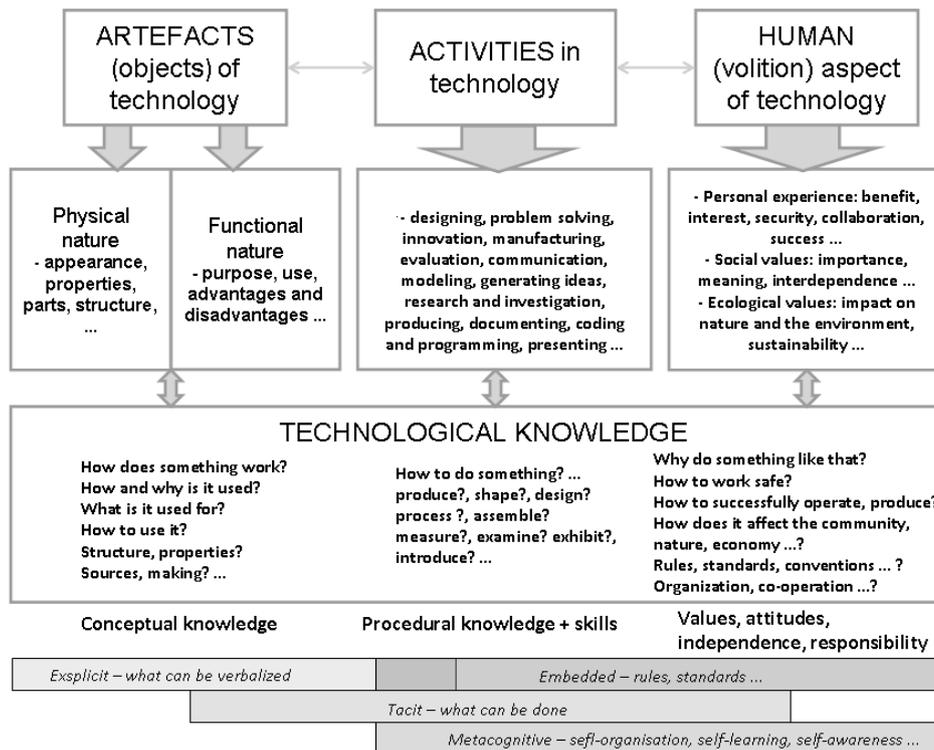


Figure 4. Curriculum Framework of Technology Education

and taxonomy of technological knowledge, as well as the type of knowledge in general, some of which have been previously presented. In this regard, it is necessary to develop a framework that will be sufficiently open for application at different levels of the technology education, and adaptable for different educational needs and different contexts of learning and teaching. For this reason, the conceptual framework for the development of the curriculum of technology education is proposed here, which is largely inspired by the framework given by Mitcham [2]. This framework is particularly important because it takes into account the human aspect of technology, but also the different ways of conceptualizing technology, which is important for education. The proposal of the curriculum framework of technology education is presented in Figure 4.

From the framework it can be seen that different approaches to the conceptualization of technology here represent certain macro-concepts or domains of the curriculum. According to this framework, the process of learning technology usually begins with insight and experimentation with objects (artefacts) of technology, that is, by recognizing the physical and functional characteristics of artefacts. However, with the artefacts, the learner must carry out various meaningful activities, which are the basis for individual development. Activities are mostly related to the application of processes, steps, procedures, operations, methods, etc. In practice, this is most often modelling, generating ideas, research and investigation, producing, documenting, evaluation, but also designing, problem solving, systems approaches, inventions, and manufacturing [27]. However, in order for an individual (student) to accept such activities, it is necessary to respect the human aspect of technology. For this reason, the activities should have sense and meaning for the student (should be done in a suitable teaching context). Therefore, it is important that every activity has a clear purpose (something useful) and prominent good and bad consequences (for the individual, society, environment). With such significant activities, the learner needs to gain insight into how technology shapes and influences it personally, on other people, on culture, on society, and on nature. Based on the experience gained, students need to think, discuss, communicate, share ideas, exchange information, etc., which helps them systematize acquired knowledge in their own mind. All of the above, from insight into artefacts, activities with them, to communication, organization and cooperation, basically represents technological knowledge. Through the systematization of the knowledge of the artefacts and only partially from the activity, the learner can achieve the conceptual dimension of knowledge, often called explicit knowledge.

Successful realization of the activity, where knowledge of the artefacts, rules and standards is applied and communicated and cooperates with other participants, the student gains procedural knowledge. This way of acquiring knowledge in technology education is at the same time the only way to develop metacognitive skills. This knowledge is largely considered to be tacit knowledge, though it incorporates the embedded knowledge. By exchanging experience, expressing attitudes, presenting results, reflecting on activities, communicating and collaborating with the real world, etc., the student accepts the value system, develops argued attitudes and becomes independent and responsible. This systematized knowledge can be considered as part of a tacit knowledge, while the successful implementation of the activity in this domain confirms the adoption of the embedded knowledge. Nevertheless, the greatest contribution in this part relates to the metacognitive dimension of knowledge, that is, self-organization and self-learning, and the gradual development of awareness of one's own preferences and possibilities. Only on the basis of one's own experiences, a learner can gain insights (with the help of teacher) into a certain system, discover their own preferences and opportunities, and develop accordingly.

## 6. CONCLUSION

This paper presents an overview of selected classifications, concepts and taxonomy of technological knowledge, as well as general taxonomy of knowledge, primarily from the aspect of education and the curriculum development. Conceptualization of technological knowledge is especially important for the development of the curriculum framework, because today's technological knowledge can't simply transformed into teaching. Although each of the concepts presented has its own advantages, some are more suitable for adapting to educational needs. It is important to understand that, as opposed to a traditional content-based structure, knowledge should be seen as a process or path of knowledge in which a human (volition) aspect plays a major role.

Based on the analysis of the taxonomy, concepts and classifications and the stated starting points of the role of human in the process of acquiring knowledge, the conceptual framework of the curriculum of technology education was developed. This framework respects different manifestations of technology, i.e. different ways of conceptualizing technology in an individual's mind. For this reason, manifestations of technology here are transformed into the curriculum domains as: artefacts of technology, activities in technology, human aspect of technology, and technological knowledge. The basis for student achievement is

the activities that need to be carried out with the artefacts, and everything must be done with the respecting of the volition aspects of the students. In such a process, the student adopts technological knowledge, and the teacher should help him to systematize knowledge in the own mind.

Although the proposed curriculum framework does not offer a final or "instant" solution for teaching, it can be an open starting point for developing each operational curriculum of technology education. The role of the teacher in this process is crucial because on the basis of the framework, it is necessary to develop its own operational curriculum. Therefore, instead of performing content-restricted topics, the teacher should be able to choose artefacts and realize activities, and the sense and meaning of these activities should be adjusted to the pupils' interests and needs, the level and purpose of education, and the needs of the community and society. During and after the activities performed, the teacher should systematize the acquired experience and knowledge of student as part of the technological knowledge system. Teacher, as the most important quality factor of teaching, can assume responsibility for the development of students' technological competences only if they have a high level of freedom in creating their own teaching, as the proposed framework allows.

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# Formal Education in Data Science – A Perspective of Serbia

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**Abstract:** *In recent years, Data Science has become an emerging education and research discipline all over the world. Software industry shows an increasing and even quite intensive interest for academic education in this area. The similar trend has been noticed in Serbia, particularly in Belgrade and Novi Sad. In this paper, we discuss main motivation factors for creating a new study program in Data Science at Faculty of Technical Sciences of University of Novi Sad. Also, we present a short survey of software industry needs for data science related experts, and discuss how we structured the new study program and addressed the main issues that come from more than evident industry requirements. The program was accredited in year 2015, both at the level of bachelor and master level studies, and this school year is its first execution, from which we expect the new experiences.*

**Keywords:** *Academic Education; Computing and Informatics; Data Science; Data Analytics; Information Engineering; Big Data Management*

## 1. INTRODUCTION

Nowadays, modern business include acquisition and store of enormous data volumes, even larger than ever before. A volume of collected data shows an enormous, practically exponential growth all over the world [4]. Most often, collected data are used in a shorter time frame, and then they are archived and almost not used, effectively. On the other hand side, such data represent a significant value that a company can utilize so as to reach created goals and provide a sustainable development. Typically, a company management is aware about significant but not exploited values ingrained in stored high data volumes. Also, we believe that the needs for generation of company knowledge from data are clearly recognized in well-matured companies. Such knowledge is to be used to raise the effectiveness of the decision and management company processes, based predominantly on quantitative, analytical methods. [1]

Unfortunately, a daily practice in many companies still intensively points out to the problem of a serious gap between the identified needs for knowledge, on one hand side, and inability of modern software products to address such needs in an effective way, on the other hand side, despite that massive data volumes already exist, while modern Information Technologies (ITs) provide the excellent technology prerequisites for a development and industry implementation of high quality software applications. We believe that this problem is just a new, "modern" form of

never-ended software crisis, present for decades in many different forms, in software industry.

Some of important causes of the aforementioned problem are in the following:

- a) Unsatisfactory level of organization maturity in regard to the: capacities for information management, quality management, and business processes, in general;
- b) Unsatisfactory level of accumulated knowledge in a problem domain; and
- c) Unsatisfactory level of accumulated knowledge in a domain of software engineering, particularly in a domain of the development and formal specification of models for software products aimed at generation of company knowledge and decision support.

In this paper, we are going to consider mainly the cause presented in c), in regard to the aspect of formal academic education, without any intention to neglect the causes a) and b), as we are quite aware that alleviating the aforementioned problem is a strategic and long life task, only possible by simultaneous addressing all its significant causes.

Following all these motives, in well-developed countries a highly emerging interest for studying a wide range of knowledge in big data processing and generation of company knowledge is present in recent years [3, 5, 6]. Such interest leads to the discipline of Data Science [2, 4]. Nowadays, a predominant attitude is that the knowledge required for development and application of Data Science is highly interdisciplinary and multidisciplinary oriented, as there is a strong need

to apply various knowledge and disciplines in a unified way in addressing the complex business problems, as a key issue in modern business [5].

Therefore, academic education in Data Science, and particularly education of engineers of such a profile, is also a strong issue in upcoming years. We notice a more intensive interest in well-developed countries for Data Science academic education even in years from 2015.

A goal of the paper is to discuss a current state, issues and development perspectives of academic education in Data Science in Serbia. Also, we present the main motivating factors for creating a new study program in Data Science at Faculty of Technical Sciences of University of Novi Sad. Also, we present a short survey of software industry needs for Data Science related experts, and discuss how we structured the new study program and addressed the main issues that come from more than evident industry requirements. The program was accredited in year 2015, both at the levels of bachelor and master studies, and the school year 2017/18 is its first execution, from which we expect the new experiences.

## 2. ISSUES OF ACADEMIC EDUCATION IN DATA SCIENCE

In software industry of well-developed economies, we can notice a strong fitting between the skill and education requirements for specific job positions, and the level of education and experience of software engineers or IT experts being hired at those positions. Also, such software engineers typically show a higher level of specialization to some disciplines or problem domains, as the Human Resource (HR) market is more mature. On the contrary, in under-developed or even developing economies, HR market in software industry is not mature as in well-developed economies. Therefore, fitting between the required skills and education level for the job positions and the level of education and experience of software engineers is often not appropriate, and we can notice hiring overqualified or underqualified experts at some positions, in a wider extent. The level of specialization depth of software engineers to some disciplines or problem domains is not as strong, as in well-developed economies.

However, nevertheless if we observe a software industry in well-developed or under-developed economy, the same paradox arises. More interdisciplinary oriented (software) engineers, capable of covering a wide range of tasks, knowledge and skills, are always significantly better positioned in the software industry HR market, while academic institutions motivate, often "in silence", education of more specialized experts. If we say here "more specialized experts", it means experts that are pure software

or informatics engineers, mathematicians, business administration managers, or various domain experts. On the contrary, interdisciplinary and multidisciplinary characteristics and skills are to be nurtured from early ages of academic education.

In a current academic education, we can identify study programs of the three categories, covering in some extent disciplines of Computing, Computer Science, Informatics, or Software Engineering, i.e. CSI&SE for short, as a basis to provide Data Science education. Those are: (1) Specific study programs in CSI&SE; (2) Study programs in (Applied) Mathematics; and (3) Study programs in Economics, Business Administration and Management. All large Serbian universities provide study programs from all the three categories, for many years.

Our multiyear experiences in teaching CSI&SE courses in study programs of all the three categories lead to the identification of typical students' behavioral patterns [1]. In the subsequent paragraphs, we discuss all the three patterns.

(1) Students from specific study programs in CSI&SE are predominantly technology oriented. Often, they express their animosity to the mathematical, and even more organizational, managerial or economics disciplines, with a belief that this knowledge is not necessary to them, and that someone else is to possess it. Study programs of this category often provide just a modest level of knowledge from mathematics and business administration. On the other hand side, such students express their strong interest for learning a typical technology knowledge in IT. By this, we name this behavioral pattern as "Let me learn one more technology environment, only".

(2) Students from study programs in Applied Mathematics, or just Mathematics are predominantly formally oriented. They believe that technology knowledge is of a lower level value, and also they are not aware of a necessity of having a knowledge from business administration, management, or economics. Development of skills aimed at practical application of adopted knowledge in various application domains is often underestimated or even neglected. Students from this category believe that complexity of things is just of a logical nature – the things are more complex, just if they are logically complex, while other forms of complexity are rather neglected. Study programs of this category often provide a modest level of CSI&SE knowledge, as well as business administration knowledge. By this, we name this behavioral pattern as "Let me prove one more theorem, only".

(3) Students from study programs in Economics, Business Administration and Management show a strong awareness about the importance of having

the CSI&SE and Mathematics knowledge in resolving the complex problems in organization systems. However, in a lack of their formal knowledge from these disciplines, they believe that someone else is to resolve such problems, while their task is just to rent high quality CSI&SE and Mathematics experts to resolve the problems. Study programs from this category motivate learning a highly formalized knowledge from CSI&SE and Mathematics rarely. By this, we name this behavioral pattern as “Let me follow the things globally and rent experts for strong and formal details”.

Literally, we may say that the three identified behavioral patterns form “a universe of not joinable worlds”. As such, a question arises (Q1) Whether such, traditional approaches to teaching selected Data Science topics can produce the appropriate experts capable of resolving complex engineering problems by the utilization of big data volumes and technologies, as well as formal modeling and data analytics methods? A derived question is (Q2) Who is capable of creating study programs that will successfully provide interfaces between all required disciplines in resolving complex organizational problems by a support of software systems?

A possible approach to addressing these questions is to profile specific study programs in the scope of CSI&SE that will nurture the appropriate level of interdisciplinarity and contribute to resolving the following two paradoxes:

(P1) More interdisciplinary oriented experts, capable of covering a wide range of tasks, knowledge and skills are always significantly better positioned in the software industry HR market, while academic institutions offer study programs that are rather self-closing, i.e. oriented to a narrower knowledge scope.

(P2) Students or young software engineers believe that they will be better positioned in software industry HR market just as they are good IT experts, i.e. programmers, while employers rather expect experts capable of recognizing and resolving their interdisciplinary oriented and complex requirements.

Following our previous teaching experiences, modern trends in many recognized world-wide universities, as well as the results obtained from the survey of software industry needs for Data Science experts already presented in [1], as well as in Sections 4 and 5 of this paper, we believe that the answer to the Q1 question is that the approaches to teaching selected Data Science topics through traditional CSI&SE, Mathematics, Economics, Business Administration and Management study programs are not enough to address the aforementioned paradoxes. As an answer to the Q2 question, we believe that profiling specific Data Science study programs in

the scope of CSI&SE can successfully address the aforementioned paradoxes.

### 3. ACADEMIC EDUCATION IN DATA SCIENCE IN SERBIA

Apart from traditional study programs in CSI&SE in Serbia, the new initiatives for academic education in Data Science are implemented in recent years.

(A) Faculty of Technical Sciences from University of Novi Sad accredited the new study programs in Data Science in April 2015, and to the best of our knowledge, it was the earliest initiative for such study programs in Serbia and the neighboring countries, and even a very early initiative in a wider area. Those are: B.Sc. level 4-year study program in Information Engineering (240 ECTS), followed by the two M.Sc. level study programs: 1,5-year Information and Analytics Engineering (90 ECTS) and 1-year Information Engineering (60 ECTS). With an unexpected delay of two years, finally in the 2017/18 school year, Faculty of Technical Sciences initiated the first execution of the two study programs: Information Engineering at the B.Sc. and M.Sc. levels. In upcoming years, we expect initiation of the M.Sc. study program in Information and Analytics Engineering.

Apart from Information Engineering, Faculty of Technical Sciences performed in March 2018 minor changes in 1-year M.Sc. study program in Computing and Control, by including a new group of courses in High Performance Computing. The first execution of the courses in High Performance Computing is planned for the 2018/19 school year.

(B) Faculty of Sciences from University of Novi Sad accredited the new 2-year M.Sc. study module in Data Science (120 ECTS), in September 2016, in the scope of Study program in Applied Mathematics. Faculty of Sciences initiated its first execution in the 2016/17 school year. Today, it is the Study program in Applied Mathematics – Data Science, offering the two study modules: Data Analytics and High Performance Computing. To the best of our knowledge, Faculty of Sciences was the first institution initiated the execution of a Data Science study program in Serbia, as well as the first institution including the module in High Performance Computing in such program.

(C) Singidunum University from Belgrade recently accredited the new 1-year M.Sc. study program in Data Science (60 ECTS), and has opened a call for its execution in the 2018/19 year.

All the aforementioned initiatives deserve a careful attention, at least as they represent the first attempts, not only at the level of Serbia, to cover Data Science in a comprehensive way, with specific study programs. By this, Serbia has a

chance to keep up with current trends in well-developed countries, in which such initiatives are considered carefully in recent years [3, 6].

#### 4. DATA ACQUISITION FOR THE SURVEY OF INDUSTRY NEEDS FOR DATA SCIENCE

So as to test the hypothesis about the importance of creating specific study programs in Data Science, in November 2016 we performed a short survey of the current state and needs of software companies in Serbia for the knowledge and experts in this discipline. We examined, in what extent it is already present or will be present in Serbia. [1]

The survey was based on a data acquisition process performed via anonymous web-based questionnaire that was filled in by managers from Serbian software companies. The form of anonymous questionnaire was selected to raise the level of data faithfulness in the acquisition process. We favored the anonymity criterion against the need of acquiring the exact data about respondents, their working and education profiles, as well as companies they belonged to. We believed that such a decision was not significantly violated validity of the acquired data. On the other hand side, we were aware that the potentials of acquired data for future analyses would be much greater otherwise, if we would acquire those exact data. Therefore, it is a matter of further research to repeat the same or similar survey in a couple of years, but this time by collecting exact data about respondents, and compare the results of different time snapshots and discover the patterns and trends in the area of Data Science industry applications and requirements.

With respect to the profile of a target group of respondents – often overwhelmed managers in software companies, we decided for a questionnaire of a short form that provides fill in the data in the time not longer than app. 10 minutes. The questionnaire contained 16 questions, from which 4 were in the form of a check list of already offered answers (a respondent may select as many answers as she or he likes), 9 in the form of a radio group of already offered answers (a respondent must select just one answer), while 3 were optional free text comments.

The questionnaire had three thematic groups of questions. The first group of 6 questions was related to the company profile of a respondent, profile of employed workers, implementation of projects in the area of Data Science and Business Intelligence (BI), employed workers educated in Data Science, and finally company current and future needs for hiring new experts in this discipline.

The second group consisted of 4 questions, related to the discipline of Data Science: if it is possible to acquire enough educated experts, which problem domains are the most attractive for Data Science applications, and what is a maturity level of this discipline in Serbia and in Serbia with respect to the regional countries.

The third group consisted of 5 questions, related to the academic education in Serbia: if there are specific study programs in the discipline of Data Science, what university or faculty in Serbia and abroad is favored by a respondent, if there are needs for education of specific experts in this discipline, and if there is a need for development and initiation of specific academic study programs.

The last, 16<sup>th</sup> question was a free text comment of a respondent, motivated by a need to report some additional message related to this research topic. In the data acquisition process, we collected 34 duly completed questionnaires.

#### 5. SURVEY RESULTS AND DISCUSSION

Declared company profiles for a majority of respondents are related to the area of planning and development of software products and architectures (67,6%), as well as consultancy services in the area of software and system engineering (44,1%), or both. (The respondents could select here multiple answers.) Declared company needs for experts in CSI&SE are predominantly related to the general purpose programmers capable of participation in various IT projects (70,6%), programmers with specific knowledge in target application domains covered by companies (67,6%), while the needs for Data Science engineers are placed as 4<sup>th</sup> in order by the number of selected answers (32,4%). The respondents could also select here multiple answers. The normalized results shown in Fig. 1 better express relative ratios of various options. E.g., we notice that the requirements for Data Science engineers are approximately four times less than the requirements for programmers, as it is expectable in practice.

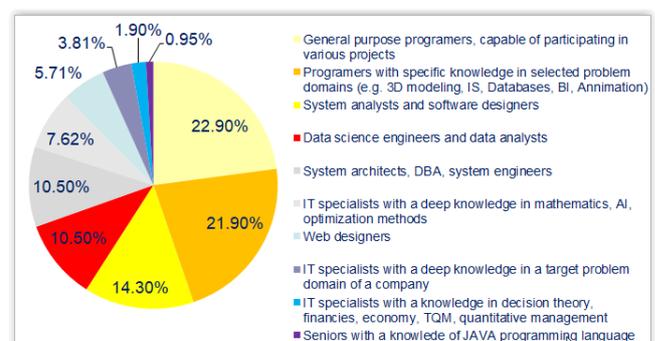


Figure 1. Declared needs for HR in IT companies

For two questions: Whether in your company are already implemented or will be implemented

projects in the discipline of Data Science, and then, Business Intelligence and Information Engineering, we obtained almost identical answers: about 50% of respondents declared that such projects are already implemented, or the implementation of such projects is initiated, while 29% of them declared that their companies have exact plans or clear intention to initiate such projects, while just in 24% remaining cases, such projects are not seen as close to the company goals, as shown in Fig. 2.



Figure 2. Data Science projects in IT companies

26.5% of respondents declared that their companies already have developed HR resources, necessary to implement the projects of such types, while 47% respondents declared clear intention or exact plans of their companies to develop such HR in the next 5 years. 26.5% of all respondents only, declared the absence of any need in their companies for HR of such type. As we asked about the existing plans in companies for employing new academic educated experts in Data Science, 67.5% of respondents declared clear needs or already existing plans that are to be implemented now or in the near future, where the number of required experts is qualified in the range from 5 to 50, as shown in Fig. 3. Only 6% respondents believe that hiring such experts is not close to the company goals, while the remaining 26.5% of them is not informed about such plans in their companies.



Figure 3. Requirements for hiring Data Science experts

44.1% respondents believe that it is not possible to acquire easily experts in Data Science, where some of them believe that such experts can be imported from abroad. However, 20.6% of them

believe that the needs for such experts significantly outperform the current HR market capacities and that their import is not a long-lasting and sustainable solution. 29.4% of respondents believe that it is possible to acquire such experts, despite that it is not easy, while there is no answer at all, committing that the number of such experts on HR market is enough to meet the company needs. See Fig. 4 for more details.

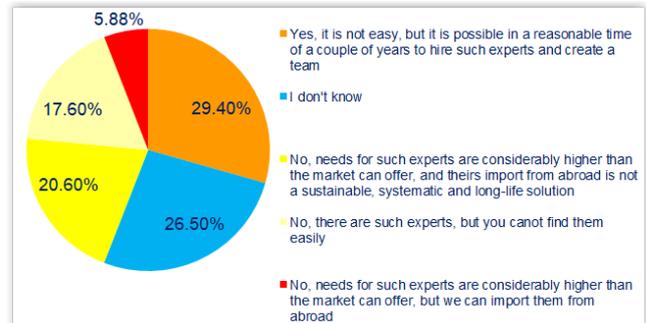


Figure 4. Availability of Data Science experts on the HR market

As the three most attractive application domains of Data Science, the respondents declare: a support of strategic and tactical company management in the decision process, financing, and telecommunication and Internet services. See Fig. 5 for more details.

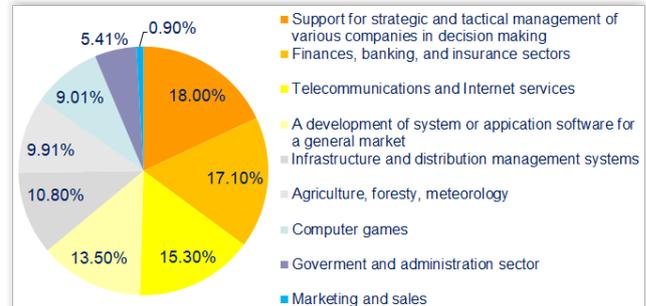
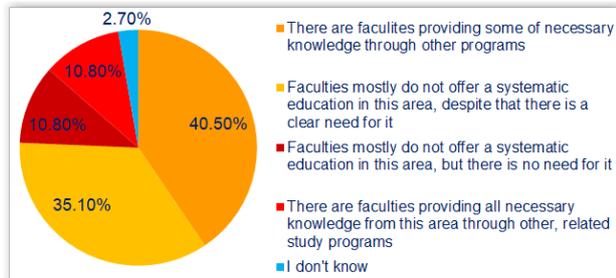


Figure 5. The most attractive application domains of Data Science

In regard to the maturity level of this discipline in Serbia, the most of respondents (70.6%) believe that there are many talks about Data Science, while there are still no tangible results on the market, or that the discipline is still in an early development stage, with high future expectations. The most of respondents (61.8%) are not familiar with the maturity level of this discipline in Serbia in comparison to the regional countries. The half of remaining respondents believe that Serbia is on a higher maturity level, while the other half believe that Serbia is on a lower maturity level in comparison to the regional countries.

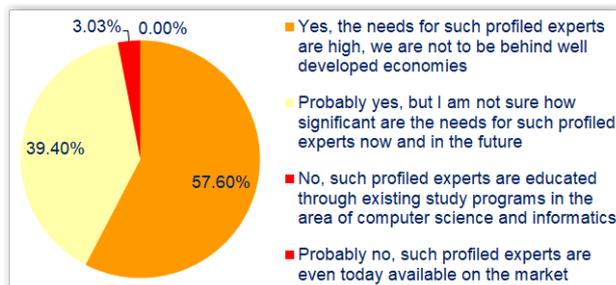
The most of respondents believe that there are faculties in Serbia offering some of required Data Science knowledge through other study programs (40.5%), or that faculties predominantly do not

offer systematic education in this discipline, in spite of a strong need for it (35.1%), as shown in Fig. 6. A number of selections of the answer declaring that there are faculties and study programs considerably covering Data Science, or there is no need for such knowledge, and finally there are faculties offering all the required knowledge through other, similar study programs is practically non significant.



**Figure 6.** Coverage of Data Science by current study programs in Serbia

Finally, 97% respondents believe that there is a need to develop academic study programs in Data Science in Serbia.



**Figure 7.** Needs to develop academic study programs in Data Science in Serbia

To summarize, we may estimate that a significant number of IT companies in Serbia, more than three quarters of all the companies, identify their strong requirements for completing Data Science projects and hiring Data Science engineers. As expected, the number of required Data Science engineers is not as huge as for general purpose software engineers. However, many companies declare their plans to hire Data Science engineers at the level of more than 5, and even up to 50 such experts. Majority of respondents notified a lack of available Data Science engineers in the HR market, and evident difficulties in acquiring the required number of such experts. They believe that current study programs in Serbia do not produce Data Science engineers having all the required knowledge, and recommend creating specific study programs in Data Science, as the needs for such expert will significantly emerge in a near future, while the discipline of Data Science is seen as one of the most promising in IT sector, in general. Since the needs for Data Science engineers are not as huge as for general purpose

software engineers, study programs in this discipline are not to be massive in terms of the maximal number of allowed students, i.e. they should be designed for a smaller number of students.

## 6. INFORMATION ENGINEERING PROGRAM AT FACULTY OF TECHNICAL SCIENCES

Our strategic decision in creating study programs in Data Science at Faculty of Technical Science was to cover both B.Sc. and M.Sc. academic levels. Also, we decided to design a study program for a maximum of 60 students, as the intention was not to create a massive study program. The main goals were to create a curriculum covering a body of knowledge of Data Science and Information Engineering, necessary to support information management in organization systems. The curriculum should provide a body of knowledge applicable in a wide variety of organizations of all types, or even in scientific applications. It should cover a wide range of aspects of information management, typically required by many stakeholders. It is supposed to nurture both interdisciplinary and formal approaches, where typical expected formality is at the level of mathematical rigor, whenever is possible. As Data Science is highly application oriented discipline, we decided to provide Financial Engineering, as the first application domain. Also, we left the room open for further development of various application domains.

We designed the Information Engineering study programs in a way to satisfy the following main didactic principles: a) Abstraction and Formalization, b) Quantification and Metrics, c) Specification and Implementation, and d) Communication skills. Abstraction and Formalization skills develop students' ability to understand and formalize application domain knowledge, problems and requirements, as well as to create meta-models, languages, concepts, or any kind of formalisms necessary to provide modeling of any knowledge in systems being observed. Quantification and Metrics skills develop students' ability to quantify, measure, analyze, simulate, and optimize anything that is required in any business or research, by comprehensive methods. Specification and Implementation skills develop ability to efficiently specify, develop, implement, and apply any software to address various information management requirements in business or research. Communication skills develop ability to successfully communicate and negotiate with other professionals, having different levels and range of knowledge.

Our intention is not to present here the whole study program structure, with a complete list of all designed courses. However, we just point out to the main disciplines, covered in a larger or smaller

extent by these study programs. They include the following disciplines.

*Computer Science, Informatics, and Software Engineering*, covering in detail all core CSI&SE disciplines according to the ACM and IEEE Computer Science curricula, and also including Formal Methods, Computational Intelligence and Machine Learning, Human-Computer Interfaces, Software Engineering, and Information Systems.

*Applied Mathematics*, including traditional disciplines for engineers, such as Calculus, Algebra, Numerical Calculations, and Probability Theory, as well as modern disciplines, such as Discrete Mathematics, Combinatorics, Logic, Graph Theory, Statistics, Operational Research, and Optimization Methods.

*Economics, Communicology, and Management*, covering the basis of Finances, Entrepreneurship in IT sector, Risks in Investment Management, Decision Theory, Business Intelligence, and Communicology, with the elements of Industrial Psychology.

*General Engineering Disciplines*, such as Mechanics, Time Series Processing, and Information Theory.

Apart from mandatory courses in the first two years, students can profile themselves better according to their affinities, by selecting some of elective courses in 3<sup>rd</sup> and 4<sup>th</sup> year, organized in the two main tracks: Analytical Engineering and Applied Information Engineering.

At the M.Sc. level, a pool of more than 55 elective courses is offered, covering the disciplines of Data Science, Information Engineering, High-Performance Computing, and Financial Engineering. By this, we offer many possibilities for students to profile themselves, according to their affinities, or already having jobs.

## 7. CONCLUSION

Following available information on development of Data Science discipline all over the world, development of study programs at recognized universities, as well as the survey presented in this paper, we conclude that the existence of specific study programs in Data Science is a strong necessity. Faculty of Technical Sciences addressed it by the new study programs, created both at the B.Sc. and M.Sc. levels. Our first experiences collected from the program execution in its first year, show rapidly increasing interest and motivation of students for such discipline. Even the students of the first year of B.Sc. studies show a strong awareness about the importance of the Data Science discipline in their future career.

Characteristic textual comments of our respondents in a completed survey presented in this paper also clearly stress the aforementioned conclusion, and therefore we quote the three of

them here. 1) "This is a unique opportunity for Serbia to become, by means of proper engineer HRs, a main exporter of such services in the region or wider, as education in the whole world is in a delay to the needs of global market, and it creates this unique opportunity for us." 2) "Those disciplines are at the early beginning in Serbia. Demands for HR are increasing, while there is a lack of high quality experts. I expect an enormous increase of market offers and demands." 3) "Analytics culture in Serbia is low and organizations do not recognize the importance of BI and how to utilize such data. It is to work on raising organization education, as today business analysis comes down just to operational reporting."

## ACKNOWLEDGEMENTS

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# New approaches in designing educational assessment instruments and its use in international studies: What's new in PISA 2018?

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**Abstract:** *The intention of this paper is to present the content and structure of the international assessment of student achievements (OECD/Programme for International Student Assessment) and, in particular, innovative solutions in the testing techniques, competencies chosen to be assessed and contextual variables. All testing material is in the computer-based format which opens up new possibilities in assessing cognitive processes that are needed to solve tasks. Besides regularly assessed reading, mathematics and scientific literacy, new testing domains are financial literacy and global competence. A part of test material (in the domain of reading literacy is based on multistage adaptive testing design, which increase the informative value of achievement data. Among number of contextual factors, students are asked to perceive their well-being exploring. Looking for students' feelings related to usual, everyday situations and activities, it is possible to conclude what they need to live happy and fulfilling life. Finally, the use of log file in order to define students' problem-solving strategies is discussed.*

**Keywords:** *assessment; education; adaptive testing; literacy; student achievement*

## 1. INTRODUCTION

OECD/PISA is currently the most comprehensive and the most referential international survey in the field of education. Its implementation has been organised by the OECD since 1997, in three-year cycles, with growing number of participating countries. In the 2018 study, over 600,000 students from over 80 countries, which make 87% of the world economy, have took part, among them over 8000 students from Serbia.

Based on PISA survey it is determined to what extent students, near the end of their general education period, have adopted knowledge and skills that are important to them in order to be successful in their professional and personal lives. Students are not only expected to reproduce acquired knowledge, but also to apply it in different, relevant situations outside the school. It is usual to use in PISA surveys the term literacy or competence instead of knowledge: be literate is about the knowledge considered to be the basic education capital that students need in order to continue with their education and to be successful

in their personal and professional roles they will find themselves in as adults. Be competent in this study does not mean only that someone has acquired appropriate knowledge, but also that he/she knows when and how to apply it. In other words, the emphasis is on functional knowledge, and all the tasks in the tests are related to real situations students may encounter (Pavlovic Babić & Baucal, 2013).

The basic research interest is not founded on the assessment of the extent to which knowledge foreseen by the curriculum has been adopted; it is rather based on whether students are able to use that knowledge and how. Adoption of literacy is a life-long process that does not take place only in school and exclusively through formal education, but also through interaction with parents and other adults, interaction with peers, media, direct and broader environment. One cannot expect fifteen-year-olds to have learned everything they would need as adults, but they should have a solid knowledge from key areas that will enable them further development and adoption of competencies. They also need to understand the fundamental processes and principles and to use them flexibly in various situations (OECD, 2013). PISA, therefore, measures how able the students are to respond to requests relevant for daily life and

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to understand key concepts, and does not assess adoption of knowledge specific for a certain area.

Originally, tests were developed in paper-pencil format, but, lately, the format is changed into computer-based. Old items are transformed, and new ones developed to fit this format. Since the 2018 cycle, Serbia is participating in computer-based assessment, as well as the largest number of other participating countries.

But, apart from changing the test format, the 2018 cycle also brought some more innovations regarding test content, structure or format. The purpose of this paper is to present these innovations and new opportunities for researchers and practitioners.

## **2. STRUCTURE OF THE TEST: COGNITIVE DOMAINS**

Since from the first study, conducted in 2000., achievements in three cognitive have been assessed: reading, mathematics and science literacy. In full range, test consists of 442 items in these three domains. As in every cycle, one of the testing domains is in the focus. This means that that one is examined in more detail, assessing student achievement in a number of subdomains. In the cycle 2018, this position belongs to the reading literacy, covered by 245 items, organized in 4 subdomains.

The structure and, consequently the number of test items, are defined by several dimensions, such as competencies (e.g. in Scientific literacy: Evaluate & design scientific enquiry, Explain phenomena scientifically, and Interpret data & evidence scientifically), situations (personal, public, occupational, educational), levels of achievement (usually 6 levels per domain are defined), text format (linear, non-linear, interactive, multiple).

In order to cover all these dimensions, a lot of items are needed. The PISA study uses a balanced incomplete block (BIB) design testing (Johnson, 1992, NAEP, 2001). BIB design has been developed for the needs of a large-scale testing in which the aim is to test a broader range of competencies or content, and to limit the time of examination subjects in a short time (2 to 3 hours). To obtain a reliable measure of the level of individual competence, a relatively large number of items are used. To reduce each respondent's test timing into the realistic framework, a set of items is divided into a number of blocks, and blocks are connected to a specific scheme in the brochure. Thus each booklet contains only a part of the items, which are chosen in a way that each brochure's content overlaps with several other brochures. The use of BIB designs has enabled the use of IRT techniques to analyze the data (Birnbaum, 1968; Lord, 1980, Bond & Fox, 2007).

Assessing literacy in reading, mathematics and science is comprehensive part of the PISA study. But besides these domains, the participating countries may choose to participate in the assessment of some other domains, also estimated as relevant for the educational status of young people. In this cycle, participating countries could choose to assess achievements in the field of financial literacy and global competence. Serbia chose to participate in both of these assessments.

### **2.1. Financial Literacy**

In recent years, the awareness about the importance of financial literacy for the professional and everyday life of citizens has been increased, as well as the responsibility of the education system to cultivate this knowledge on a systematic way. Some prominent global trends underpin the rising interest in financial literacy as a key life skill, such as: transfer of risk from governments and employers to individuals, increased individual responsibility for financial decisions, growing numbers of consumers and increased number of available financial products and services.

PISA conceives of literacy as the capacity of students to apply knowledge and skills in key subject areas, and to analyze, reason and communicate effectively as they pose, solve and interpret problems in a variety of situations. PISA is forward-looking, focusing on young people's ability to use their knowledge and skills to meet real-life challenges, rather than merely on the extent to which they have mastered specific curricular content (OECD, 2010).

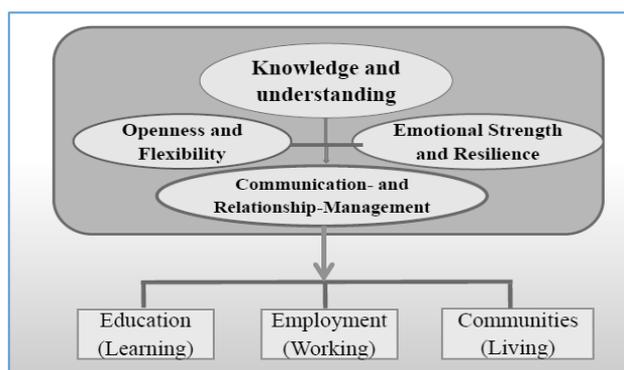
Information about background, non-cognitive factors of achievement in the field of financial literacy is collected by a short student questionnaire. Items address aspects of the following areas identified as key areas: access to information and education; access to money and financial products; and spending and saving behavior. The questionnaire consists of a small number of questions that explore the range and types of students' interest in and their experience with financial matters.

Besides Serbia, 20 more countries are participating in students' assessment of financial literacy, such as Australia, Bulgaria, Brazil, Canada, Chile, Spain, Estonia, Finland, Georgia, Indonesia, Italy, Lithuania, Latvia, Netherland, Peru, Poland, Portugal, Russian Federation, Slovak Republic, and United States.

### **2.2. Global Competence**

Can you deal with uncertainty? Can you deal with ambiguity? Are you ready to engage in different value systems? Are you competent to make sound judgements?

This type of competence is called Global competence and, first time from the beginning of the PISA assessment, will be evaluated in this cycle.



**Figure 1.** *Global competence: Dimensions and contexts*

Global Competence is defined as the capability and disposition to act and interact appropriately and effectively, both individually and collaboratively, when participating in an interconnected, interdependent and diverse world. This is a draft definition, and the construct will be more precisely defined and described in upcoming research report.

The draft definition shows that the construct is highly saturated with personal attitudes and values. Four dimensions are relevant for understanding the General competence, those are: Knowledge and understanding, Emotional strength and resilience, Communication and relationship-management, and Openness and Flexibility. Items are situated in three contexts: Education (Learning), Employment (Working), and Communities (Living).

Besides Serbia, 31 more countries are participating in students' assessment of global competence, which clearly show the interest for this competence as an educational outcome.

Despite the expressed interest, it is questionable to what extent the data collected will be suitable for the interpretation and formulation of educational policies. Without the pilot study we do not know is the construct well conceptualized (the question of construct validity), is it well differentiated in relation to related concepts and is it well operationalized for measurement needs.

### 3. BACKGROUND VARIABLES

Along with knowledge tests, questionnaires for students and schools are also used. They are used to collect information on different factors that may be relevant for performance, e.g. material and educational resources families have; students' view on learning, motivation for learning, strategies and habits in relation to learning; students' ability to apply modern information technologies, school's contribution to computer literacy; different aspects of school operation such as: characteristics of

teaching staff (level of education, professional motivation, styles of work), size of a class, composition (homogeneity or heterogeneity), atmosphere in the classroom and the school, attitude of the teaching staff towards students, sense of belonging to the school, school anxiety; material resources of the school, mode of financing (public or private), management and decision-making process, involvement of parents in processes and decision-making in the school, etc.

Based on the information from the questionnaires, it is possible to link student performance to students' and schools' characteristics and identify the most relevant factors of achievement.

Besides the student questionnaire, five more questionnaires are administrated: 1. Use of informative technologies (in school and at home), 2. Plans for educational career, 3. Questions about experiences with financial means and institutions, 4. Questionnaire about multicultural and global topics' experiences (which follows assessment of Global competence), and 5. Students' well-being questionnaire. Two last ones are newly developed and first time administrated. These questionnaires will be described in more detail.

Questionnaire for parents is also developed, but Serbia does not participate in this option.

Schools (principals) are asked to fulfill the school questionnaire which covers topics such as: Resources, human and materials, Decision making, including financial decision, Participation of students and parents, Assessment, including reporting to parents.

#### 3.1. Global competence questionnaire

Some global developments, challenges and trends are recognized as important and students are asked to demonstrate how they understand their causes, implications, and / or possibility for change. They are asked about their personal experience with topics like: the student's engagement with others about global events/issues (e.g. chat online), extent of exposure to/awareness of global developments/challenges/trends (e.g. via news, other media). The second topic is migration/movement of student, for example: the student's own background; the student's experience living abroad; the possibility of the student working/studying abroad in the future; demographics in his/her community from other countries/cultures. The third topic is student interaction with or exposure to people from other countries/cultures; student's travel experience; student's degree of curiosity/ motivation to travel.

#### 3.2. Students' Well-being questionnaire

Students' well-being refers to psychological, cognitive, social and physical functioning that students need to live happy and fulfilling life. Numerous recent research shows that the sense of

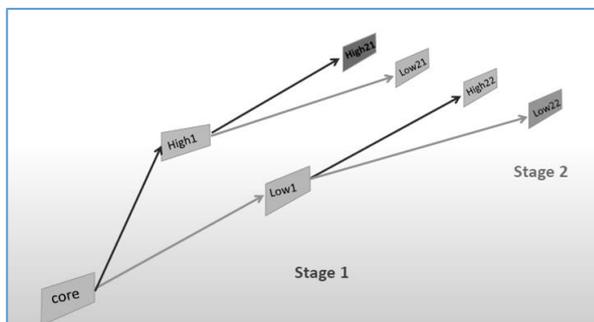
well-being correlates significantly with his/her achievement in the academic sphere, but also with other indicators of success and good adaptation, e.g. in an emotional or social sphere. So, the evaluation of the students' well-being must be sensitive to both their actual or present states and achievements.

The questionnaire consists of a small number of questions exploring students feeling related to usual, everyday situations and activities, for example, feelings during math classes, on the break, while doing homework or physical activities.

#### 4. ADAPTIVE TESTING

Computerized adaptive tests (CATs) are a sophisticated method of test delivery based on item response theory (IRT). They operate by adapting both the difficulty and quantity of items seen by each examinee (Way, Twing, Camara, Sweeney & Mazzeo, 2010).

Considered to be on the leading edge of assessment technology, computer-adaptive tests represent an attempt to measure the abilities of individual students more precisely and to get more information about student' ability. Computer-adaptive tests try to match the knowledge and ability of a test taker. Basically, there's a simple strategy in test design: if a student gives a wrong answer, the computer follows up with an easier question; if the student answers correctly, the next question will be more difficult, as it is showed in Figure 2.



**Figure 2.** Paths in multistage adaptive testing, basic model

There are a lot of advantages if the adaptive testing is used. From the student perspective, this is more efficient way since it is time-saving. It will take less time since only those questions considered appropriate for the student are offered. The most current forms of computer-adaptive testing are typically administered online, and because the scoring is computerized, teachers and students can get test results more quickly than with paper-pencil tests. That way, the pool of items needed for test is much smaller, which means less time for test development and/or smaller number of item writers.

From the perspective of data use, a wide range of benefits is provided using adaptive testing: shorter tests and reduction of cost and examinee fatigue; more precise scores; more control of score precision (accuracy) which makes the test much more fair while traditional tests measure the middle students well but not the top or bottom students; greater test security because everyone is not seeing the same form; a better experience for examinees, as they only see items relevant for them, providing an appropriate challenge which can increase students' motivation; immediate score reporting; more frequent retesting is possible; individual pacing of tests; examinees move at their own speed; storing results in a database immediately makes data management easier.

#### 5. USE OF LOG FILES

In PISA 2018 cycle is possible to analyze log files for computer tested reading items.

Basically, log files could have only limited number of information: 1. Variable „time“ corresponds to the time when the event was written to the log file. This is measured in seconds, and 2. Variables „event“, „event\_value“ and „event\_detail“, together, can be used to describe the activity of students or the system during the test. Those activities are: start item, end item, click, double click.

Although it is possible to extract only a limited number of information, their significance for understanding the work strategies and their effects on the achievements, is potentially high. Some researcher confirmed that a general indicator of the motivational level could be predicted from very basic data commonly recorded in log files (Cocea, & Weibelzahl, 2007). Within PISA assessment some analysis of relationship between time spent on the task and success in task solving has been done (OECD, 2015).

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# **Session 1: Technics, Technology and Informatics in Education**

**Notes:**

# Application of interactive whiteboard in the consideration of concepts pollination and pollinators

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**Abstract:** *Teaching biology is characterized by a great number of concepts and facts. Particularly, it is very important that students understand the role of insects (especially insect pollinators) and their importance in nature. In order to effectively present important concepts such as pollination and pollinators, interactive white board (IWB) can be used. In this paper, an analysis of the efficiency of application of an IWB in the biology teaching was presented in terms of attained knowledge among students. In particular, the pedagogical experiment with parallel groups was applied to determine whether the IWB was effective as teaching technology compared to the usual teaching approach without this technology. The E group covered programme content related to pollination and pollinators by applying IWB. The C group was exposed to the same content, without IWB in teaching process. It was evidenced a difference of the attained knowledge in favor of the experimental group after the introduction of the experimental factor (application of IWB). The application of IWB directly contributed to better learning and knowledge acquisition in teaching the biology content Pollination and Pollinators. It was concluded that IWB are determined as very effective teaching technology.*

**Key words:** *interactive whiteboard (IWB); biology teaching; insect pollinators; pollination; elementary school*

## 1. INTRODUCTION

The interactive board is an information and communication technology [12]. It is an electronic device that allows interactive work with the computer directly connected with the table by clicking on the projected image with an interactive pen or finger [11]. Information is sent from the board to the computer for further storage, or in the form of a command that is projected in a fraction of a second on a board. The image is controlled by a computer and it serves as a curtain on which information is continually designed and as a generator of feedback into the computer system [15]. It can be distinguished two types of IWBs from the point of view of the projection direction, those with the front projection and those with the rear projection. They can also be divided into static, mobile, and portable in relation to the way they are connected and set up. Connection of the board can be provided via USB cable or wireless [3].

The interactive whiteboard (IWB) is part of information and communication technologies (ICT) which enhances learning and teaching and is able to combine a lot of beneficial features of ICT in one medium [7]. It was considered that interactive

whiteboard is a large touch-sensitive and interactive display that connects computer and projector. The use of IWB in the classroom can make a difference for students who have trouble with thinking abstractly in abstract subjects, because it makes the teaching/ learning process more concrete, when using the features of the IWB [4]. Within the context of using the interactive whiteboard in the teaching and learning of Science, many surveys emphasize the effectiveness of using this technology tool to improve students' capacities and teachers' professional development [16].

In the traditional frontal form of teaching, the student is passive and oriented to lecturing professors and capturing notes, while in interactive teaching it is much more active. There are few studies based on the presentation of good practices on integrating IWB in teaching science, where teachers can promote an interactive learning and stimulate students' creative potential [18].

The wide spread introduction of IWB technology and screens into classrooms, makes the multimodal resources of color, image, dynamic movement, and sound available for pedagogic design in newly connectable ways. These facilities present teachers with new questions about how to design and use

teaching materials, new possibilities and constraints [8].

An IWB represents an important turning point in the classroom around the world and researches by numerous authors suggest that if properly used they could have a positive effect on student results [19].

### **1.1. Application of IWB in the assessment of the terms pollination and pollinators**

Pollination is a fundamental, essential process in any ecosystem that allows reproduction of plants and the production of food for humans and animals [10], [17].

Pollinators are a key component of global biodiversity, providing vital ecosystem services to crops and wild plants [14].

Among animal pollinators the most effective are insect pollinators. In addition to numerous insect pollinators, bees have the greatest effect. When most people think of bees, they mostly think of the honey bee. The honey bee is the principal species used for honey production and crop pollination. Although honey bees pollinate a wide variety of crops, they are often relatively ineffective pollinators. Apart from honey bees, solitary bees are used for pollination. Efficiency in pollinating fruit trees of one female solitary bee can be compared with the efficiency of 120 honey bees. Also, in the process of collecting pollen, solitary bees cross the pollination, which enables a better and higher yield of fruit [17].

There is clear evidence of recent declines in both wild and domesticated pollinators, and parallel declines in the plants that rely upon them [14]. The decline of pollinator populations is one form of global change that actually has credible potential to alter the shape and structure of terrestrial ecosystems. Pollinator declines can result in loss of pollination services which have important negative ecological and economic impacts that could significantly affect the maintenance of wild plant diversity, wider ecosystem stability, crop production, food security and human welfare [1]. This has led to demands for a response by land managers, conservationists and political decision makers to the impending 'global pollinator crisis'. In questioning this crisis, it becomes apparent that perceptions of a pollinator crisis are driven mainly by reported declines of crop-pollinating honeybees [5].

Results of recent studies and experts in pollination ecology confirmed that losses of honey bee and other bee colonies leave us in the uncertainty of survival in terms of food and life as a whole [14]. Based on the aforementioned importance of the concepts of pollination and pollinators, there is an urgent need for their complex interactive presentation. In that sense, the application of IWB would be very appropriate.

## **2. THE AIM AND METHODOLOGY OF RESEARCH**

The aim of this research was to determine whether the IWB is effective as teaching technology compared to the usual teaching approach without this technology, in terms of acquiring knowledge of the programme content of pollination and pollinators in elementary school. The task of the research was to determine and measure the difference in acquiring student knowledge by applying these didactic models and comparing the efficiency of these models.

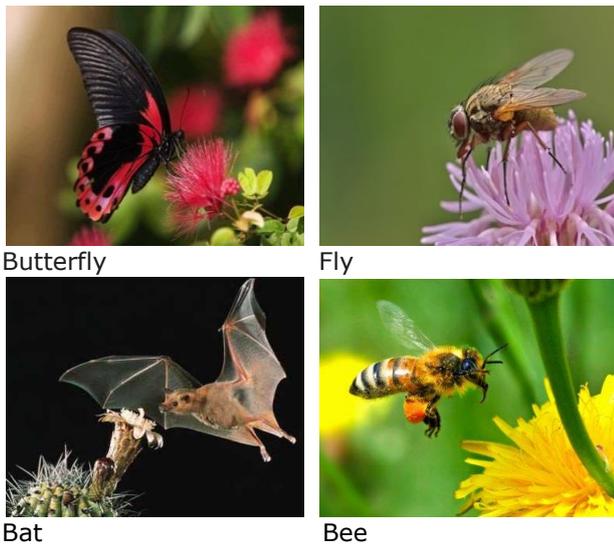
The basic zero hypothesis from which it proceeded is that there is no statistically significant difference in achieving results in master content between the students of the control and experimental group after the introduction of the experimental factor (application IWB) into the experimental group.

An alternative hypothesis was: there is a statistically significant difference in master content of Pollination and Pollinators between the experimental and control group after the introduction of the experimental factor (IWB) into the experimental group.

The difference in the quality of acquired knowledge between the experimental and control group of students is expected in favor of the experimental one. The pedagogical experiment with parallel groups was applied [9].

The research involved 64 students of the sixth grade of elementary school (Elementary school Nikola Tesla, Belgrade, municipality Rakovica), who were divided into one experimental (E) and one control (C) group. The E group covered programme content related to Pollination and Pollinators by applying IWB. The C group was exposed to the same content, without these innovations in teaching process.

Before the introduction of the experiment (IWB) in experimental group, the groups were made uniform concerning the number of students, gender and general knowledge of biology, as determined by the results of a pre-test of knowledge. The test was related to all the program content that preceded the teaching field of Pollination and Pollinators. The pre-test included tasks classified into three broad categories of the cognitive domain [2]. The maximum points that student could score on the test was 100. After equalizing the experimental (E) and control group (C), group E was taught the prepared programme content Pollination and Pollinators by applying IWB. Within the figure 1, 2, 3 and 4, the look of the IWB is presented in the realization of this content for the E group. Different types of animal pollinators were shown at the beginning of the introductory part of the school class (Fig. 1).



Butterfly

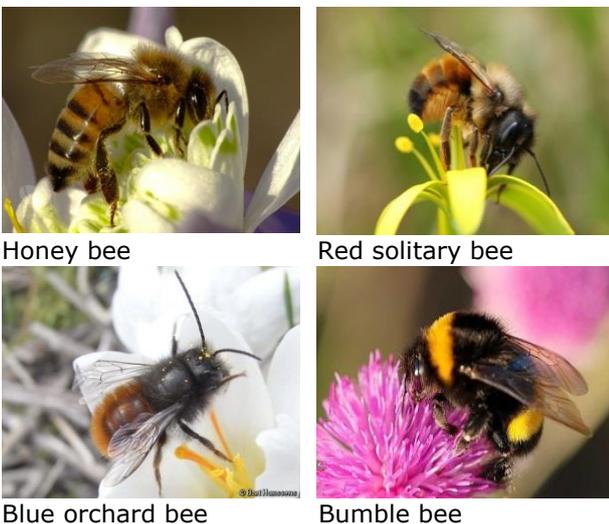
Fly

Bat

Bee

**Figure 1.** Animal pollinators

Also, the different types of pollinator bees have been discussed (Fig. 2).



Honey bee

Red solitary bee

Blue orchard bee

Bumble bee

**Figure 2.** Insect pollinators

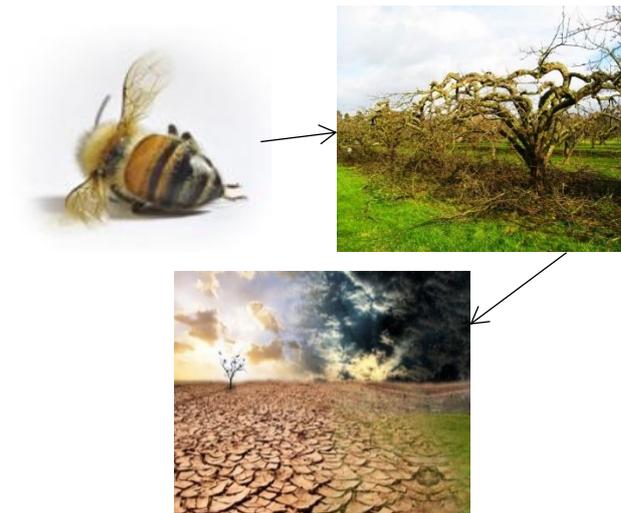
Students had the opportunity to see the differences between honeybee and solitary bees (Fig. 3), as well as the consequences of declines of pollinators (Fig. 4).



Community of honeybee's

Solitary bee

**Figure 3.** The difference between the honey and the solitary bee



**Figure 4.** Consequences of pollinator declines

Flipchart software made it possible to organize those teaching materials through the pages that are not visible simultaneously, but it was easy to display them again, with the ability to print concepts below the presented photos.

The students in Group C were exposed to the usual teaching approach without IWB for the same teaching content. Teaching methods that are used are oral presentation, illustrations and demonstrations. Also, students didn't have opportunity to see photos of pollinators and schema of pollinator declines. After that, a post-test was distributed in order to evaluate the knowledge acquired by the students who were learning by using IWB and those exposed to the usual teaching approach without this technology. This test measured the quantity of the students' knowledge only in the teaching field Pollination and Pollinators. Like in pre-test, there was the same number of the tasks and the maximum points that student could score was 100.

### 3. RESULTS AND DISCUSSION

The results of the pre-test are presented in Tables 1 and 2. The standard statistical indicators (mean of the number of achieved points-M, standard deviation-SD and coefficient of variation-CV) are presented in the table 1.

**Table 1.** Basic statistical data for the pre-test

Group	M	SD	CV
E	38.5	13.18	0.34
K	41.1	13.82	0.33

Table 2 shows relations between E and C group, according to t-value (for pre-test).

**Table 2.** Relations between E and C group, according to t-value (for pre-test)

Relation	t
E: K	0.40

Based on the results presented for the pre-test for Groups E and C, it can be observed by using Student's t-test for a significant level of  $p=0.05$  and a critical value of  $t=1.96$ , that there is no statistically significant difference in the achieved number of points between Groups E and C (Total:  $t=0.40 < 1.96$ ). These two groups were balanced in terms of their general knowledge of biology before the introduction of the experimental factor (IWB).

The results of the post-test are presented in Tables 3 and 4. Table 3 shows the students' achievement on the post-test expressed in above mentioned statistical indicators (M, SD and CV).

**Table 3.** Basic statistical data for the post-test.

Group	M	SD	CV
E	60.26	16.80	0.27
K	46.20	18.27	0.39

Table 4 shows relations between E and C group, according to t-value (for post-test).

**Table 4.** Testing group uniformity in terms of the post-test, using a t-test

Relation	t
E: K	3.10

By comparing the average values of the results achieved, a clear difference can be observed between Groups E and C in the test as a whole, favoring the former. On the basis of the results presented for the post-test of knowledge for Groups E and C (Table 3 and 4), it can be noticed that there are statistically significant differences in the number of points achieved in the test as a whole, in favor of Group E (Total:  $3.10 > 2.58$ ).

The obtained results show that the experimental group to which the content of pollination and pollinators was presented through IWB achieved better results in the final test of knowledge than the control group to which the same content was presented without them.

There are also many other studies based on the use of IWB in natural sciences and other topics related to biology.

The use of IWB has yielded good results in other field of biology such as genetic (with concepts of chromosomes and DNA) [20].

In research on the topic: "Photosynthesis: Energy Linking" it was concluded that the use of IWB was

more effectively on students' achievement than teaching according to the curriculum [13].

The application of IWB in the theme of the Cell Division proved to be very effective in order to acquiring of knowledge [22].

Lessons about food chains and gas exchange in the lungs, also were presented with IWB. It has been shown that teachers have had different pedagogical approaches to encouraging and supporting activities in which students shared, evaluated and developed their ideas using an IWB [6]. In that sense, the teachers will be able to use the benefits of IWB in active learning process and support students in their collaborative work and active dialogue [21].

#### 4. CONCLUSION

The teaching content Pollination and Pollinators was implemented through IWB in the experimental group, while in the control group it was implemented through the usual teaching approach without this technology. After introducing the experimental factor (IWB) in Group E, this group achieved better results in the post-test of knowledge than Group C. There is a statistically significant difference in mastering the given content between the students in the experimental and the control group. It was proved that the experimental group had a greater quantity of acquired knowledge as compared to the control group. Therefore, the zero hypothesis is rejected and the alternative hypothesis is accepted that there is a statistically significant difference in mastering of the program content of the pollination and pollinators (in the final test) between the experimental and control group of students in favor of the experimental group. It can therefore be concluded that the application of IWB directly contributed to better learning and knowledge acquisition in teaching the biology content *Pollination and Pollinators*. IWB allows teachers to present certain content more easily, so quantity of students' knowledge has been increased. In order to improve biology teaching by using IWB, it is necessary to provide training for teachers to apply this technology. From this aspect, further continuous training of teachers for the applying of this technology is planned.

#### ACKNOWLEDGEMENTS

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## ICT and Art Education

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**Abstract:** *Information and communication technologies have become an integral part of our lives. They have changed our social habits and changed our perception of ourselves and the world around us - affecting human behavior. Art works the same, even more, because it can provide unexpected performances of the world and thus provoke new insights. By utilizing new media resources, students can expand their creativity through digitally simulated information. Flexibility of digital data is what makes new media of vital importance for the teaching of fine arts. By using automated media tools and graphic software, students can quickly see the results of their ideas. By applying ICT, the amount of work in creating visual information is minimized, so students will have more time for creativity, collaboration, research and assessment.*

**Keywords:** *Information and communication technologies, art, art education*

### 1. INTRODUCTION

Communication and information exchange is one of the cornerstones of the human community. From the first attempts of a man to address the environment, the development of techniques that a person serves to communicate begins. "However, the first words that a man uttered and the first drawings he made on the walls of the caves were at the same time the means of communication and means of expression, which we will later call artistic" [15](Todorović, 2009: 13).

Information and communication technology has become an irreplaceable tool in many professions, even in the arts. Work in any branch of applied art is inconceivable without a computer: architecture, interior, graphic design, multi-media design, industrial design, advertising are just some of the tasks that involve two-dimensional and three-dimensional design techniques with the help of computers. In classical art disciplines, painting, graphics, drawing and sculptures of ICT can be directly involved in the process of creating a piece of art or indirectly.

One of the driving forces of modern media is their ability to connect people through multiple sensory experiences, and this new ability of the media to connect their users has led to a change in the way people communicate. Communications in today's world increasingly emphasize interconnected multimedia messages for both personal and professional use, students should learn to critically interpret media messages, transfer their ideas through multimedia art forms in a collaborative environment, show creativity and innovative ideas,

possess information and communication skills media literacy, use ICT, be flexible and adaptable, productive and responsible with interdisciplinary and multicultural education.

Boro Drašković, thinking about our world says; "We live in the civilization of sound images, contemporary media are syncretic, they contain all the art, science, and form of the game; not only the rhythm and harmony, through them, the united energy, knowledge and achievements of all these areas of human research are penetrated in the soul, so that the strong consequences of this compressed influence on the mental circuits and emotions of man can hardly be followed. By giving a more attractive look, the media cowered the world, and formed the human being into a mass communication par excellence." [6](Drašković, 2012: 147)

### 2. IN EDUCATION AND ART EDUCATION

Digital technology has triggered one of the most important changes in education from the invention of the printing press: students are expected to think and communicate as artists and designers in order to create multimedia products. Art has become one of the four pillars of literacy, as important as the three original ones - reading, writing and calculating. It became important at school because it is so important in the world of work. Worldwide works have accepted multimedia as the primary form of communication, as well as the international language of the Internet. In addition, millions of television channels, CDs, DVDs and web portals and other new media that have not

yet appeared require musicians, storytellers, web designers, choreographers, video artists, graphic designers, creative consultants and many other professionals from the field of "art".

The prevalence and availability and use of the media and participatory tools with all the available Internet have led to profound changes in the way people communicate, work, play, buy, learn. Newer versions of Web users become producers of their own content and media products, and this process includes educational, economic, and political institutions. Participatory media tools provide links to outside content, and learners and teachers can access them online for learning and creation. This does not mean that conventional media such as pens, dyes, clay, paper, etc. forgetting and replacing, but increasing opportunities for learning and creating in the classroom. All modern media technologies have a place in school, provided they can help promote the goals of teaching arts culture. Newer educational technologies deserve special attention because they allow students to engage in an innovative form of communication, learning and expression, using modern media that they use in everyday life.

The development of new expressive means of communication, the discovery of new media, especially the development of photography, film and television, new means of reproduction and modern technology have contributed to the visual and communication expression in our century of completely new forms and dimensions. Due to the interweaving, complementing and joint action of all these areas in this development, it was understood, understandably, that enriching the expressive possibilities. Visual communications, as an irreplaceable medium for communication and expression, have become an integral part of our everyday life, as they complement and accelerate the linguistic way of communication, and have the ability to express those relationships and values in spatial coordinates that the living or written word will never be able to express. All previous experiences in any of the mentioned fields have contributed to the gradual formation of a new, expanded, or integrated area that explores and explains a universal way of understanding and shaping space.

### 3. POSSIBILITIES FOR TEACHING ART

Teaching of art culture is important in our educational system. The art and teaching of fine arts should also be seen as a field of literacy, and not only as a subject area. The visual form of communication is the primary form of communication in the modern world, and art should be absorbed in all subject areas, just as it is with other types of literacy. In order for students to be successful in school and work, as well as in their

community and their private life, they will need artistic and designer skills that require a digital age.

The media through which pupils learned about art were mainly lecturers, textbooks, reproductions of works of art, various monographs about artists or encyclopaedias and rare visits to museums by the end of the twentieth century. Today, using information and communication technology in teaching, there are available world museums, databases of works of art, various software that can be used for artistic purposes, and, more broadly speaking, any data that can be useful to students and teachers.

Art teachers have been trying to understand and master the tools and media of their crafts through history, and to transfer that knowledge to their students. Today, this same desire can be seen through teachers' aspirations to integrate traditional and contemporary media into their teaching. On the other hand, students do not come to school as blank pages of paper that teachers write, they come with a rich experience that can be used in teaching. Their experience in the use of ICT outside the school is high and should be taken into account when planning and conducting teaching. [9](Ilić, 2015)

Computers came to schools in the eighties of the last century, and some schools then began to use computers to help students in learning. Different authors, here we will mention only individual ones, then notice the possibilities of using computers in the teaching of arts (or fine arts, as this subject is called here). Diane Gregory insisted that art pedagogues soon adopt interactive digital technologies as important for the future of teaching art. [8](Gregory, 2009) Crowe Bruce commented that ICT can help research design issues, improve decision-making, and provide new learning opportunities. "The incredibly exciting time for the teaching of fine arts brings new opportunities through the use of ICT." [5](Crowe, 1998: 7)

ICT is a unique opportunity to support and extend visual arts outside of classical fine arts. Computers create new aesthetic experiences, with their enormous potential as a visualization tool for ideas. (China & Duthie, 1994)

Phelps and Maddison, based on a research conducted in Australia, emphasize the benefits of integrating ICT in fine arts education and state that technology provides great opportunities for enriching the teaching of fine arts, enabling students and teachers to use new tools with the support of multimedia. ICT is a unique opportunity to support and extend visual arts outside of classical fine arts. Computers create new aesthetic experiences, with their enormous potential as a visualization tool for ideas. [13](Phelps & Maddison, 2008)

Art teachers, and all those who were interested in the interaction of ICT in teaching, began to think

about the use of computers in the teaching of fine arts at a time when computers began to be used in art, in fact when it was possible for computers to display a large number of colors in quality resolution. This contributed to the development of a graphical user interface and art software, and this situation was also significantly contributed by the fall in computer prices on the market. The rapid advancement of ICT has offered significant opportunities to use in teaching fine arts, interactive and dynamic learning with the availability of global resources.

German Association of Art Teachers (Bund Deutscher Kunstlerzieher) recognized the potential of ICT for use in the teaching of fine arts and published the document "Digital Media in the Art of Learning" (Digitale Medien im Kunstunterricht) in which, among other things, it says: "Communications in the information society are done with the help of digitally generated images. This fact puts the school ahead of new demands, primarily the teaching of fine arts, which is the only subject that explicitly deals with the creation and understanding of visual messages, which puts it in a special place among teaching subjects [1](BDK, 2004: 2).

Nikolaj Selivanov (Николай Селиванов) he made conclusions based on his research in Russia, that ICT can be used in teaching the arts differently depending on the type of activity. Multimedia of ICT provides a comprehensive impact on the user; ICT possesses expressive possibilities of various means, including the illusion of three-dimensionality, enabling the creation of an illusion of movement, as well as creation and virtual modeling; ICTs enable interactivity including digitized video, animated objects and movies; ICT provides non-linear interaction between users and interactive elements; ICT encompasses various communication models among users; ICT provides users with the opportunity to use information at their own pace with personal motivation. Selivanov particularly highlights multi-media ICT, 3D animation software and virtual reality, interactive capability including database, video conferencing, communication among users and the ability to explore the Internet. [14](Selivanov, 2003)

Georg Peez and Michael Schacht paid attention in the project "Multisensible learning of art by including computer technologies" (Multisensueller Kunstunterricht unter Einbeziehung der Computertechnologie - MuSe-Computer) aimed at creating situations for increasing creative behavior through ICT. The main question was: "How can we integrate computers and their components into the teaching of art through more multisensational shaped processes between reality and the digital world." They believe that creative skills are necessary for life in today's daily work, as one of the so-called "key qualifications in all sectors of life, although the

development of creativity can be integrated into all school subjects, the teaching of fine arts is a central place for creative behavior. [12](Peez & Schacht, 2004)

#### 4. CHARACTERISTICS OF THE USE OF ICT IN ART EDUCATION

Multimedia in education has not been created by the emergence of computer multimedia systems, but today these systems are the most accessible, making them necessary in education as well. It is still Jan Amos Komenský, recommending that students learn what they learn, "see, hear, touch or taste", give the idea of using more media in teaching, so that they are complemented and enriched each other. In the present conditions, the richness of the media can easily and consistently be exploited in the teaching, using the possibilities provided by modern computerized multimedia systems.

Computers possess characteristics that differ from other visual media, and these characteristics determine the way users think, access the problem, and how to solve the task. Zolt Gyenes, lists some of the characteristics of computers in the teaching of fine arts: Using computer software can make countless copies of works without loss of quality, can be much experimented with ideas, it is easy to get variations of works and works can be saved and automatically in different states, and many programs have automated steps with different effects. Unlike analog media, adding or subtracting elements is not a problem and work can be increased or decreased. Different variations of work can be seen at the same time. Of all variations of work, the best ones can be selected and the others deleted at a time. The whole history of creation is available. [7](Gyenes, 2002)

Jonathan Matthews noted that the characteristics of contemporary media and ICT in the teaching of fine arts are close to students, easy to use, varied, attractive, they are a creative tool, and a large number of variations can be given in the process of creating artistic work. [11](Matthews, 1997).

Avril Loveless says that ICTs in the teaching of fine arts feature the following characteristics:

- Ease of use. The user communicates with the software through icons representing different software installed on the computer. Clicking the mouse runs various software that can have graphic tools displayed with icons: pencil, shower, oily colors, spray paint, pastel, watercolor and a simple mouse click selected tool is ready to work.
- Practicality. Creative possibilities of computer art far exceed the possibilities of traditional media. Without much knowledge, surprising works can quickly be created. Better software

knowledge, of course, gives even better results.

- Attractiveness. Works created with computers are interesting and teachers can attract a large number of students who are not otherwise interested in art. Computers can be a tempting door to students in the art world and the opportunity to create works.
  - Interdisciplinarity. Computers and teaching of fine arts can connect different subjects and can increase interest in interdisciplinary collaboration of colleagues and students of different subjects.
- A creative tool suitable for experimentation. Creating work with a computer is easier than working in traditional media. The computer is a great tool for experimentation and research, the original drawing can be saved, and then all its variations in the process of operation. In order to achieve this in traditional media, the process can be complicated and time-consuming. Computers can easily connect photos, video works with computer images and drawings. With all this, there is the possibility of canceling the last steps. Although there are many types of artwork that can not be created with the help of computers, they are without competition in creating two-dimensional works.
- Applicability in life. Knowledge acquired through the use of computers in the teaching of fine arts can be applied in various occupations in life. Knowledge in using ICT can be described as being actively used, and includes understanding, selection, critical evaluation, openness to novelties that are susceptible to further development. [10](Loveless, 2005)

Pupils and teachers, with the help of the Internet, gain access to thousands of sites with artistic content: museums, various tutorials and other resources that can be interesting for the teaching of fine arts. Many museums, collections, software companies and various publishers publish material, exhibitions, paintings, specialized monographs of artists, educational software on CDs, DVDs or the Internet - and they are a wealth of additional information and use in teaching.

Konol and Dajk cite the characteristics of the use of ICT, such as: accessibility, speed of achieving results, possible large number of variations, communication and cooperation, multimodality and non-linearity, uncertainty and immediacy. [2](Conole & Dyke, 2004)

ICTs bring a recognizable contribution to the active, enable users to do things that can not be done effectively, or in general, using traditional tools in art. This potential, which includes: interactivity, capability, great choice, speed and automated functions are a significant element of ICT capabilities and enable learners and teachers to use

them in the learning and process of creating a piece of art when appropriate.

When considering ICTs and their impact on teaching and learning in the teaching of fine arts, it is important to define the nature of these media in order to better utilize their resources. There are five characteristics that define the nature of modern media. These features include: integration, interaction, hypermedia, and experience in the use.

Integration suggests that arts and sciences are mixed up to create a unique experience. Integration can be seen on television, the Internet, the movie. For example, the creation of a TV show requires several people of different talents, writers, actors, artists, technicians, engineers ... The result is the collaboration of science and art, all working for the same goal, but approaching the problem from different perspectives. If this concept applied to the time of art culture, it would have multidisciplinary collaboration through an integrative teaching model.

Interactivity. Interactivity suggests a dialogue between a person and a computer, a computer, a person, and a computer with a computer. Working in the isolation of other students represents educational practice from the past. The ability of students to communicate with other students through ICTs will play an important role in their learning success. Digital resources by themselves do not bring creativity, but allow an overview of artistic practice, participation and active demonstration of works of art or practices that can be an inspiration for their own creation. They participate in the development of ideas, making connections, creating and creating works of visual arts with cooperation and communication, and ultimately evaluating artwork.

Hypermedia. Hypermedia is an upgrade to multimedia, which means multimedia content that is interconnected. The network is most often built with hyperlink, although it can be created in some other way. In the teaching of art culture hypermedia can be used as a research tool in the classroom. Students may ask for direct and indirect, relevant information related to a particular topic on any issue in the classroom.

The last characteristic is related to the experience in the use of ICT. The use of ICT in the teaching of fine arts requires specific knowledge in the use of different software. Initially, they are not the best users but are more exploring the possibilities. Over time, as students gain more confidence in the use of ICT, they become less and less focused software, and are increasingly concentrated on their work and thinking about their work. Over time, students find ways to adapt contemporary media with their own creative intentions. [9](Ilić, 2015)

Roland Craig on the possibilities of ICT in the teaching of fine arts is presented in the document „The Art Education 2.0 Manifesto“:

The Internet looks beyond the simple place to search for images and information, it is seen as a place to use participatory media and tools for sharing ideas and resources actively working with others, presentations of creativity and learning to the world audience, and a critical view of the ideas and work of others;

By using technologies, building a rich environment in a classroom where the teacher and pupils follow the curriculum goals. Focusing on results, and less on tools.

Technology can be used throughout the curriculum. Insist on building a stronger link between content, didactics, learning goals, and the use of curriculum technologies, and not technology treatment as an add-on. ICT should be viewed as something that is composed both in art studios and classrooms.

Conscientious use of technologies, recognize the advantages and limitations of new and conventional media technologies, and the decision to use is for one goal, which is what is better for the student. Sometimes the use of Internet resources makes sense, and there are times when books and textbooks will better suit the needs of students. Students should be encouraged to combine digital media with conventional artistic media.

Establishing global connections. From sharing students' experiences with students from other cities, countries, participating in a global art project with other schools or students, exchanging lessons and experiences. Participating media offer a variety of ways to connect, communicate and collaborate with peers and colleagues around the world.

Using free tools and open source software to support teaching and learning activities in the classroom. The availability of free online application tools along with open source software distributed at little or no cost and offering a wide range of alternatives to commercial software.

Pupils and teachers are partners who need to learn together in a way that everyone can learn and anyone can be a teacher. Feedback should help teachers build more effective pedagogical approaches to the Internet for future students.

Encourage personal expression, but also cooperation and community. Nurturing and participating in creativity and knowledge sharing communities. The introduction of social media of participatory art into the curriculum draws attention to social aspects of learning by offering projects and activities in which students work together to achieve common artistic and educational goals. In this way, a richer, more diverse classroom and environment is created, in which students actively learn from each other as well as themselves.

Sharing experiences and works of students with the world audience. Art teachers have long used the

recognition that comes with public display of work as a way of motivating students. The Internet adds a new possibility in this practice, instead of just the teacher being responsible for presenting student work, students can use participative media tools themselves to show the world what they know and can do. (Craig, 2009)

## 5. CONCLUSION

The incidence of images in the lives of young people has transformed the way in which they learn and experience the world, their use of visual messages has created the need for new skills in order to actively engage young people in life. Today, most theoreticians believe that the education of visual arts and that art itself should be integrated into other areas of learning to ensure that all young people become visually literate in the visual age. However, there are some shortcuts of countries that have reduced classes of visual arts education, and the emphasis is on mathematics and science.

The school, and art education, should be adapted to the current social and educational needs. With constant changes in our environment, today's childhood changes, not just habits. Types of media, various social conditions, have led to new ways of life and changed childhood experiences. Today's students live in a time that works hard on them: with a little free time, often emotionally neglected, in a fast pace of life, parents torn apart in uncertain life conditions, a collision of different cultures and various media influences, all of which characterize the heterogeneous conditions of life of today's students. Teaching is under the strong influence of competencies and standards, on the one hand, and works of contemporary visual arts, works of different cultures and everyday visual information for which technical and visual requirements are to be met, on the other.

Throughout history, artists have sought to improve the tools and media of their trades, experimented with new technologies, whether they themselves explored and experimented or used the inventions of others in their work, always sought to use new media, new innovations for their work. According to Giorgio Vasari, Jan van Eyck found an oil technique, and with him a kind of revolution began in painting, Leonardo da Vinci experimented with Camera Obscura - the predecessor of the modern camera, David Hockney accepted the new technology at the exhibition at the Royal Academy in London, 2012 he showed 50 drawings making on the iPad.

The importance of the teaching of fine arts is increasingly recognized in the world and in Europe, it offers students a useful guide to developing their creativity, imagination, sensitivity towards themselves and the world around them in mutual relation. In addition, the teaching of fine arts enables students to develop the ability to express themselves in a wide range of visual techniques.

Teaching of art culture enables students to understand art, also enhances the critical skills needed to think and move freely and consciously in our society with full stimulation and information. In addition, the teaching of fine arts has the responsibility to bring students closer to different cultural heritage and cultural diversity.

Using the computer is interesting, but it is also challenging to understand the wide range of applications that are available. It is therefore important that students learn skills in using and managing computers and creatively explore a range of software tools in order to understand their values in much the same way as we learned using traditional tools and the media. The use of ICT in the teaching of fine arts is a new field of experience for both students and teachers, and ICT provides students with access to a wide range of processes and tools that until recently were available only to professionals.

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# Learning to Sing Byzantine Music Online: The Intersection of Rich Content Education and Special Education

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**Abstract:** *In the majority of scientific fields, as far as instruction is concerned, analysis, synthesis and resynthesis of findings and clues can be conveyed with multimedia enriched e-Learning courses. In other disciplines, however, there is peremptory request for exact appreciation, consideration and acknowledgement for accurate diagnoses from scientific data. Even further, strict accreditation is needed, setting up a blockade in the expansion of on-line teaching. Nevertheless, as interactivity increases the potential for regularly hosted, nearly private sessions over the Internet, with photorealism alongside an immense potential offered by advances in Mobile Communication and Learning, there are hopes that extremely demanding teaching, like musical mentoring, medical training or special education counseling, may become commodities offered by on-line courses, seminars and institutes. As this perspective lies within the intersection of formal and non-formal education, it provides reasonable optimism for a constructive transformation of immature forms of teaching to reliable, accredited nomenclatures of remote tête-à-tête tutoring over the Web.*

**Keywords:** *On-line Education, Multimedia Learning, Rich-content, Blended Learning, Accreditation and Skills, Educational TV*

## 1. INTRODUCTION

E-Learning constitutes a very promising continuum for decisively improving modern synchronous or asynchronous education; handling imminently factual content rather than merely stylish in expression texts, it employs cutting-edge technologies, that most of the times are not counterbalanced by classic education initiatives. Therefore, leading the way to offering "rich content" education, it contributes to developing massive multimedia communication structures, in unprecedented size, quality and quantity mashups of related information, typically assessed by a simple point-and-click method.

Particularly, for tertiary education, the asymmetrical growth of information and communication technologies (ICTs) offers a vehicle for providing services that some years ago were thought of as impossible [1]. In every day practices, by digitally combining and synchronizing videos along with texts, sounds, animations, digital libraries and assessment tools, vast repositories have emerged as dominant media for educational purposes in many Massive Open Online Course (MOOC) platforms [2].

Recently, the term "rich content" has been used for describing these commodities, which extend the notion of "learning objects" to highly interactive spheres of influence, as is the case of Mobile Communication and Learning [3].

Learning Object (aka LO) is any entity, digital or non-digital, that can be used, re-used or referenced during technology-supported learning [4]. Examples of learning objects include multimedia content, instructional content, instructional software and software tools that are extensively used by technology transferring methodologies in on-line learning [5].

Patterns of smaller reusable digital resources include digital pictures or photographs, animation and video clips, small pieces of text, simulations and smaller applications available via Web. Examples of bigger reusable digital resources include entire web pages that combine text, pictures and other means, or applications that offer a complete educational experience [6].

Rich content relies on high quality visual components offered via online learning platforms. They are particularly interesting for students who are visual learners and who learn best by watching the short format engaging videos rather

than by just reading or listening to course materials. The paper focuses on the categorization of factors that are responsible for the success/popularity of online learning videos [7].

Rich content, cropping out of high quality multimedia design, is accessed via Content Management Systems and Virtual Learning Environments [3]. The hype for more learning resources ameliorates the quality of the offered services, drives multimedia production close to TV quality standards, and redefines learning communities in a saga for global penetration and distribution (Fig. 1).



**Figure 1.** Microsoft technologies for Mobile Learning instruction paradigms

By exploiting rich content LOs, e-learning pledges to improve the quality of tertiary education and the effectiveness of learning. Due to the ubiquitous use of ICTs in the form of Mobile Communication, e-Learning gives easier and almost instant access to data and information in a digital form, empowering manipulations that are sometimes not possible otherwise. E-Learning can lead to innovative pedagogic methods, new ways of learning and interacting, due to the ease for sharing these new practices among learners and teachers, as well as by easier comparisons between teaching materials and methods [7][8]. E-Learning can also be seen as a promising way to reduce the cost of tertiary education, which is critical for expanding and widening its access worldwide.

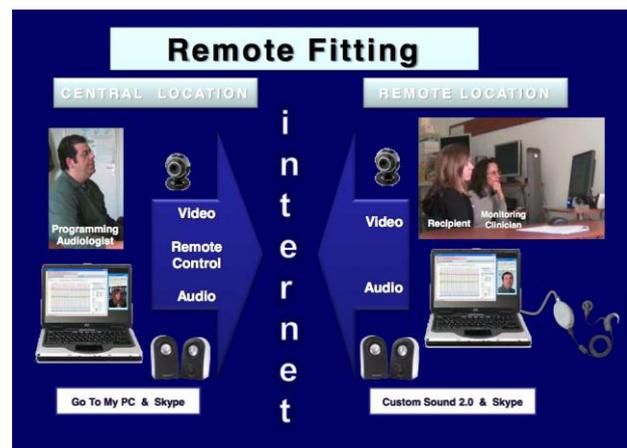
E-Learning, and favorably its offspring for Multimedia Learning, is quite wide in conception and even wider in instrumentation. It implies the use of online services along with whatever resources the Web offers. A global societal shift takes place every time the World Wide Web (W3) shifts paradigm, i.e. from Web 2.0 to the current phase of Web 3.0. At the same time, it takes advantage of electronic gadgets and paraphernalia with omnipresent identity characteristics. E-Learning can also provide support services to classic education, like the authorized online distribution of presentations, tutorials, notes, and e-tests. At the other end of the spectrum, it may

become the vehicle for integrated services provision, as is in the case of online universities [6].

However, although Rich Content is adding value to high quality educational TV like productions [9] by confiscating all the transactions held between instructors and learners, there is a boundary that is difficult to be surpassed: the accreditation part. Indeed, while e-Learning has penetrated all fields of knowledge, and virtually any whatever Bachelor of Science may be offered more or less in its on-line version from an "Open University" [10], some fields like Medicine, are characterized by educational conflicts, when it comes to inner core nomenclatures: it has not been heard of a patient, yet, entrusting himself to a doctor that has been certified solely with on-line courses.

In this paper, examples from medicine and musicology will be deployed, i.e. from disciplines that manipulate media rich content that has a very low tolerance for misinterpretations (Fig. 2).

The focus of this specific research, however, emphasizes on musical instruction and teaching.



**Figure 2.** The remote fitting procedures over the Internet, for cochlear implant recipients, audiologists and their fitting clinicians. Courtesy of Dr. G. Kyriafinis, AHEPA General Hospital Cochlear Implantation Unit, Thessaloniki, Greece.

Key components of e-Learning that promote knowledge management and performance support are:

- Content development tools and architectures
- Collaborative learning tools
- Assessment tools

As it stands, e-Learning becomes, amongst others, a valuable tool for expanding and widening access to tertiary education.

The degree of its acceptance and adaptation for forming blended learning curricula depends on the positive or negative experience instructors transcribe to the academic community and to the decision-making councils.

When mobile communication applications are well planned and suitable to task, they facilitate instruction, becoming indispensable tools for the delivery of well supported teaching; on the contrary, misfits and unapt remedies provoke embezzlement, and the parties involved, instructors, learners and technical administrators find themselves spending more time on interacting with the IT center particulars than with the content or the learning process itself [10]. In such a situation, especially when LMS and CMS are open source, a drift for extra functionality, for code improvement and plug-in versatility is needed, to adhere adequacy with self-confidence, promoting e-Learning methodologies and remedying aversion.

## 2. THE SOCIOECONOMIC SUBSTRATE

Although the term "Balkanization" is often used to denote territorial administrative fragmentation or co-existence of mutually hostile groups under one government [11], the Balkans and Europe in general are by far the most advanced regions of this planet in conferring tertiary education skills and accreditations, both in quantity and quality.

However, as one moves eastwards or southwards, the situation deteriorates drastically, as far as education is related to the structure and functioning of localized societies.

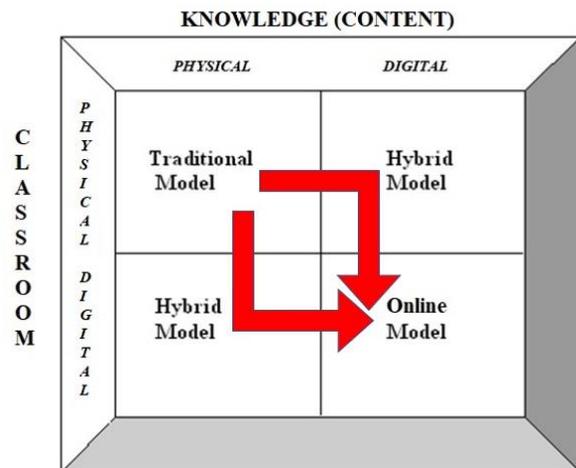
Therefore, e-Learning conveys a potential that may extend its benefits, under certain circumstances, beyond segregational lines or exaggerated sectarianism. In a global view of the issue, a "hybrid" form of blended learning emerges as a universal all-inclusive agenda.

Learning (and instruction in general) has undergone rapid changes over the last decade in the way it takes place due to technological advances. New hardware and software tools have revolutionized the available ways that a learning object can be implemented and taught. As a result, open and distance learning is constantly spreading as a suitable and more flexible vehicle for learning in today's fast-paced lifestyle; enjoying the benefits of its ability to extend frontiers of knowledge beyond separating lines, it leads a trajectory of fruitful attainment and gains unprecedented popularity.

### 2.1. Modern Education Models

The new rising hybrid models for blended learning can be compared and represented as an analogy to the contemporary models of music sharing [12], where music can be replaced by the digitized learning objects (Fig. 3).

In Fig. 3, two major factors mainly affect the models of learning: the *classroom* (whether it is a physical space with the presence of both teacher



**Figure 3.** A framework for learning models. The arrows show the transition from the traditional model to the online model through hybrid and blended forms.

and student or a digital environment with no actual face-to-face meetings) and the *knowledge* to be transferred itself (learning content). On the axis of knowledge, the content is actually divided into the limited *physical* materials of a course (textbooks, notes, exercises on the blackboard and slides) and the unlimited *digital* resources that can be created for the course's needs or already exist in the web (multimedia, digital libraries, resources on demand, synchronous and asynchronous communication tools etc.). In the case of a course delivering all or most of its content (over 80%) online, it is considered to belong to the pure online model. The intermediate ways of mixing elements from traditional and online learning are considered to belong to hybrid or blended models. Another model of learning (following the online advent of mobile devices) is mobile learning (*m-learning*), which has yet some drawbacks if used as a stand-alone model but will soon be an essential extension of e-learning [13]. In addition, mobile devices can well be used for entertaining serious games to enhance the learning experience.

Moreover, these learning models can be provided either for free (by public bodies or dedicated web portals for learning) or via some business models (e.g. subscription or a-la-carte model) [14]. Whatever the case, the successful completion of the learning process requires some form of assessment and certification of the learner. Typical forms of assessment are: written examination (live in person), online tests, the successful elaboration and submission of a project.

Open universities worldwide tend to provide open and distance learning by using hybrid or purely online models. Following the social constructivist approach, instructors in such structured have to

adapt to the role of facilitators / counselors and not teachers [15].

## 2.2. Technologies and Learning Methods

An online learning environment should provide as many assistive tools for the needs of a course as possible. An e-class portal usually provides personalized spaces for each profile depending on the role (teacher or student) with several subsystems serving the learning process: event calendar, documents space, systems for projects submission, announcements space, forums, offline video-lessons, file exchange space, discussion groups etc. Moreover, specialized systems for teleconferences with desktop sharing and whiteboard functionalities allow real-time interaction and the virtual metaphor of the traditional classroom-style way of teaching.

Current research [16] has shown that appropriate social networks (Facebook™-style) can provide additional benefits to the learning process, particularly through the communication channels between remote groups of learners and teachers.

Hybrid learning models that are being developed seem to be increasingly appealing to adult learners and find application already in academic (postgraduate and undergraduate) courses.

## 2.3. Online Learning and Music

Online education systems serve mainly distance learning and can be proved as extremely helpful and successful in many disciplines, especially of theoretical nature. Another area with high rates of success in online learning is computer science, where programming languages and special purpose software can be mastered in their 'natural environment'. In general, studies show that online learning is modestly more effective, on average, than the traditional face-to-face instruction [17].

With the use of technology, Internet and multimedia dynamics, any course of theoretical nature can be presented in multiple desirable levels of complexity and accuracy, maybe even more effectively than its presentation in the traditional way of teaching. However, is this also true for music education?

Music contains many different aspects and considerations (history of music, morphology, harmony, performance etc.), which cannot be integrated into the same context. For instance, history of music could well be taught with an on-line model with good results, as it is a theoretic course. There are already such online courses available [18]. However, performing a musical instrument (or vocal/singing performance) does not belong to this category. In fact, there could be a parallelism with the science of medicine. Would it be possible for somebody to be certified as a doctor (e.g. a surgeon) only from an online distance-learning program? The answer is rather

negative for obvious reasons. The main reason is: practice.

The same stands for music too. Learning how to play a musical instrument or how to sing needs a lot of practice time (apart from understanding the theoretical rules). Consequently, this kind of learning requires cultivating specific skills. If a student is left alone learning how to play the piano or sing in an autonomous and remote way, it is most likely not to perform well and eventually fail in the course. There are two reasons for that: technique and aesthetics. There is absolutely the need for guidance in person by the teacher possessing the specific skills and relevant experience. Even in the case of evaluating some kind of distant learning for such a discipline like music, there must be systems of special requirements to support it: high fidelity sound and a sense of space, fully synchronized supervision of the technique and bi-directional functionality. Mislearning of such a discipline may lead to repeated mistakes during practice by the learner. As a result, not early corrected mistakes may lead to bad habits of practice, and, thus, improper performance.

Of course, the audience that needs to learn a new skill (e.g. playing a musical instrument) should be taken into account. In case of beginners or people that want to learn something just for hobby, even YouTube™ videos with instructions prove to be adequate [19] (non-formal/amateur learning). This method, however, is not suggested for an academic course or for advanced studies at a professional level.

Although not much research is available in the literature concerning the effectiveness of a purely online model for teaching music performance, it seems that a blended approach to teaching music may be an effective solution that addresses the feedback component essential in performance-based courses, while retaining the benefits of an online-learning approach [20].

## 3. MUSIC INSTRUCTION OVER THE INTERNET: THE CASE OF BYZANTINE MUSIC

The term "music training" engulfs all the procedures aiming to develop such skills through practice and instruction, over a period of time, so one may be able to recognize by hearing, notes, tones, pitches, intervals, melodies, chords, rhythms, tempo, and other musical elements. In other words, music training combines theory (scales, notes, chords) with an adequate understanding of the music sounds listeners perceive in a daily basis. The more a recipient's hearing is capable of categorizing combined vocal or instrumental sounds, the better it morphologically apprehends the beauty of form, harmony and aural expression.

Ear training, one of the constituents of music instruction, is analogous to dictation in language training [18]. Once mastered, it is helpful for solfège, i.e. exercises in singing using solmization syllables.

The upmost stage for ear training is the capability to write in semantics a melody or a song heard. It is a remarkable step in the direction of musical education.

Ear training facilitates music categorization and reproduction of the melody based on hearing, without any help from semantics or musical score utilization. This capacity is crucial for composers who conceive a melody through "internal", esoteric hearing. Perceiving the acoustic dimensions of this melody, they can reproduce it either instrumentally or in writing in some form of semiotics.

Even musicians who perform already fixed up music can benefit from this rather difficult to acquire skill. It allows them to reconstruct, or as it is set-up in music terminology, to "remix" performances and produce variants. Overall, in practical terms this is the case with the American national anthem, perhaps the most frequented such clip in the virtual sphere of social media. Written and orchestrated some two centuries ago, it could not consider the potential of singing it solo in front of huge live audiences, and therefore it leaves plenty of room for variations, ameliorations and performer-centric adaptations.



**Figure 4.** *Left, the Aristotle University of Thessaloniki orchestra performs in the campus's open space an operatic song. The leading singer uses a microphone. Right, a well-known singer, Lady Gaga, sings solo the American national anthem, in front of a huge crowd; the lady on the left transcribes the televised event using the sign language for the deaf*

Indeed, the use of microphone alongside equipment for the electromechanical amplification of sound waves to unprecedented hearing levels has reshaped overall the field of music. As seen in Fig. 4, it allows musicians giving solo performances to address themselves to vast live or televised audiences in an immediate manner.

Even further, the use of multimedia LOs in TV style footage delivers multiple channels of communications. On the right of Fig. 4, at least four parallel channels for tranceiving the musical message are simultaneously effectuated:

1. acoustically, an excellent performance
2. for the deaf or impaired in hearing, a sign language interpretation
3. for the huge crowd that attends interactively, the lyrics roll in at the back in scrolling panels
4. the video LO conveys synchronization of bodily and kinesthetic elements with the music itself.

In a parallel manner, a music master class teacher, using the Internet based multimedia learning potential of online instruction, can address himself to remote students that would never dream otherwise of having such a privileged education.

### 3.1. Byzantine Music Learning distinctive features

As it is the tradition with singing, Byzantine Music mastering requires the student to develop a close mentoring relation with his or her teacher. After the basic levels, taught in amphitheatres with big audiences, a master class instructor gathers his students around him in small groups and monitors each one's individual features with every detail.



**Figure 5.** *Professor N. Paris instructs his choir during a mass service at the Vlatadon Monastery, Thessaloniki, Greece*

Teaching may take place in anechoic chambers or quiet offices in one-to-one, usually, or one-to-few sessions. As students advance, they participate as disciples in their master's choir, typically performing regularly in public church services (Fig. 5). Little by little, they increase their contribution to the choir's output and their ability to carry out the singing of certain hymns alone.

The major problem with Byzantine Music lies in its geographical dispersion. While the field of its exertion is highly decentralized, covering provincial parishes and congregations in remote communities, high-level instruction is available only in metropolitan areas [21][22].

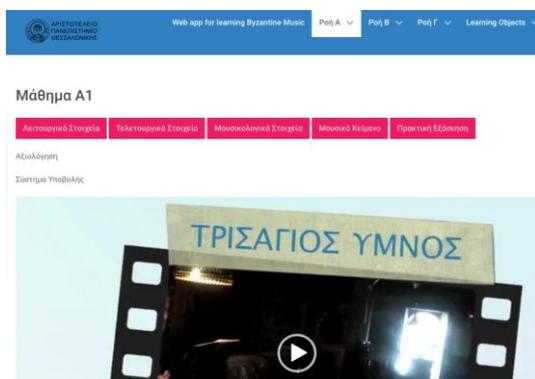
Even further, as is the case with medicine, acquiring a good level of performance in singing is

not merely the case of obtaining a four- or five-year training at BSc and MSc levels, notwithstanding how talented and suitable for the task a learner may be. It requires constant practice in the field, empirical and theoretical engagement with ceremonial observances, and an overall maturing process that correlates phonetic features with neurological control over the quantitative and qualitative characteristics of the type of tone with which a person sings.

**3.2. Interacting online with an AI agent**

To remedy this situation, an online portal has been set-up for offering self-contained instruction over the Web at master class levels (<http://byzmusiconline.ddns.net>).

Although in its initial phase, it has already developed its first complete LOs (Fig. 6).



**Figure 6.** An interactive LO for a Eucharist canticle in Greek

For the learning phase, apart from the multimedia material, it is important to have a handy, library-like online assistant that serves as a "study tool".

At the first stage, there is theological and ceremonial documentation about the hymn sung. Although the learned scholar will catch up with most of the rituals seen as musicokinetic events in the main video of the LO, for most students there is need for a theoretical foundation refurbishment that will propel their awareness (Fig. 7).

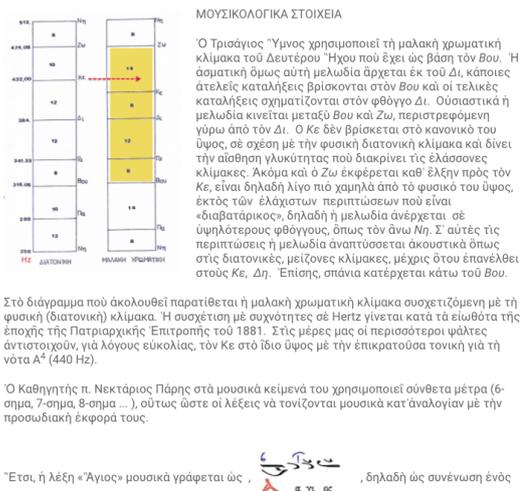


**Figure 7.** Online study tools for the envisaged hymn LO in the form of "learning cards". Left, a liturgical concordance elements, and right ceremonial ones

Of course, the most difficult part lies on the musicological understanding of the singing substrate. In fact, there is ample insight on the special scales and modes used for its proper rendition. The concept of chromaticism is strongly associated with the perception of music for the

peoples living in the Balkans and around the Mediterranean basin. Musical chroma is mostly associated with the music intervals [23]. The interval sizes may cause a chromatic perception in a melodious piece, which is the notion of somehow different from mainstream Western style hearings, "Eastern" in its ethno-musicological orientation, and by any means idiomatic of the great civilizations that have flourished around the Mediterranean Sea and Middle East.

The musicological insight is presented in details, as seen in the snapshot in Fig. 8.



**Figure 8.** Part of a musicology specific "learning card" for the hymn in perspective. It has detailed description of the chromatic substrate of the mode used

Once the remote learner has become familiar with the theoretical foundations in ceremonial, ecclesiological and musicological matters, he may proceed with the main learning element, the video lesson of the LO. He or she will hear the prototypal performance, see the musicokinetic elements in practice and predominantly, will have always in front of him or her a link of the score sung (Fig. 9).

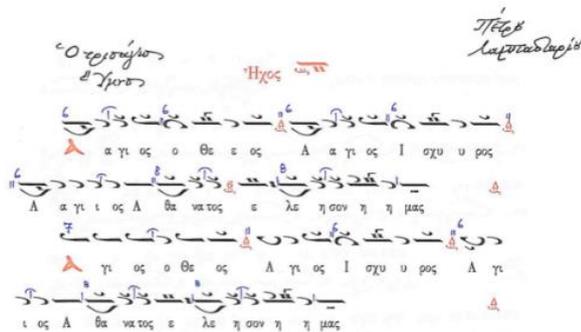


**Figure 9.** Many concurrent channels of musicokinetic, ceremonial, singing and ecclesiological communication are present in the main event of the LO, the video lesson

The remote learner is encouraged to repeatedly indulge himself or herself in the multimedia

material of the LO. Once one has become familiar with the level of instruction supplied, he or she may proceed with practicing alone.

Out of the many liturgical books, the learner will be provided with the exact musical score performed by the choirs (Fig. 10).



**Figure 10.** Part of the complete music score of the hymn, originating from a 1760 AD grand master score, as transcribed in a modern rendition by Professor N. Paris

The remote disciple is advised to spend ample time in practicing the musical composition. When confident enough, he may interact in a karaoke style with a multimedia support system for his learning. While playing the video, he is advised to watch carefully the moves of the hands of the instructor, as if he or she was participating in his choir, and to synchronize his or hers singing, in terms of compression, with the strong, regular, repeated patterns of knocks that form the arrangement of musical meters. At the same time, the learner hears the first syllables of each rhythmic entity encountered in composite music meters within the hymn, 6 and 8 rhythmic units for the specific two words in perspective (Fig.11).



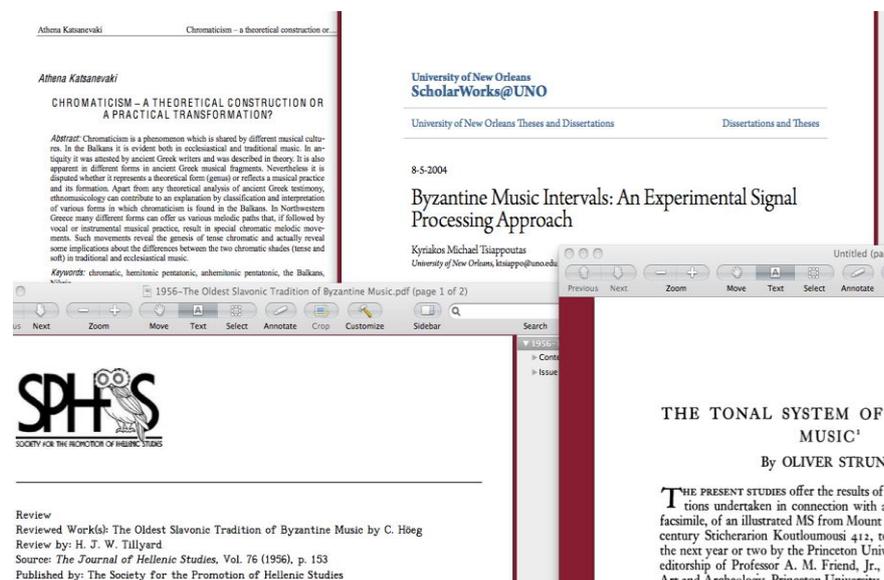
**Figure 11.** The karaoke style self-practicing agent for the remote learner

After that, he or she may invoke the second-level agent. It encourages the learner to practice having less support. He or she hears the knocks of each strong rhythmic unit in a 2/2 mode and has guidance for the beginning of each composite measure of 6/4 and 8/4 hearing a drum like knock and nothing more.

The learner is directed to repeat this stage many times so to match the compression and timing of his phonation and his breathing with that of the performing master. For women performers there is bigger margin for tolerance, since they have different tonal, phonological and breathing functional characteristics.

### 3.3. The research potential

For the ones that are at MSc level or further, there are, apart from the learning cards, ample theoretical treatises, in English most of the times, offered for in depth analyses of the performed hymn (Fig. 12). They provide deeper knowledge than the learning flashcards that readily appear.



**Figure 12.** Exemplar treatises suggested for further study as far as a certain LO is concerned

They sum up to some hundreds of pages and provide grounds for comparisons between neighboring countries traditions or phonological variations that incur when the melody is sung from one language to another.

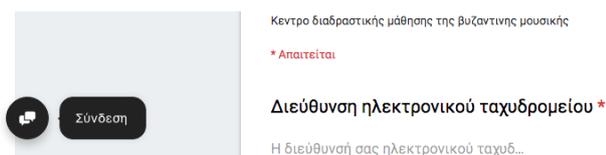
At the moment, complete support is offered for renditions in Greek. On the contrary, for the research part of the video lessons, most of the studies accompanying the video lessons are in English and a few in other European languages. However, the system envisages its core transition to languages spoken in areas like the Balkans and Middle East. English is a good option [24].

### 3.4. Online mentoring for personal evaluation

At any point of his online interactive navigation, the learner is provided with the means to

- send his queries to the online system supervisor
- to ask for a Skype™ session with his online mentor
- to submit his recordings so to have an evaluation of his advances in singing

as seen in Figs. 13 and 14.



**Figure 13.** Interacting online with the learning portal supervisor



**Figure 14.** Submitting one's recordings for personal evaluation and assessment

## 4. CONCLUSION

To remedy the "Balkanization" effect [11] in education, the case of learning to sing Byzantine Music hymns was used as an exemplar paradigm for developing online mentoring tools and machine learning support.

As a prototypal paradigm for the development of AI support in learning to sing served the back-up system of special education counselling deployed for the rehabilitation process of cochlear implant users at the AHEPA University Hospital, Cochlear Implantation Unit, Thessaloniki, Greece.

At that center, Play Audiometry is committed with young children with and without hearing aids. It relies on techniques developed with the use of audiometric equipment. In addition, Operative Speech Therapy is carried out, and more importantly, language assessment tests are performed on a regular basis.



**Figure 15.** Audiometric (left) and Speech Communication (right) assessments used in the rehabilitation processes of cochlear implantations

Phonological, linguistic and musical training involves professionals and scientists activated in diverse interest groups. It seems that, after all, physicians, sound engineers, videographics producers and musicians share a common background, when demanding and vigorous education is encompassed, characterized by extensive observation, analysis and reconstitution. Assessing after all the potential of a learner to sing (as is in parallel the case of a student in medicine or special education) is a far more complex phenomenon than simply evaluating written examinations and oral tests [25].

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# Educational software for learning psychics - combination of simulations and formative assessment

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**Abstract:** *Based on results of literature review in the field of computer simulations, feedback and formative assessment, educative software which contains simulations and elements of formative assessment is presented in this paper. The software is created for the purpose of learning as well as for evaluating efficiency of this learning approach on learning process and students' achievement in field of psychics. The evaluation of usefulness of this software should be investigated in the future from different aspects.*

**Keywords:** *simulation; feedback; formative assessment; electrical circuit*

## 1. INTRODUCTION

Short theoretical bases and literature review about usefulness of computer simulations and different types of feedback in education are given in this section.

### 1.1. Simulation in STEM education

Computer simulations are tools for demonstrating real physical process and they enable changing parameters and measurement in interactive virtual environments. Simulations are based on constructivist learning theory and engage students in being active participants in learning process [1]. According to this, simulations are useful for developing inquiry skills. By using the simulations, students identify problem, set own hypothesis, analyses the results of observations, compare their hypothesis and make conclusions [2].

For example, teacher can require from students to decide what will happen with the value of electrical current in the electrical circuit if the parameters of voltage or resistance are changed. Firstly, students identify problem regarding to given values and parameters in circuit. In other words, they find the relationships between elements in circuit and given variables. Secondly, students set a hypothesis with own solution and then they check their understanding by using simulation. Depending on whether students set hypothesis correctly they can improve understanding and overcome misconceptions or confirm knowledge. This can enhance retention of content in long-term memory and facilitate applicability of knowledge.

Applicability of simulation in teaching is a topic investigated very often in the field of STEM

education. The large number of authors have found the positive effects of using computer simulation in different subject areas. For example, authors of numerous studies recommend using simulations for enhancing conceptual understanding of content [3], [4], [5], [6].

On the other hand, literature review suggests that there are a lot of studies which deal with comparing effects of using computer simulations to traditional approach – hand on activities with real equipment and their combined application on students' conceptual understanding. The results of these studies indicate that computer simulations are effective tools when used in combination with hand-on activities [7], [8]. Similarly, the other studies have found positive influence of using computer simulation like preparation for hand-on activity [9], [10].

However, there are studies which results indicate that there are no differences in efficiency simulations and hand-on activity [11]. According to that, it can be concluded that simulation can be at least effective as traditional activity. Nevertheless, simulations can replace the use of traditional labs and reduce costs of equipment as well as dependence on time and place.

### 1.2. The role of formative assessment and feedback in learning process

Formative assessment is defined as procedure which includes discovering what student know and how students achieve the set aims of learning. Based on results of formative assessment, teachers decide whether instructions were effective and develop new instructional strategies to improve students' learning [12]. On the other hand,

students receive feedback about finished task. In this way, students see where they made mistake or confirm their knowledge. This can lead to the adoption of new learning strategies [13]. Feedback which students receive need to be constructive and to help students reflect own learning process. According to this, there are two general types of feedback [14]: directive – guides students what need to be improved and facilitative feedback which contains comments and suggestions for solving problems.

Thus indirectly, feedback as key component of formative assessment can have significant influence on learning process [15].

In computer –based environment, numerous types of feedback are applicable [14]: verification feedback (knowledge of results – KR); correct response (knowledge of correct response – KCR); repeat-until-correct feedback; elaborated feedback (providing explanation why a specific task was correct or wrong). There are a few types of elaborated feedback (EF). Some of them include giving central attributes of target concept; focuses on the specific students' response; feedback with re-teaching material; feedback which requires error analysis and diagnosis; feedback which guides the students to what to do next or gives a worked example or demonstration.

Studies have shown positive effect of elaborated feedback on conceptual understanding [16]. However, the effect of elaborated feedback can vary depending on content and context of learning [17].

For example, Meyer et al. [18] found more positive effect of EF on students' reading comprehension than simple feedback. Other authors claim that EF is more useful for learning in combination with KCR feedback than KR feedback [19]. Authors of meta-analysis which investigated effect of feedback in computer-based environment found that ER is more effective from simpler form of feedback only for higher learning outcomes [15]. Because of that, there are a lot of factors which can influence feedback effectiveness. Also, depending on students' abilities to understand feedback and use it in the correct way, usefulness of feedback can vary [20]. Similarly, Timmers & Veldkamp [21] claim that attention paid to feedback by students depends on length of explanations as well as task difficulty.

The results of other study showed that EF has more positive effect on solving new tasks in comparison to repeated tasks [22]. Thus, when students once receive feedback in form of explanation, students can conclude whether they have reasoned correctly and eventually where they have made mistakes. It

can help students to solve similar task in other attempts.

Based on mentioned researches which confirm usefulness of using simulations and elements of formative assessment, particularly elaborated feedback, these approaches are integrated for creating education software in the field of physics.

The aim of this paper is to describe created software for learning physics. Nevertheless, this paper represents the opportunities for using educative software with simulation in combination with elaborated feedback in education. Mentioned educative software can be an example for using similar software solution in different subject.

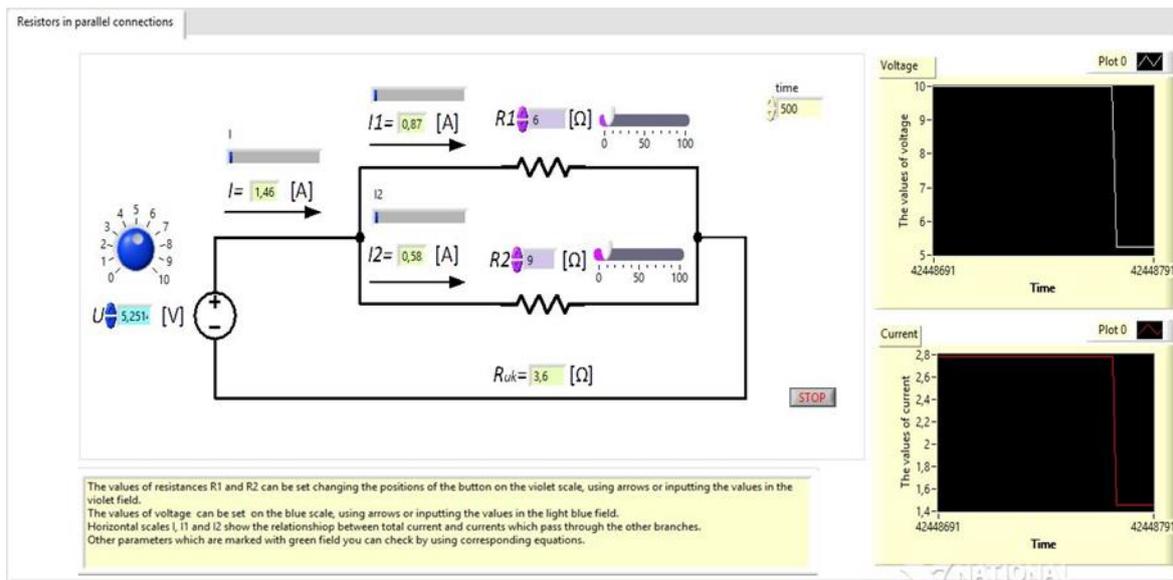
## 2. SOFTWARE SOLUTION

Created software contains simulation of electrical circuit, instruction based on text and images, as well as elements of formative assessment. The software is intended for 8th grade primary school students. Lessons are based on curriculum content for 8th grade [23]. The software was created by the authors of this paper.

Simulations were created in LabView v12 software package [24] and an interactive web page in Java programming language and HTML. Simulations are based on measurement of the values of the total current and voltages on the end of resistors in circuit (for circuit in serial connection) or currents in branches of electrical circuit in parallel connection depending on given values of voltage and resistances (Figure 1). Simulation also contains hint for using simulation when students need to learn without teacher support (yellow field). On the right side student can see graphs which present changes in the values of voltage and current in set time.

The tests in lessons contain tasks which measure different levels of achievement according to Blooms' taxonomy [25]. In tests there are tasks which require factual knowledge (e.g. knowing the units of voltage, resistance and current); understanding (e.g. understanding the relationships between voltage, resistance and current); applying acquired knowledge (e.g. calculating the value of current); relationships analysis between elements (e.g. predicting what will be happen with total current and current in one branch if the value of resistance in other branch are changed).

Student first access web page inputting name, surname, name of school and class into log in page.

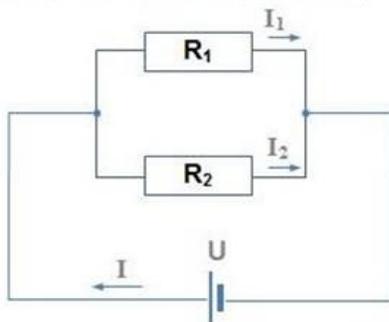


**Figure 1.** Simulation - parallel connection

Then, students get access to web page which contains instructions for learning Ohms' law. The aim of this page is to familiarize student with simple electrical circuit and measurement of electrical current and voltage. The web page contains link to first simulation. When students access to simulation and finish measurement, they can get test for this part of lesson. If students do not pass lesson, software will give instruction for accessing

first simulation again and elaborated feedback in forms of explanations for each task but without giving information about correct and incorrect answers. The aim of this type of feedback is to direct student how to find a solution for similar tasks. After that, student can access test again. When student passes the test, software will give elaborated feedback again for each task and KCR feedback (Figure 2).

2. For the two resistors  $R_1 = 5\Omega$ ,  $R_2 = 5\Omega$  in parallel, and  $U = 10V$ , as shown in Figure , the calculated values of  $R_e$ ,  $I$ ,  $I_1$ ,  $I_2$  will be:



- $R_e=2,5\Omega$ ;  $I=4A$ ;  $I_1=2A$ ;  $I_2=2A$  ✓
- $R_e=2,5\Omega$ ;  $I=4A$ ;  $I_1=0,5A$ ;  $I_2=0,5A$
- $R_e=10\Omega$ ;  $I=1A$ ;  $I_1=0,5A$ ;  $I_2=0,5A$
- I DO NOT KNOW



Since, it is  $R_e = R_1 * R_2 / R_1 + R_2$ . The value of the current is equal to the voltage and the equivalent resistance ratio. The value of the individual currents is equal to the total voltage and resistance value through which this current flows ratio. Check if you've used these equations to get the right solution!

**Figure 2.** Example of elaborated feedback + KCR feedback (passed test)

Then, students can access to second part of lesson – serial connection of resistors in electrical circuit. The procedure for testing is repeated until students pass the second test. After that, student can access the third part of lesson – parallel connection of resistors in electrical circuit (Figure 1). When students finish this part including accessing to

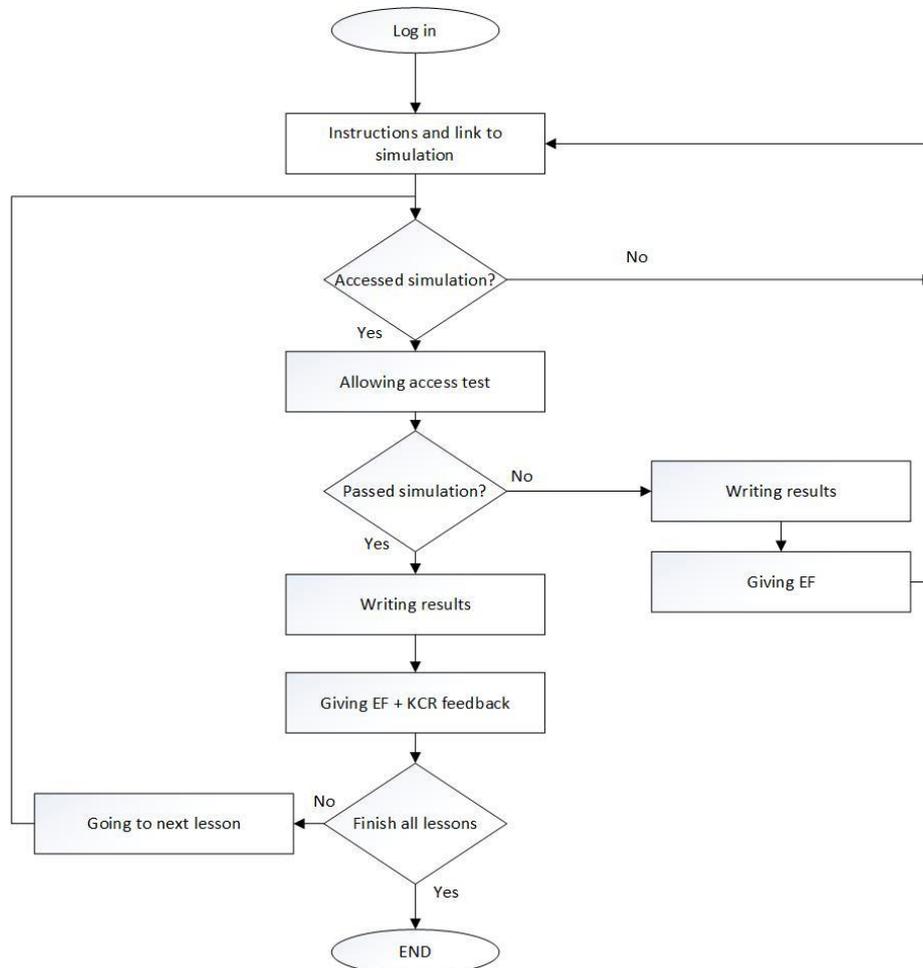
simulations and passing test, they receive message about whole finished lesson.

For each test, reports with information about students' achievement, percentage of correct and incorrect answers, and number of attempts to solving tests are given. Tests have dynamic form

which gives opportunities for randomly choosing the task from the date base for each new solving tests attempt. In this way teacher can track achievement for each task, analyze task and get feedback about students' misconceptions. Based on these results, teacher can conclude which types of

tasks are difficult for students and which points of content are critical.

The simplified algorithm of presented software is given (Figure 3).



**Figure 3.** Algorithm scheme

### 3. CONCLUSION

As it has already been mentioned, efficiency of any type of feedback must not be generalized for all learning context, subject and students. Because of that, created software can be used as educative tool for learning physics as well as tool for evaluating usefulness of elaborated feedback in combination with KCR feedback in this field. Nevertheless, the created software is based on three-layer software architecture which enables students to acquire content divided in three parts (Ohms' law, serial connection and parallel connections) and can make learning less difficult and more systematic. According to this, this software should be evaluated from more aspects to determine which factors make it effective for learning. It can be influence of instructions, feedback, simulation, as well as three-layer organized lesson.

### ACKNOWLEDGEMENTS

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# Programming and Simulation of Model Controls in Teaching Technics and Informatics

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**Abstract:** *Functional, adaptable and available systems for model programming and control are very important for the realization of teaching lessons from technical and technological school subjects. For that purpose, IT, web applications/services and simulation software for electronic circuits, microcontrollers and devices are optimal solutions. In the paper the following systems were considered and analyzed: Micro:bit and Circuits. They are directly linked to informatics and computing, thus encouraging students to acquire and develop their digital competences. Micro:bit is a small programmable computer and an online programming environment for encoding in two regimes: Block and Java Script, with created and derived examples in those operating modes. Web application Circuits serves for modeling and simulation of electrical/electronic circuits and devices. It contains electronic components (passive, active), sensors, relays, multimeter, protoboard, Arduino board. For programmable components, working modes are set via coding in affordable Arduino environment. The different models of electronic circuits and devices with LED, seven-segment display, servo motors, remote control have developed. For the listed models, the codes are written, and then realization of the virtual models functions in real time have done. With this innovative teaching approaches professional and intermediate competences by students are acquired and developed. On that way will be satisfied the required learning outcomes and fulfilled the legal frameworks in teaching technics and informatics.*

**Keywords:** *programming; control; simulation; technics, informatics.*

## 1. INTRODUCTION

Computers and microcontrollers are used to control machines, devices and systems. In order to control it, it is necessary to write specific programme codes in one of the dedicated programming environments. For this purpose, most commonly are used programming languages, such as: C, C++, C#, Java, Arduino, etc.

It is necessary to use modern technologies for the teaching process, as much as possible. In addition to computers (desktop and laptop), tablets, mobile phones and PDA are more common. Today, there are also small programmable computers for learning the basics of programming. They are designed so that learning and teaching are simple, obvious, efficient and fun. The specifics are classified into modern, innovative, and inexpensive teaching tools, which are very practical today for teaching processes in schools.

Arduino is a hardware-software computing platform called the open-source based on a simple input/output (I/O) board and development environment. Because of its simplicity and

affordability, the experience of using various systems based on Arduino in classroom is very positive. It is used in teaching at different levels.

Arduino boards are easy to use and require low voltages, and therefore are installed as a flexible and accessible teaching tool for technical areas. Arduino works on different operating systems: Windows, Mac, Linux. Students and teachers use Arduino for programming, automation, robotics; or use it for the production of cheap measuring instruments in various areas of technical testing.

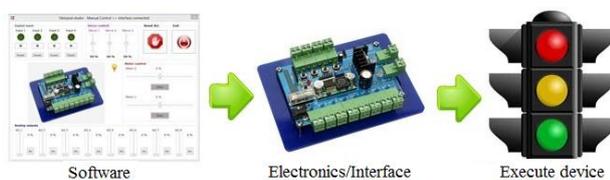
The Arduino platform allows reading (as voltage, current measurement) and writing (LED flashing, electromotor control, sound activation, etc.) from their digital and analog pins. This application mainly used ready-made external modules, for which libraries can be downloaded from the Internet.

There are available and specific online applications for modeling electronic circuits with Arduino boards. They have certain characteristics, with more or less options, and such simulations in real time can present and show the principle of operation of various technical and technological systems. In some of these web simulators,

multiple operations can be combined at the same time, namely to write, test, and execute generated program codes.

## 2. CONTROL OF TECHNICAL SYSTEMS

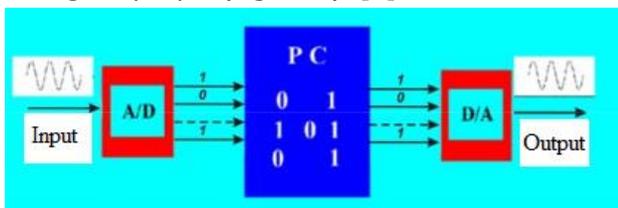
Connecting computers to external devices is done through ports, i.e. digital sockets. These devices can be grouped into two groups: input and output. Mechatronics is a multidisciplinary engineering discipline that includes electrical engineering, computing, mechanical engineering and automation. Today there are many models, i.e. reduced imitation of modern automated systems. Each such system consists of: software, control electronics (interfaces) and input-output parts. This is simplified present in the following figure 1, where the traffic light is given as an example of an executive part. [1]



**Figure 1.** Simplified control concept through the interface

Computers have a very important application in the control process of machines, devices, processes, business systems etc. By using computer it can be controlled sound, light, mechanical and other phenomena. This is done by satellites, robots, railways, home appliances, medical devices, smart homes devices, production processes, traffic, etc.

Computers work with a binary number system, using only two elements, i.e. logical 0 and 1, which represent electrical signals (impulses). Sound, light and other analogue impulses should therefore be converted into combinations of 0 and 1, and this is done by the analog-to-digital converter (A/D). When a computer accepts data in binary form, all operations are performed exclusively with binary numbers. Lastly, the results of these operations are also combinations of logical 0 and 1, and it is necessary to convert these series of numbers through those digital-to-analog converters (D/A) to something which is intelligible people (Figure 2). [2]



**Figure 2.** A/D i D/A converters

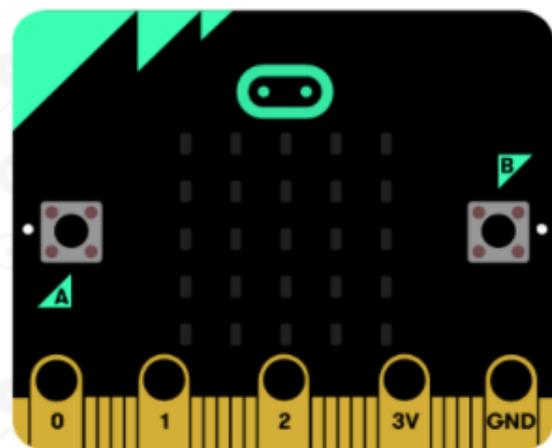
The models can be controlled through the appropriate interfaces. The following programming languages are used for software modeling, i.e. for coding: Visual Basic, C++, C#, Java, Arduino, Pascal.

In modern control systems, microcontrollers are indispensable elements. The microcontroller is a

so called "small computer" located in one chip. It contains microprocessor, RAM memory, programmable memory, analog-to-digital converter, digital inputs and outputs, interfaces, oscillator. This chip will not work without accompanying electronics, which will provide it with regulated and precise power supply, as well as communication with the computer through which the microcontroller will be programmed. Unlike the microprocessor, which is designed for working on PC, the microcontroller is targeted for installation in various devices and systems, where it has a defined purpose, and such special computers are denoted as embedded computers. Microcontrollers are used in a variety of technical products: robots, telecommunication devices, satellites, cars, instruments, mobile phones, cameras, home appliances, etc.

## 3. MICRO:BIT

Micro:bit is a new product in the field of computer technology, supported by the BBC company. It has a 32-bit processor running on batteries, 25 LEDs and 2 programming switches. There are also add-ons in the form of a sensor; including a built-in compass, accelerometer, Bluetooth Smart technology, five input and output (I/O) rings, a micro USB connector (Figure 3). For the basic model the price is about 20 Euros, and those with better performance (and even more expensive) can be ordered and purchased. [3]



**Figure 3.** Micro:bit

Because of a simple graphical environment, programming on it is designed to be the easiest possible (for lower levels of education). However, it is also compatible with advanced programming languages, and also enables direct programming (coding) for teaching at higher levels of education. Micro:bit is a small computer, or a miniature programmable tile (size 4x5cm). Software is an application that is accessible from PC, tablet, mobile phone. Parts of the working environment are the following: simulator, commands - tools and workspace for code input (Figure 4). [4]

The simulator is located on the left side of the screen, and a virtual micro:bit device shows the execution of functions. The tools are in the middle of the screen, there are several different

categories, each containing a number of blocks, that can be dragged into the programming workspace on the right. The workspace is located on the right side of the screen and it is a program part, where the command blocks are placed or the codes themselves are written.

There are many commands in the following categories: Basic, Input, Music, Led, Radio, Loops, Logic, Variables, Math, Advanced. After entering the codes, the project can be saved and then executed in real time (response is directly visible). There are in total two options, Blocks and JavaScript, to enter the commands.

This interactive simulator provides students with instant feedback on how their program is running, and allows them to debug their code.

Blocks is graphical drag and drop code editor, understandable and intuitive. In it are entered ready commands with the possibility of certain changes in their parameters. Students new to coding can start with colored blocks that they can drag and drop onto their workspace to construct their programs.

With JavaScript, the codes are in the lines one below the other. JavaScript is a popular programming language for programming dynamic web sites, not complicated, but extremely powerful. JavaScript does not have to be run through a compiler, that reads the code into something the browser understands, but the browser effectively reads the code in the same way, and then interprets it. When students are ready, they can move into a full-featured JavaScript editor with code snippets, tooltips, and error detection to help them. [5]

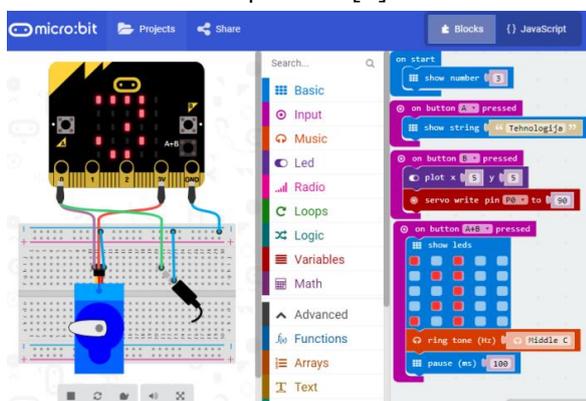


Figure 4. Micro:bit – Blocks

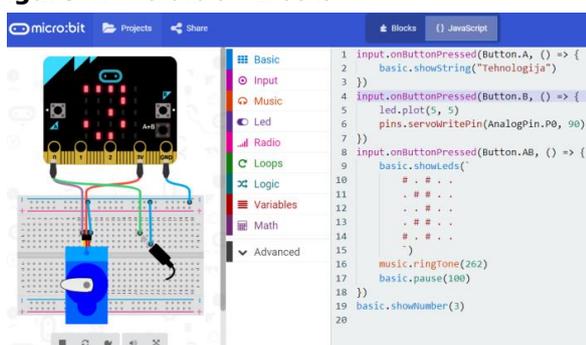


Figure 5. Micro:bit – JavaScript

In Figures 4 and 5 above, examples of created codes in the micro:bit are given. More precisely, they are presented the same in parts of the Blocks and JavaScript (in the images on the right). At the same time, the implementation of the mentioned control codes are visible (in the images on the left).

#### 4. MODELING AND CODING IN THE CIRCUITS/TINKERCAD APPLICATION

Circuits is an online tool for designing projects in electrical engineering and electronics. Basically it is easy to use, free and convenient web service for simulating electric circuits in the classroom.

Formed models are automatically stored and, if necessary, quick and easy to add/delete components. It can serve to explain and present programming to students and how to connect electronic components to circuits, especially if there is no actual Arduino platform. Certain component characteristics can be easily and effectively modified as needed.

There are many components and libraries in options, which is enough to work in this environment (for 7th and 8th grade of elementary school), and even at higher levels (secondary technical schools). It has been noted that over time, this application is upgraded and expanded with additional options.

Application helps in creating electronic circuits, without the use of real components, with the option of control the programmable components (encoding). In other words, it is a virtual prototype platform that provides the ability to work in an electronic environment (Lab View) without the need to purchase and connect real components. This environment makes a lot of different components available, which we use the same way as the actual ones, with the difference that they can not cause physical damage during testing. Then it offers the ability to start creating original project, or download it from other users.

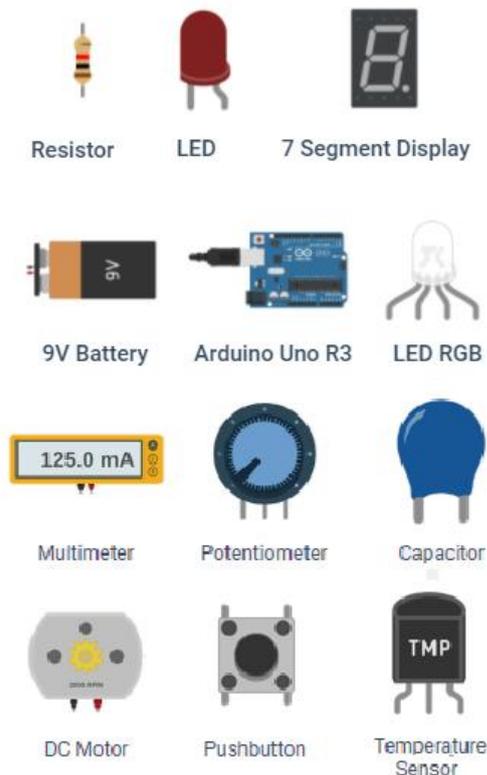
The Circuits application has the ability to debug the code, which is quite complicated on most actual models, and also has a timer during model simulation. It is so called emulator and is some kind of Arduino platform, intended for the writing, testing and executing certain specific codes. [6]

When the development of a project is completed, the program code can be transferred to the Arduino device, where it will run in the same way, as in the virtual Arduino.

The command in the considered application are: Undo, Redo, Zoom To Fit, Delete, Rotate, Share, Export.

In the Components section, there are many parts for presenting electrical/electronic elements, circuits, machines, devices. Clicking on the component it can be easily dragged on the working space. Besides of active and passive electronic components, several types of Arduino boards, there are also sensors, relays, displays, motors, measuring devices, etc. Some

components from the Circuits application in Figure 6 are shown. [6]



**Figure 6.** Certain components in the application Circuits

Circuits application helps students in direct realizations of electronic projects, without the use of real components, i.e. it's a virtual prototype platform, that provides the ability to use an interactive electronic environment. For programmable components, specific codes are written in order to define and control the operating modes.

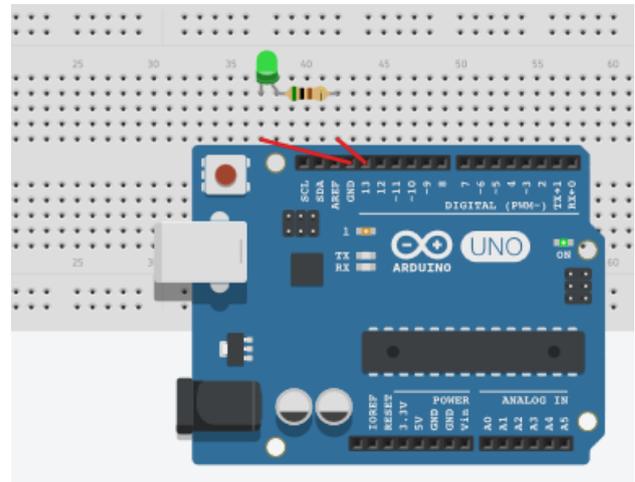
Various functional electronic models were created in the Circuits application with the Arduino UNO board, the appropriate components (and conductors). The lines of codes written in the Arduino environment determine behavior, and also controlling the operations of these models, i.e. programmable components in them over time. Application is used for teaching in the field of robotics and model control by computers. During the research, the following models have been created and control (with specific coding):

- LED model
- RGB LED model
- Traffic light model
- Running light model
- Seven-segment display model
- Robotic arm model (with servo motors)
- Advertising light model with remote control (IR).

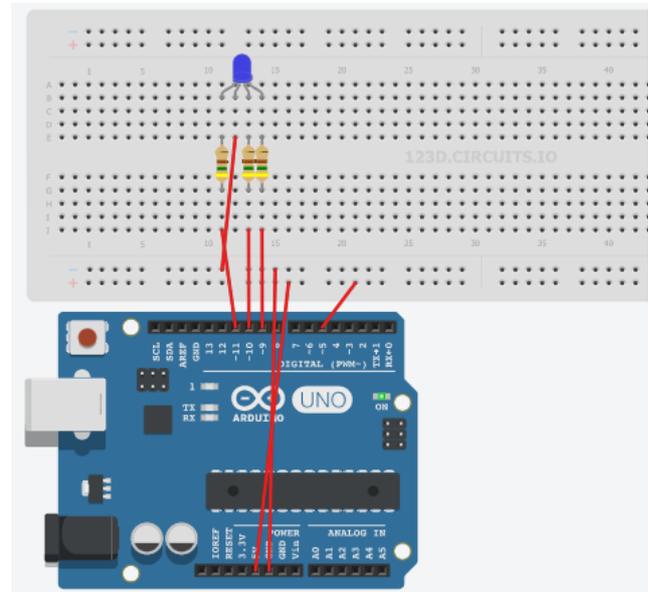
The realization of above mentioned models are clearly seen in Figures 7, 8, 9, 10, 11, 12, 13. Circuits has a certain base of electronic components, it defines the operation modes of programmable components, allows the expression

of creativity, the implementation of project oriented teaching and further learning through research by students (and also teachers).

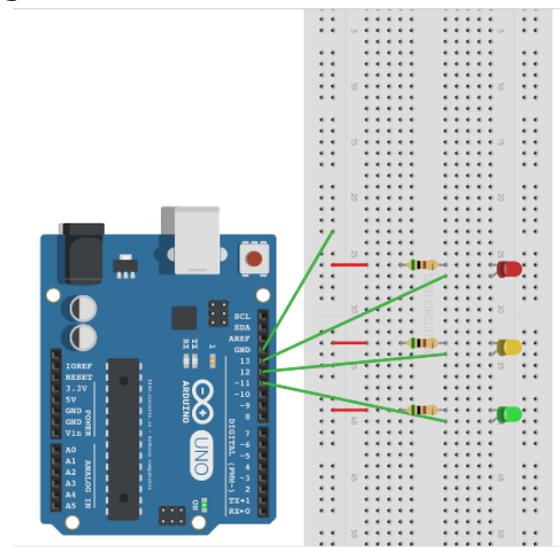
Thus students can prototype and simulate certain circuits with Arduino code without hardware.



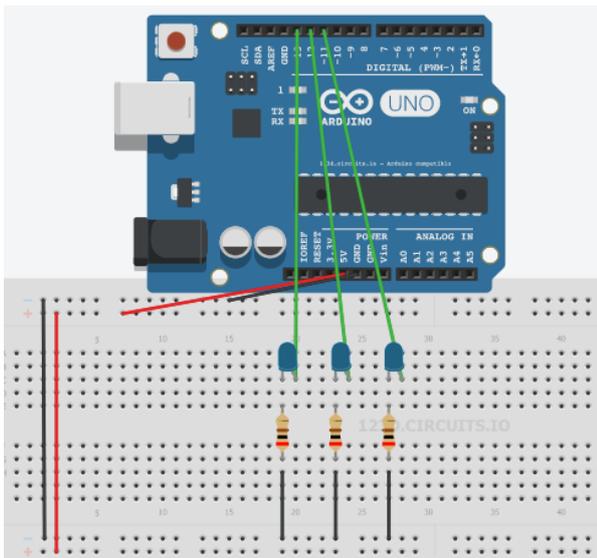
**Figure 7.** LED model



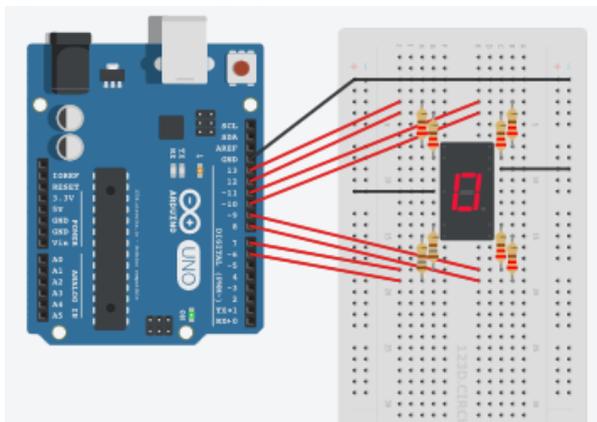
**Figure 8.** RGB LED model



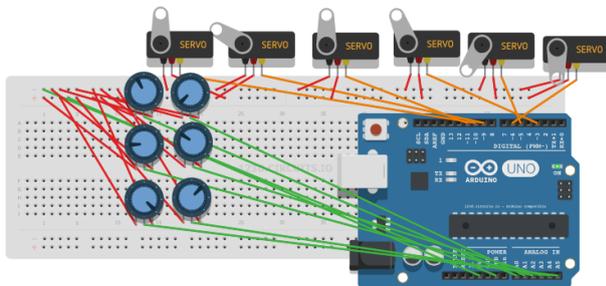
**Figure 9.** Traffic light model



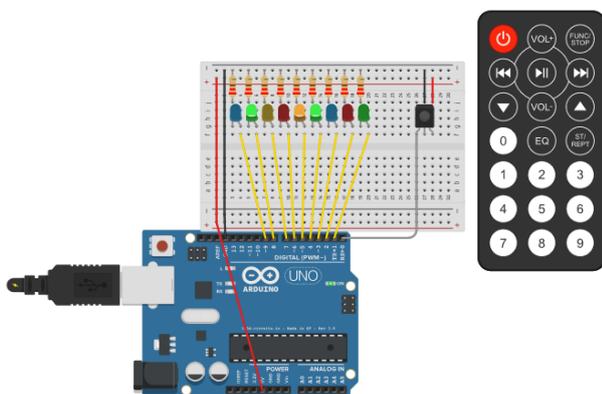
**Figure 10.** Running light model



**Figure 11.** Seven-segment display model



**Figure 12.** Robotic arm model (with servo motors)



**Figure 13.** Advertising light model with remote control (IR)

## 5. CONCLUSION

Optimization of existing resources to achieve the necessary goals, tasks and outcomes in education is imposed today as an imperative. Teaching plans /programs, but also methods, equipments, technologies for general and professional technical and technological school subjects, must be fairly rapidly changed, innovated and adapted to require job markets and standards. IT-based learning tools become irreplaceable in teaching and learning. This paper examines the programming and control of models in the teaching technology and computing (approximately levels of primary and secondary schools). The two relative new teaching tools were considered and analyzed, i.e. Micro:bit and Circuits. Besides of that the main elements of the control system have analyzed, and the roles of microcontrollers/PC in controlling certain technical devices and systems have explained.

Micro:bit can be used as a programmable computer (hardware) and online encoding programme (software). The coding are not so complex for students. It works in two optional operating modes, i.e. Block and Java Script. As a teaching tool, it is adapted to learning the basics of programming, and visually gives quite direct views/responses of the realized control on the previous created models. Micro:bit devices can be used in a large number of school subjects that, at first glance, are not directly related to programming and thus help digitize the teaching process and encourage learning in a creative way.

The Circuits application (from the Tinkercad environment) for modeling and simulating electrical/electronic circuits is a solution for efficient teaching, with the optimal use of ICT. The application is not complex, it has a functional graphical interface, then availability online (free cost), easy to enter components on the board and certain changes in their parameters. With the model simulation, by programming (coding), and appropriate control them, the application combines the inventive approach to teaching, with innovative computing technologies, needed for modern and up-to-date education from electronics and programming.

In the paper the following models have researched and developed in Circuits: LED, RGB LED, traffic light, running light, seven-segment display, robotic arm (with servo motors) and advertising light model with remote control (IR).

These listed teaching tools make connection between curriculum from technics/technology and informatics/computer science. Teaching units from the different school subjects are complemented and functionally linked, for the better and deeper understanding technics and informatics materials, as the continuous knowledge and skills acquisitions by students.

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# Video Games - Influence on Children's Cognitive Abilities

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**Abstract:** *The purposes and functions of play in children's development have been researched for well over a century by scientists of different disciplines. Like everything else, the play itself is experiencing transformations in the contemporary, digital age. Children spend more time with computers and other smart gadgets, both at home and at school. The question that arises is how the use of information and communication technologies and especially playing video games can affect and change children's lives – from educational and learning aid, to the emergence of depression and the promotion of violent behaviour. The paper reviews the conclusions of the research concerned with each of the five main types of play in which children engage; and highlighting the benefits of playing video games for the development of children and their skills. Article provides an overview of the limited research on the effects of using information and communication technologies on the cognitive and social development of children. The influence of playing video games on the development of cognitive abilities in children is analyzed in particular. In conclusion, the guidelines and tips for possible further research of the effects of playing video games on the children development are provided.*

**Keywords:** *video games; cognitive skills; ICT; play; children*

## 1. INTRODUCTION

Psychologists, anthropologists, sociologists, pedagogues and many others experts have been researching and theorising about play and its role in human development, for well over a century. 'Play' is sometimes contrasted with 'work' and characterised as a type of activity which is essentially negligible, trivial and deficient in any serious purpose and intention. As such, it is seen as something that children do because they are immature, and as something they will grow out of as they become adults. Numerous studies have exposed this attitude and this view as incorrect. Play, in all its forms, is among the top achievements of the human species, beside language, culture and technology [1]. Definitely, without play, none of these other achievements would be possible. The importance of play is increasingly recognised by researchers, for adults as well as children, as the evidence mounts of its relationship with intellectual achievement and emotional well-being [1]. The evolutionary and psychological proof points to the essential contribution of play in humans to our success as a very adjustable species [2]. Playfulness is strongly related to cognitive development and emotional well-being. The mechanisms underlying these relationships appear to involve play's role in the development of linguistic and other representational abilities, and its support for the

development of metacognitive and self-regulatory abilities [2].

It has recognized five fundamental types of children play by psychological research. Those games types can commonly be classified as: physical play, play with objects, symbolic play, pretence or socio-dramatic play, and games with rules [1]. All five types of play are found in different manifestations, depending on available technology, in all cultures. Each of them supports a range of cognitive and emotional developments. Therefore, a good balance of various play experience is considered as a healthy play diet for children. Some types of play are more fully researched than others, while much more of them remains to be understood relating the underlying psychological processes involved.

The most important benefits for children, considering each of the above types of games, can be highlighted:

- Physical play – since this play type includes active exercise (jumping, running, cycling, wrestling with friends, ball playing, various fine-motor practice...), it is associated with the development of the entire body of children and hand-eye coordination. Also, it is significant in building strength and endurance [3].
- Play with object – it begins as soon as infants can grab and hold some object; early investigative behaviours include mouthing/biting, rotating while looking, rubbing/stroking, hitting and dropping.

This might be described as 'sensory-motor' play when the child is exploring how objects and materials feel and behave. And in the older age children begin to arrange objects, also building and constructing things of them, which progressively develops into sorting, organization and classifying activities. When playing with objects, children maintain their attention, developing problem-solving skills and competencies, as well as self-regulation [4].

- Symbolic play – humans have and use a wide variety of symbolic systems (spoken language, reading, writing, numbers, various visual media, music etc). This type of play supports children to develop their technical abilities to express and reflect upon their experiences, ideas and emotions [5].

- Pretence/socio-dramatic play – this type of play has repeatedly been shown to be very strongly related with the development of cognitive, social and academic abilities. It strongly influence on narrative skills, as well as on deductive reasoning and social competence [6]. This kind of play makes some of the greatest demands on children's self-discipline, or self-regulation, because children are obliged to follow the social rules according to the character and role they play.

- Games with rules – children tend to give meaning to their world and therefore they are very motivated to establish rules. As a consequence, from a very young age, they enjoy games with rules, and frequently invent their own. In addition to helping children to develop their understanding of the rules, the main developmental contribution of playing these games arises from their essential social nature. While playing games with their friends, relatives and peers, children are learning a whole range of social skills related to exchanging, sharing, taking change, understanding the perspective of others etc [7].

From the presented it can be seen that the play is not irrelevant at all, and its influence on the development of the young beings is very significant. International bodies, such as the United Nations and the European Union, have begun to consider and develop policies concerned with children's right to play, with the educational and societal benefits of play provision, and with the implications of this for educational institutions and educational programs.

## 2. PLAY IN A CONTEMPORARY ENVIRONMENT

The play, like everything else, is susceptible to change (social, technological, scientific...). The appearance of personal computers and other ICT (Information and communication technologies), in the first place of the Internet, had a big impact on the play form transformation. The play was

evolving in the 21st century, from outdoors play and games to computer, video games.

It can freely be said that the electronic age produces an entirely new sort of individuals. But what kind of an effect will such an age have on them, primarily on children? Actually, many begin to call these new, technological natives' generations "Generation M" (M stands for media). The world that they are growing up in is totally different from their parents' world. Contemporary world and society are under the influence of the media and technologies of various types. With the greater role of personal computers and other smart, mobile, handy gadgets in children's lives, has come increased concern about how children may be affected. The growing amount of time children are spending with computers, at home and school, has raised questions about how the use of computer technology may make a difference in their lives – from helping with learning and homework, to causing depression and to encouraging violent behaviour. Time spent on computers and using ICT may displace other activities (other type of play), that have more developmental value. So, the advantage of the computer-based activities has also been questioned. The daily use of ICT has enforced many questions about the impact on children (in terms of health, education, psychological impact, social impact etc.). The overall ICT impact on children is a complex issue and requires numerous, extensive research, which would approach to this problem from a various aspects. It is necessary to explore different types of impacts of different types of ICT. In this article we will try to present some of the posture how new forms of technology-assisted play can affects children's development and education.

During previous decades computer video games became a significant source of entertainment for young people (i.e. children and young adults). Nowadays such games can be played on relatively low specification technology gaming platforms, including mobile devices and other smart gadgets. This makes the video games accessible even to those who may not own personal computer; as a consequence, we have many children spend a significant amount of free time playing computer games. Video games have quickly become a general aspect of child development [8], and their rapid rise to importance has stimulated scientific inquiry and public concern [9]. Researchers emphasize that children may be particularly vulnerable to the effects of playing video games [10] [11], the effects of video games on children's psychosocial development remains highly debated. Like any medium, video games are communication channels whose effects vary greatly depending on their content. Thus video games are in general studied as a possible cause of aggressive knowledge, cognitions and behaviour [12], emotional problems such as depression [13], and

hyperactivity and lack of concentration [14]. In some research works, video games are described as an overwhelming entertainment medium whose wise use of feedback loops and positive back up schedules train unhealthy habits of mind [15]. Experimental, longitudinal and meta-analytic data show that playing violent video games increases aggression, hostility and aggressive thoughts [12] [10] [16].

On the contrary, researchers have recently begun looking at video games as a domain for training healthy habits and positive cognitions and behaviour [17] [18]. From this point of view, many video games recompense communication and cooperation as well as resolving negative emotions such as frustration. In addition, it's obvious that video games provide a context for fulfilling self-deterministic needs, thus contributing positively to the psychological, mental well-being [19]. Games with positive content show positive effects. For illustration, playing a dancing video game can help children lose weight [20].

### 3. VIDEO GAMES AND COGNITIVE SKILLS

When it comes to certain cognitive skills, researchers have found that ICT, especially video games, can improve visual spatial skills (such as visual tracking, mental rotation and targeted localization). Computer games can also advance children's problem solving skills. Researchers still need to fully understand the issue of learning transfer via electronic media. Studies suggest that, in some circumstances, children can transfer what they learn through ICT (and video games) to other applications, but it is still not certainly known how this transmission takes place [21].

Research was carried out, aimed at determining whether learning through ICT (which affects both the auditory and the visual system) is more or less effective than learning only through the symbolic system. Several studies Kozma [22] conducted compare the learning achievements through combined audio-visual presentations with learning outcomes only to audio or visual media. It turned out to be an advantage on the side of audiovisual presentations. The subjects are more familiar with what they hear and see together, than with what they only see or just hear. One study found benefits of video gaming for visual attention, including greater attention capacity, faster attention deployment, and faster processing [18] [21] [22].

According to Salomon [23], different media forms engage, and develop, different cognitive processes. He demonstrates that repeated exposure to cinematic codes presented on film, such as the zoom technique, leads children to essential adoption of these codes [23]. Salomon's research also provides confirmation that educational programs can enhance particular cognitive abilities [24] [25]. Analysts have conducted many

researches on video games. Several studies imply that video game may improve spatial reasoning skills in children. These studies suggest that video games may positively affect a variety of visual spatial skills (video game players, for example, have better hand-eye coordination than nonplayers) [24] [25]. Children's previous video game experience has also been associated with shorter reaction times on colour and shape discrimination and stimulus anticipation tasks [21] [24] [25].

Video games might also improve children's problem-solving skills. The long-term positive benefits of video games depend, in large part, on whether children can learn abstract knowledge or problem-solving skills and transfer them to new situations [17] [18] [21]. Video games provide informal training in inductive discovery – as play went on players induced the set of rules and strategies inherent to the game.

Children growing up in the digital era are far more practiced and capable at processing information rapidly than were their predecessors and are bored if they have to 'slow down' at educational environment [26] [27]. Regardless of the existing theories of learning and cognitive abilities, we must be aware and recognize the existing changes that are caused by ICT. In childhood, the use of ICT is mostly reflected in the playing of computer games. Changes in the cognitive skills of digital natives are evident, and this can only be ascribed to the daily use of ICT in all life aspects. Ten main cognitive style changes have been observed in the 'video games generation' [27]:

- twitch speed versus conventional speed
- parallel processing versus linear processing
- graphics first versus text first
- random access versus step by step
- connected versus standalone
- active versus passive
- play versus work
- payoff versus patience
- fantasy versus reality
- technology-as-friend versus technology-as-foe.

These changes pose considerable challenges for the educators who wish to promote literacy skills. All the games make use of the visual, but they always make use of much more: there is a musical score, elementary, simply dialogue, and there is writing – usually as in comic strips, in a box above the rest of the visually saturated screen. It's exactly this kind of video games multi-layered layout that makes them an essential medium for developing the cognitive skills of children. Their general acceptance and informality is only an advantage over traditional, sophisticated systems. Children more easily and quickly accept activities that are

closer to the play; they are more dedicated and devoted and are more motivated to take part.

#### 4. CONCLUSION

Like most things in life, there are two sides to the video game discuss. Researchers have found many negative effects, mainly from violent games, while positive effects have also been seen – mostly in the more effective learning that occurs in interactive games. In brief, it seems that the moderate amount of the video game is not harmful to the development of children. In fact, playing of video games may produce critical thinking, healthy exploration, and skills development in children. However, an excessive amount could obstruct exercise, learning or social activities. While violent video games may lead children to more at-risk behaviours. A number of issues have been highlighted about the use of ICT and video games for education by children. Researches' findings often conflict in their outcomes, so longitudinal studies are needed. In reviewing the literature, particular areas of investigation are raised. Some directions of future research may be:

- the cognitive and social effects of the newer video games generation and other software, especially the multi-user games available on the Internet
- the long-term cumulative impact of interactive video games on cognition and academic achievement
- more completely investigation on the relation between violent games and children's aggression
- simulation and simulated world impact on children's developing identities and sense of reality
- how video games can be used more adequately as a valuable educational and instructional tool.

So far, very few studies have been conducted, in our country, on children using ICT and video games (which can have literacy, computing or other basic skills requirements). Consequently, there is little reporting on the social needs, social and behavioural issues in children's age that relate to the education.

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# Video Conference in Terms of Application of ICT in Education

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**Abstract:** *Modern education must follow the development of information and communications technologies. It is necessary to introduce new teaching resources in the educational process as well as a new methodological approach in order to supplement and enrich the traditional manner of learning. In this paper videoconferencing is described as one of the aspects of the application of information and communications technologies in education. The technology of the videoconferencing system and the proper choice of conference tools and ways of realization are crucial for the success of a videoconference lecture.*

**Keywords:** *video conferencing, technology, methods, tools*

## 1. INTRODUCTION

Video conferencing is connecting individuals and groups via telecommunication networks and video technologies in real time. The sound and images are transmitted electronically in a digital format, which provides simultaneous interactive communication.

The contemporary university becomes increasingly permeated by digital mediation both on-line and face-to-face, relationships between digital media, time and socially-situated practices of meaning-making are foregrounded. [14]

Video conferencing services tend to offer more than just face-to-face interactions. Video conferencing services let users share their screens, remotely access one another's desktops, chat via text, exchange files, communicate via digital whiteboards, and even broadcast conferences to large groups of passive viewers.

Video conferencing has a variety of applications, of which the most important are: meetings, interviews, education, management, remote diagnosis in medicine and perform regular work.

Education takes on a new dimension by using a video-conferencing system. A small group of students fully corresponds to the mode of functioning and video-conference meeting. Using data exchange, for example, a presentation between sites gives away a group experience the same lectures as well as local students. [1]

Virtual Learning Environments seem like the perfect blend of efficiency and practicality for a generation accustomed to speaking over video call, learning via the internet, and expanding their lives beyond their locations—and who might well be headed for a

partly or entirely telecommuting job. Attending a college lecture in the digital world involves the same process of information exchange as talking via smartphone. [15]

## 2. TECHNOLOGY OF VIDEO CONFERENCE SYSTEMS

Technology video conference system consists of three essential components, namely:

- equipment at all locations record sounds and images, converts them into digital form and sends them over the network
- networks by which signals are sent
- conference room environment or room

The installed video conference system must be connected by either IP or ISDN lines. If the system is used at different locations, the connection must be provided at each location. In some locations, it is likely to be provided by IP while on the other, on the contrary, by an ISDN connection.

The starting point for effective video conferencing is the proper conference room, or the environment. The acoustics of the room, light, and many other factors have to be controlled for the most effective video conferencing. Video conferencing is a form of television and has similar guidelines. The high contrast and huge patterns on clothing should be avoided. The movements should be minimal. The conference may suffer from the delay; may be subject to the change of one image to another speaker, every time you hear a different voice. In these conditions, any interruption and a short-term interruption of the few things can be counterproductive, because it will distract attention from the one who speaks. Video conferencing requires discipline and respect of certain rules.

### 3. METHODS OF IMPLEMENTATION OF VIDEO CONFERENCING

The user to the user is an example of point-to-point video conferencing. [1,2] Only two terminals are included in the connection. In the case that both PC are based, the system runs compilation application. As long as the application software and hardware components are compatible with the standard protocol, the conference will be a success. The user may not be aware of any differences in the application software that is run by some of the PC machine.



**Figure 1.** Point to point video conferencing

The connection is established via one of the terminals that makes calls to another. endpoints be placed anywhere, they can be in the same building or in different offices or even in different parts of the country or the world.

The user to the study is another example of point-to-point of the video conference system. As in the video conference user to user, here are only two terminals or included endpoints. One of the endpoints may be any type of a terminal device. The difference here is that at one terminal, there is one individual, but there are more at the second.

Studio to studio video conferencing system is a final example of point-to-point internet connection. It should be expected that at both ends, the users have more similarity to the functional mode of the work cited in the previous example, the user to study. This connection is achieved by complete video-conference communication between groups in a studio with a group of participants in another, remote study.



**Figure 2.** Studio to studio video conferencing

Multi-point video conferencing is more complex than the previous examples, and requires

additional management parameters and conditions for setting and controlling the links between terminals. The multi-point video-conference sessions are sublimated, all simpler and previously described methods of managing video-conference events. For this reason, here are sublimated and the biggest difficulty for equipment and software support. It is necessary to carefully and constantly take into account all parameters of audio-visual signals and comply with all the necessary rules for the proper flow and conduct of video conferences. At the same time this form of video conferencing gives the greatest effect by enabling connectivity and communication of greater number of points and their complete interaction. [2]



**Figure 3.** Multi-point video conferencing

Continuous presence or managing events permanent presence, is the process where the video streams of remote video conference participants are simultaneously displayed on the display on the local display. During a call, the phase of the multi-point video conferencing is adjusted so that each terminal establishes its own operational parametre. The number of video flows can be decoded and prominently set on display through the terminal during this phase.

Voice activation of inclusion and integration, is the basic model of work and the use of the large percentage of video-conferencing. [14] This control model conference is facilitated by the MCU connectivity for transmission rate by the video signal to a current exhibitor. The current exhibitor does not get his own video display back, but the ones of the previous exhibitors. The effect of the current exhibitors accepting audio and video presentation of the previous exhibitors is that it gives the impression of giving a direct answer if the current speaker of the conference is in a distant place. The output signal on the remote display of the remote sites represents monitoring of the representative and exhibitors from other remote sites. Website in this elsewhere is the site of previous exhibitors.

Control of the chairman is a model where one site, which is allowed, controls over the speech by indicating through hardware or software control.

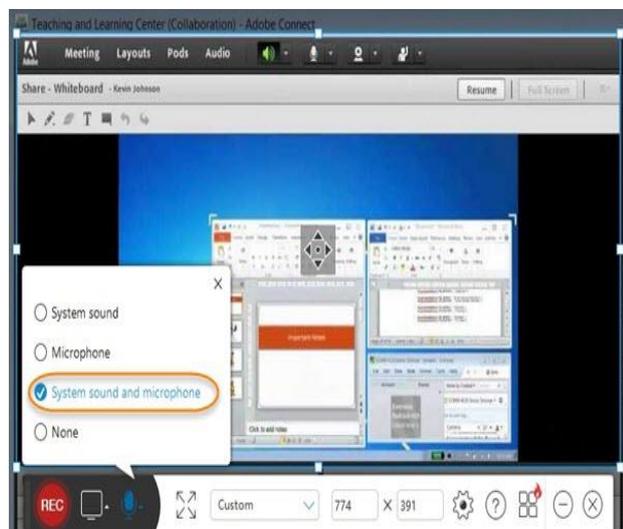
The example of control of the chairperson may be in terms of providing legitimacy and publishing award words of the exhibitor that can be uttered during the legal debate between the two parties.

## 4. CONFERENCE TOOLS

### 4.1. Conference tools used in Serbia

**Adobe Acrobat Connect** is derived from software Macromedia Breeze and provides audio-visual communication in the form of virtual conference rooms. Video conference tool Adobe Connect is a hosted tool, i.e. the company offers only online version of the tool, which is located on their server.

Adobe Connect is an innovative system for collaboration and distance learning. It enables business communication with associates, clients and partners regardless of where they are located, without obstacles and limitations. It combines various communication in real-time and on demand, which makes it an optimal solution for the most demanding organizations. [7]



**Figure 4.** Adobe Connect Video conferencing system

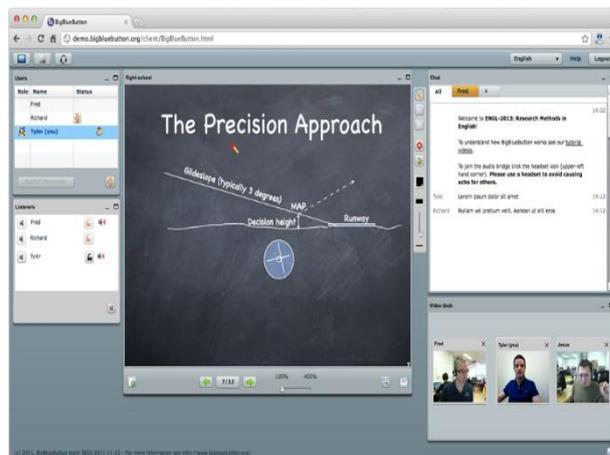
Thanks to the fact that Adobe Acrobat Connect Professional is based on the flash player, there has been a large degree of flexibility in the application of this system on a variety of platforms. [6]

Adobe Connect is a web application that allows efficient interaction and exchange of rich content among participants in communication. Access is enabled on all desktop platforms (Windows, Mac, Linux) with a browser, and on all mobile platforms (Android, iOS, Blackberry) through the client application of Adobe Connect Mobile.

The software allows: personalized URL address to the conference room, screen sharing, administration speakers, record meetings for later viewing, viewing multimedia content (animations, video clips, demonstrations of software...), sharing files and documents among participants of the conference/meeting, voice communication among

participants using VoIP, video communication, text message, whiteboard visible to all participants, the possibility of assigning the right to use local applications to remote participants and many more. [6]

**Big Blue Button** is an open source web conferencing system developed primarily for distance education. Interested developers can get involved in the further development of this project. There is no need to install it. It is localized to over 40 languages. There is a possibility for it to be installed in another application. [5]



**Figure 5.** BigBlueButton Video conferencing

It allows sharing: desktop speakers, documents (PDF, PPT, Open Office documents) cameras without limitation participants, white board, chat room correspondence, phone calls (voice over IP), record and play videos with the web conference (slides, audio and chat).

**Video Whisper** contains a number of video conferencing tools that can be installed or integrated into any site or LMS. On the official website [www.videowhisper.com](http://www.videowhisper.com) we can find details about each tool that is offered by Video Whisper, intentions and instructions for the installation and integration of the same.



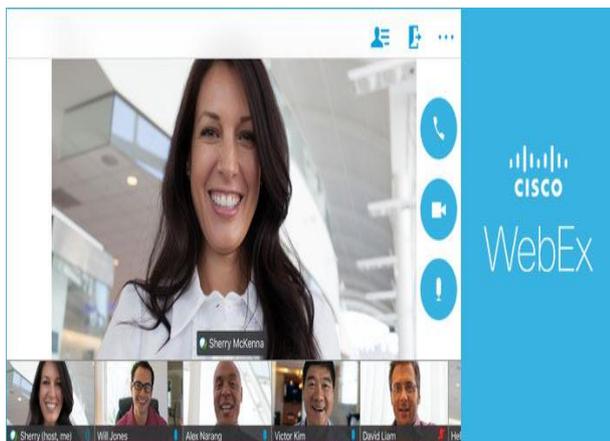
**Figure 6.** VideoWhisper conferencing system

The tools offered by Video Whisper are: exchange video messages live, online video consultation, two-way video communication, video conferencing

software, streaming software in real time, software for video recording.

**WebEx** is a licensed web video conference tool, Cisco. Cisco offers a trial version which is limited to 14 days and the participation of a maximum of three participants.

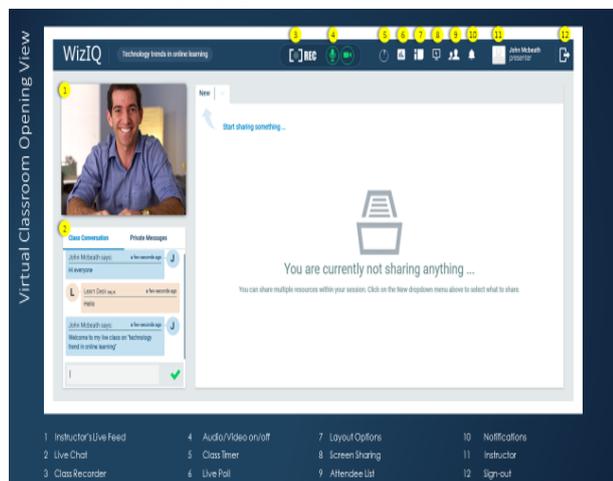
The characteristics of the web video conference tool WebEx are rooms for private meetings with their own logo and design, verbal communication and real time text communication for participants, presentations containing audio streaming and video animations, interactive whiteboard, document exchange, animation, and even the computer interface, use the mail box, a conference can be held on all platforms. [10]



**Figure 7.** WebEX Cisco Video conferencing

WebEx can be used not only for business but, it is also a great tool that can be used in distance learning. WebEx conference tool can be integrated into the LMS.

**WizIQ Live Class** is another in a series of softer skin solutions for web video conferencing, which has all the necessary elements for the good functioning of the meeting. It is licensed, with its official website [www.wiziq.com](http://www.wiziq.com) which offers a free trial for 30 days.[9]



**Figure 8.** WizIQ Video conferencing

WizIQ is a great tool for web expansion of the teaching process outside the traditional classroom. WizIQ conferences are based on the Web which is

equipped with tools for real-time collaboration, such as the live, two-way audio and video communication, writing board and share content.

It is possible to integrate the same with the LMS. The registration is required on WizIQ official website to download the plugin after getting the activation key. After installation, the new "Activity" feature, WizIQ Live Class begins to be displayed in an LMS. Administrators and teachers can choose this module to create new classes to their course, of course, like every other standard activities. At the scheduled date and time, students and teachers can attend on-line time by simply clicking the link.

**Dimdim** started in 1996 with the goal of providing web conferencing software that was both simple and free. With over 15 years dedicated to simplifying complex web conferencing software, Dimdim is now able to claim its web conferencing software as being the easiest to use and simplest web meeting tool available today. Dimdim is a web conference service where users can share everything with other users: files, screen, slides as well as to correspond, talk and use a webcam at the meeting. Dim dim allows holding meetings online using search. Dimdim is a free meeting room. This service offers the possibility to organize a virtual meeting of twenty people (the free version), where the whiteboard (on which everyone can draw, write and delete) is available to the participants, a tool for presentations and demonstrations, with the inevitable communication voice and video - if you have a webcam, of course. You can record the meetings for later use. This service is suitable for the organization of e-learning, because the professor can schedule a meeting or lecture at a desired time and invitations for attendance to the student by e-mail. In the e-mail students obtain login data used for access to lecture. Dimdim is used as a supplement to various LMS systems at a time when it is necessary to hold a short demonstration or establish a video interaction with the teacher. [8]



**Figure 9.** Dimdim conferencing system

#### 4.2. Top 10 web conference tools in the world

Collaborating with eLearning team members, offering live training events, and enabling online learners to reach out to their peers are just a few of the many uses for web conferencing software. However, due to the sheer abundance of web conferencing software tools that are available today, finding the one that suits your needs and fits your eLearning budget can be challenging. will be displayed a list of the best 10 web conferencing software. [13]

**AnyMeeting** is the go-to web conferencing and webinar tool for small organizations, thanks to the fact that it is an all-in-one platform which features everything from video and phone conferencing support to webinar hosting. It's been around since 2011, and has quickly become one of the most popular options available, boasting over 800,000 registered hosts. You can sign up a free trial and pay just \$18 for small group meetings after that.

**Onstream Meetings** is great for eLearning professionals who want a more personalized web conferencing platform, as it allows you to customize every aspect of your web conference screen. Its interface is easy to use and they offer a wide range of plans that are just right for organizations of any size. Some of its standout features include: real-time reports, mobile apps, and on-the-spot meetings.

**Zoho Meeting** is a user-friendly web conferencing software tool gives you the power to hold virtual meetings and host live webinars in a matter of minutes. You can even embed the web conferencing platform directly into your eLearning blog or website, which can significantly boost attendance rates. It's also a great tool for eLearning professionals who wish to offer online support to their online learners without having to rely on other instant messaging platforms.

**InterCall** offers both audio and video conferencing support, and it is compatible with a variety of different secondary platforms, including: Adobe Connect, Google Hangouts, Cisco WebEx, Microsoft Live Meeting, and Microsoft Lync. Their plans start at \$25 per month, which covers up to 10 participants, making it one of the most affordable web conferencing options online today.

**ClickMeeting** features a user-friendly interface and a great price point. You can sign up for a free trial without even entering any payment information, then choose from one of their many packages after that. Their basic package starts at just \$30 per month, which is a bit more than other options, but that covers up to 25 attendees. If you plan on hosting large scale webinars, you can opt for their \$280 per month package, which covers up to 1,000 users. Their 30-day trial can support up to three presenters, five participants, and two hours of recording time.

**Join.me** interface is sleek and streamlined, making it easy to host events without having to shift

through a variety of different functions and buttons. For the Pro plan, they offer a 14-day trial that does not require any payment information. Another perk is their whiteboard integration, which is available via an iPad application.

**Adobe Connect** is another web conferencing tool that excels when it comes to personalization. In fact, you can fully customize your meeting space to reflect your brand image. However, you need to use a VoIP or other third-party service for the audio components. You don't need to provide any payment information to take advantage of their free 30-day trial, and after that there are various plans, starting at \$45 per month depending on your corporate needs. Adobe Connect also provides for both mobile and computer access to the virtual events, as well as a customized URL, storage, and recording. You can even edit your recordings directly in the tool.

**The WebEx Meeting Center from Cisco** stands out from the crowd for two very important reasons. First of all, it boasts an impressive array of features. Secondly, it's free! If you do want to give their premium plan a try, you can sign up for a free 14-day trial that gives you access to all of the upgrades. However, the free plan is even top notch. It includes: a host license, VoIP audio connection, document and screen sharing, whiteboard integration, SD video, and 250MB of storage on the Cloud. If you want to take advantage of the premium free trial, you'll get to host up to 25 attendees, HD video quality, and dial-in number support.

**Citrix GoToMeeting** is one of the most intuitive and user-friendly platforms available. Citrix offers a free version that includes up to 3 participants. However, you can also sign up for a free 30-day trial to get upgraded features. One of the most notable highlights of GoToMeeting is that it offers a 60-day refund policy, just in case you're are dissatisfied with the platform.

**eVoice** is a great tool for eLearning professionals who need VoIP in combination with video conferencing. It features toll-free dial-in numbers to boost your professional image, screen sharing which supports up to 2,000 users, and a free trial so that you can try out all of its features. The only downside is that they don't offer whiteboard integration.

## 5. VIDEO CONFERENCING IN EDUCATION

New technologies such as video conferencing brought new ways for teachers to work with students and encouraged the development of strategies more consistent with the emerging technology. [12]

Video-conferencing provides an interactive teaching session in three basic forms:

- lecturer in the studio teaches a group of remote students
- lecturer teaches a local group of students with the transfer of remote students
- lecturer at the same time teaches a local and remote group of students with full interaction



**Figure 10.** Video conference lecture

Selection of lectures, as well as equipment depends primarily on the possibilities and the aim of solving the real problems in the classroom.[4]

Video conferencing improves work and classes enabling the connects to a variety of sites, media, learning, audio and video files, graphics, animations, computer applications.

Experienced trainers around the world are saying that technology video conference meets the learning and education of students in the following directions:

- increasing significantly the level of communication. The experiment with the use of new technologies and interaction with other students increases the level of awareness and motivation. It happens that students give up the break so that they should follow this program that provides them with an unusual atmosphere, and further participate in it.
- improving communication, quality of presentation, the level of knowledge and skills. It is much better to accept the communication of students than in live communication, and by planning and participating in the video conference, students gain important communication and managing knowledge and skills.
- increasing the level of connection with the outside world because, when a live communication is not possible, video conferencing creates and implements the only possible communication "face-to-face." Video conferencing is easier and less demanding than the actual physical visits and ensuring that training is more frequent while preserving time

and resources. Students now have the ability to create relations with others, who are very different from them, and whom, otherwise, in the real world, they would never have met. The richness of communication reinforces the connection between students and mentors.

- expanding the scope of learning results in the student developing skills to ask the right questions and to arrive at the required information and develop the ease of communication. Instead of learning from the book it provides learning firsthand of what students show more interest in and depth of understanding. Learning and experience video conferencing also leaves a deeper impression of the lecture, which is long remembered

## 6. THE REASONS OF APPLIED VIDEO CONFERENCING FOR EDUCATION

Education across the world has a changed character, where reaching out to substantial knowledge isn't impossible. Video conferencing has made classrooms walls invisible, allowing students to have the entire world as their learning resource. Moreover, this technology has also helped in easy retention of knowledge in learners as visuals are always better remembered than words. Visual communication has double-fold benefits, both for the teacher and the taught as it opens up the door towards global learning. Here are some impending reasons to invest in video conferencing for education. [11]

- Reading begets knowledge while visualizing help in understanding. Virtual field trips, face-to-face collaboration with the Subject Matter Experts, virtual classrooms, all these can be made possible through the effective use of a standardized video conferencing solutions built for the learning sector. This encourages cross-cultural bonding among students and assists them to mutate into more tolerant global citizens.
- Rural students often have lesser learning options due to the lack of infrastructures and resources. A video conferencing solution can help them get access to some great learning materials. They can get enrolled in a course of their choice, communicate with tutors, participate in group discussions, refer to the prerecorded resources from the digital library and remarkably improve their learning experience.
- High definition videos have now replaced chart and presentations, teachers are sharing their screens with the students for better and more life-like experience. An improved pattern of interactive learning suddenly opens up a wider spectrum of a subject that engages the students even more.

- Students may not alone refer to teenagers; some of them may be professionals or even stay-at-home parents, who struggle hard to fit education into their busy schedules. Video conferencing for education promotes self-paced learning for all such knowledge aspirants. Education can now be scheduled. They may learn when they wish to, time is longer a constraint. Prerecorded videos, archives are great student aids that add to their self-paced learning spree.
- Video conferencing for education isn't just restricted to imparting knowledge alone; it acts as a great admin tool for educational institutes as well. Circulating administrative updates, holding an interactive parent-teacher meeting, training sessions for teaching and non-teaching staffs without the requisition of the physical presence of the attendees, are some added advantages of the video conferencing solutions for the education industry.

## 7. CONCLUSION

The benefits of video-conference communication methods are reflected in the fact that: connecting people who are separated by time and space, sharpens the sense of meaning as commonly it requires a greater concentration and greater discipline, increases objectivity, eliminating the cost of travel, accommodation and meals, minimizing the discomfort of work that is constantly interrupted, reduces downtime and increases productivity.

In the context of video conferencing, the term "success" means that the videoconference technology enables communications between the companies to do their job without having the technology as the disturbing factor and that is not destructive, and second, that it is not an end in itself and that it does not interfere with the goals and outcomes of the communication process. From the perspective of the video conference managers, the term "effective" should be understood that the technology functions in the way it is designed. The question is, however, how to define the "successful" communication process accomplished through video conference system? What criteria is it determined by, whether or not they have technical features (profile of attendees, topics being discussed, etc.)?

Bearing in mind that, the communication aspect, the shortcomings in the work of the video conference system can be both technical and non-technical in nature.

Technical problems can be divided into three categories, namely: sound problems, problems with video, network protocols and architecture.

Problems of non-technical nature can be divided into two types, namely: eye contact, the question of confidentiality and security of information.

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# Application of a remote experiment in elementary school teaching

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**Abstract:** *In an effort to track the rapid development of the technique and make their teaching more interesting and meet ever-increasing demands, technology and technology teachers need to be interconnected and in continuous cooperation with their faculties. This paper presents an example of cooperation and sharing knowledge and resources of faculties with students and teachers in elementary schools. The paper presents an experimental lesson held in a small village school, which participated in the competition "Digital Class" organized by the Ministry of Trade, Tourism and Telecommunications. Different methods and forms of teaching were applied at the same time, and at one time the students actively participated in the experiment at Faculty of Technical Sciences in Čačak.*

**Keywords:** *teaching; school; university; cooperation; resource sharing*

## 1. INTRODUCTION

No other scientific field is subject to such enormous changes as it is the field of technology. The problem that teachers have already encountered is how to harmonize the actual situation in this field with the curriculum framework and the contents of textbooks. Rapid changes can lead to a possibility that the textbook contents become outdated in relation to the features and performances of technical devices. For a long time it has been clear that teachers cannot rely solely on textbooks, but they must also enrich their teaching with more comprehensive materials using contemporary information communication technologies (ICTs). The access to remote laboratories and usage of remote resources have already come to life. Such opportunities exist in our education system as well, but they are long way from being exhausted. This paper presents a lesson in Technics and informatics realised using remote experiments within the teaching of problem solving skills in the elementary school "Petar Leković" in Požega.

## 2. LESSON DESCRIPTION

The unit "Construction and application of electromagnet" is taught in the 8th grade within the subject Technics and informatics, the topic "Electrical machines and devices".

The lesson was realized according to the model of teaching problem solving in the digital classroom, using:

- Moodle learning platform
- the Internet for finding the necessary information and for accessing remote resources

- an experimental set-up of Tesla's egg located in the hall of the Faculty of Technical Sciences in Čačak [1]
- Immediate participation of the Faculty professors

The objective of this lesson was to introduce the students into the concept and application of electromagnets by developing basic competences in science and technology, digital competences, entrepreneurship, etc.

### 2.1. Introductory part of the lesson

The lesson began by telling the students the first part of the anecdote about Columbus's Egg [2]. They were given eggs with the task of placing them in an upright position (in the same way that Columbus asked the Spanish nobles to do), (Figure 1). By setting up a problematic situation the attention of the students is activated and they are trying to solve the problem.



**Figure 1.** *Trial of the problem solving*

After a few minutes of unsuccessful attempts, the students were told how this story ended and that the term "Columbus's Egg" refers to an easily

solved problem, which is only apparently unsolvable.

A clip from the film "Nikola Tesla" [3] was shown in which it is explained how this great scientist managed to put a copper egg in an upright position by means of a rotating magnetic field and in that way, provided money for further research from American investors. The question for the students was: "Can we do something similar to this? To start the rotational magnetic field, set and hold the copper egg in an upright position? Before we try, we need to learn what the electromagnets are."

Through their accounts, the students accessed the prepared teaching materials on the Moodle platform [4] (Figure 2).

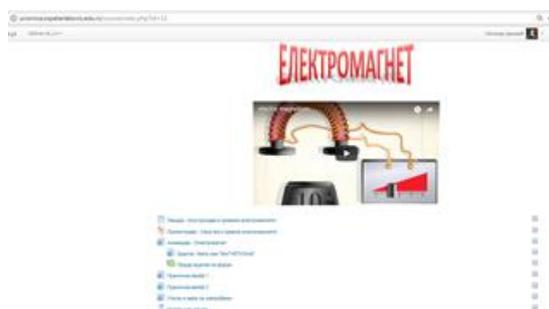


Figure 2. Teaching materials on Moodle

## 2.2. Main part of the lesson

In this part of the lesson, the students studied the prepared materials: the lesson "Construction and application of electromagnets", presentation and links to videos placed on the platform (Figure 3). The contents of this lesson are related to the contents that the students learn in physics. The links have also been set up for those students who want to learn more, so that teaching is modified in such a manner as to conform to the individual characteristics of students. In this way they learned how to learn, developing a positive and responsible attitude towards learning, independence and organization, knowledge improvement, research and use of different sources of knowledge.



Figure 3. Studying the teaching materials on Moodle

The students had a task to create their own mind map (Figure 4) in the mindmap tool [5]. Using the inexhaustible base of the Internet, they explored independently, found the necessary information, classifying, selecting and highlighting the most relevant parts. In this way, they developed the

ability to use information and work with data from different sources.

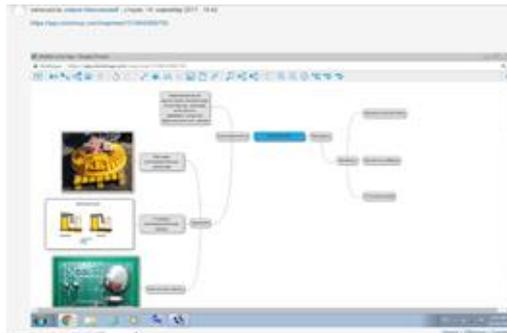


Figure 4. Mind map

The students also had a task to look at and evaluate other students' works based on the given criteria (Figure 5).



Figure 5. Evaluation criteria

In this way, students learn to evaluate quality of the work of others and to compare their own work with that of others.

The next part of the lesson was intended for group work (Figure 6). In groups, the students tried to make a model of an electromagnet by finding ideas on the Internet. By working in a group, students learn how to adhere to the rules of teamwork and how to distribute work and responsibilities. They also learn to be tolerant and to communicate with others. They tried to create a model that would be both functional and aesthetically pleasing.



Figure 6. Model development in practice

Students will be able to apply the knowledge obtained in this way in real environment.

## 2.3. Final part of the lesson

In the final part of the lesson, the teacher reminded the students of the question from the beginning of the lesson. They showed their electromagnet models and explained the way they operated. They concluded that they could not create the model of Tesla's egg, and therefore they were not able to start it.

The teacher accessed the Internet and opened a display of the hall at the Faculty of Technical Sciences in Čačak, where the experimental set up of Tesla's egg is located [6]. The students were directly addressed by prof. Miroslav Bjekić, who explained to them the principle of operation of the model and invited them to start the experiment by managing the remote model (Figure 7).



Figure 7. Students start the experiment

The students started the magnetic field within the experimental laboratory for electrical machines and drives at the Faculty of Technical Sciences in Čačak. The students noted with enthusiasm that they managed to place the egg in an upright position. Each student could start the magnetic field, stop it, turn the direction of the magnetic forces, and therefore the direction of rotation of the egg. The video recording of the lesson can be found at [7].

In the final part of the lesson, the students were given a task to assess how satisfied they were with the amount of knowledge they had acquired, by highlighting one of the options offered in the "Choice" activity.



Figure 8. Self-assessment of the amount of acquired knowledge

83.33% of the students chose the option "I am very satisfied, I completely understand the lesson", while 16.74% of the students opted for "I mostly understand the lesson". Nobody marked the options "I understand the lesson to a lesser degree" or "I don't understand the lesson." The diagram clearly shows that the students understood the concept of electromagnet, how it is created and its operation and where it is used.

### 3. CONCLUSION

The lesson in question is based on a problem setting. The teacher presents the problem of the operation of Tesla's egg, a complex invention of the renown scientist Nikola Tesla. Students are faced with an apparently unsolvable problem, and the teacher guides them through the intricacies of the problem, suggesting possible solutions. In accordance with their abilities and past experiences, students use the Internet to find valuable information, classify it and select the most relevant data, building models based on theoretical knowledge. Finally, they figure out that, in accordance with their capabilities, they have made models that in a way represent an example of magnetic field, but that they are still incapable of solving the problem posed before them at the beginning of the lesson.

The availability of experiments of remote faculty labs was a great experience for the students, given low potentials of technical equipment in Primary schools.

The major objective of education is to prepare students for further education, work and production as well as for jobs that are yet to come. Today, more than ever, there are numerous ways to achieve this and make students participate and enjoy each part of the class.

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# Enhancing Teaching and Learning in Greece by Implementation of ICT in Educational System

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**Abstract:** *Nowadays, there is a general consensus about the importance of applying ICT in all areas of life, and certainly in education. In educational process ICT can be applied by teachers at all levels of education and in different educational context. There are many benefits that can be achieved in this way. In order to achieve the desired results, it is of great importance how ICT support is organized at the level of the entire educational system. Great progress in this area has been recorded in Greece in recent years.*

**Keywords:** *education, ICT, Greek educational system*

## 1. INTRODUCTION

Nowadays the ICT have been perceived as the principal driver of educational changes and major innovations in school practice. According to Becta 2007 [1], the application of ICT in schools should be seen as a major innovation that directly improves the various aspects of school life, as it has a direct impact on communication between schools and with the wider community, on administration, management and workload, on communication with parents and the wider community. And, of course, a huge step forward in the teaching process. ICT in education should be seen as an excellent tool that can lead to significant educational and pedagogical outcomes and support students' development on the knowledge and skills.

Researchers have pointed to well-crafted use of technology benefiting, for example: increased learner effectiveness or performance gains, increased learner efficiency, greater learner engagement or satisfaction, more positive student attitudes to learning. There are also benefits of increased collaboration, greater engagement and persistence, more on-task behaviour and better conceptual understanding [2, 3]. Another important element of ICT is the possibility of individualized supported learning for people with special educational needs [4], whether through adaptive or assistive technologies specially designed to support pupils with specific disabilities or through the use of mainstream technologies such as digital video and photography.

Since learning is a social activity and understanding is socially constructed, e-learning should be designed to promote participation, allowing all students to take part in all subjects and activities, enhancing cooperative learning, offering powerful opportunities [5].

Information and Communication Technology is very important in pupils' communication, interaction, cognition, and learning, as well as in their emotional and social development [6]. Therefore, integration of supported technologies in teaching students at all levels of education is useful.

Simultaneously, ICT is important for teachers' competency also, since it can improve teaching by enhancing an already practiced knowledge and introducing new ways of teaching and learning. Transforming and reorganizing teaching is difficult to achieve. There is no doubt that the relationship between teacher and student (face to face) can't be replaced by any surrogate. But opportunities arising from the use of ICT for a more creative approach to teaching, using new pedagogical strategies by aiming at cooperation of a different type with students and other teachers can make the learning and teaching process more efficiency and interesting [7]. Of course, it is a slow process and the main goal is not to apply a radically different vision of pedagogy, since there is no evidence that society really desires a transformed, technologically-mediated relation between teacher and learner [8]. Changes that take full advantage of ICT will only happen slowly over time, and only

if teachers continue to experiment with new approaches [9].

## 2. GREEK EDUCATIONAL SYSTEM AND ICT

The situation in Greek educational system concerning the ICT, some years ago, was bad. Based on 2011 EU survey [10], in Greece there were considerable fewer computers available for all grade students than the EU average. As for computers connected to the internet in schools, in Greece desktop computers were below the EU average at all grades, and also generally much lower than the average for laptop computers at all grades. In Greece most computers were desktops, ranking among the lowest percentages of internet-connected desktop computers in Europe. The same thing was going on and in terms of internet-connected laptop computers; the result was again among the bottom group of countries.

Also, in Greece general percentages of students taught by teachers for whom ICT training was compulsory were among the lowest in the EU. At that time, Greece was again in the bottom group of countries concerning a digitally well equipped and supportive schools and digitally confident and supportive teachers as well.

- Therefore, within the framework of the Digital Educational Content of the "Digital School" (2010), the Greek Ministry of Education, Research and Religious Affairs developed the project "Digital Educational Platform, Interactive Books and Repository of Learning Objects". It was national and EU co-funded project, and the most important one of the Ministry of Education for the period 2010-15. The "Digital School" [11] refers to approach aiming at the integration of ICT in the whole educational system. It was implemented with a series of projects grouped in five axes. In this paper, we will not analyze the E-Administration of Education and the Horizontal Support Actions, although these projects changed and enhanced the organization and management of the schools in Greece. But in this paper, we want to stress the practical influence of ICT in teaching process, so we will focus on the other three axes developed by Greek ministry of education/
- Strengthening school equipment with interactive boards and portable computer labs (digital classroom) - For the first one of the axons, we could say that just the first step is made. There is still a big lack of equipment in the schools. But, certainly, the situation is better than it was a few years ago.
- Teacher Training - For the in-service teacher training, we can also say that things are better, but there is still a lot of work to be done. This

is a slow process, almost all of in-service teachers have a basic knowledge of ICT (first level of ICT education), now a lot of teachers finished the advanced ICT education (second level of ICT education), many of teachers are still in the process, and many others are waiting for they turn to accomplish the advanced education. The ministry first provided the possibility of training to primary education teachers, and teachers of language, mathematics and science. Training of teachers who teach other subjects is now in progress. This process will continue in the coming years. According to the official website of the Ministry of education-Teacher training , the subject of the second level ICT education for in-service teachers is to learn the principles of pedagogical use of ICT, acquiring skills for the pedagogical use of educational software, general use of tools and the Internet, with emphasis on Web 2.0 tools and services, as well as the cultivation of the knowledge, skills and attitudes, which contribute in two ways: continuing education, personal and professional upgrading of the educated teachers, and the utilization and application of ICT in the class by themselves and their students for research, interaction, collaboration and building new knowledge. Additionally, the subject of training includes the learning and teaching of interactive teaching systems as well as educational content management systems such as the available educational platforms and repositories for collecting and distributing educational material (e.g. "Fotodendron" [12, 13], E-book school system [11]).

- Digital Educational Content - Huge work has been done when it comes to digital content. From the start of the project to the present day, over 200 teachers, under the scientific guidance and coordination of University Teachers, have joined the project. The project "Digital Educational Platform, Interactive Books and Repository of Learning Objects" concerns the design, development and operation of central Internet services of the Ministry of Education for the digital educational content of Primary and Secondary General Education: the "Interactive School Books" and a series of digital repositories of educational content called "Photodentro". When we talk about the interactive school books, we should say that it includes the digital form of all the primary, secondary and high school textbooks in pdf format, student books in editable html format. But there is more. There we can find over one hundred Interactive School Books (e-books),

i.e. books enriched with interactive digital educational material in order to facilitate collaborative, experimental and flexible learning. Interactive books, as well as the digital repository can help teachers to enhance the educational process by using different materials from the repository. There we (practitioners) can find a lot of learning objects like educational videos, educational software, user educational material, open educational practices, external resources from other institutions, e.g. cultural collections from digital libraries, museums etc. There is also the Digital Learning Platform e-me (e-me.edu.gr) [14].

- The Photodentro is made as the Greek national repository of Learning Objects for Primary and Secondary Education [15]. The learning objects you can find for teaching and learning concern a wide range of subjects (Mathematics, Geography, Chemistry, Biology, Physics, Aesthetics, Religion, History, ICT, English, French, German and Greek Literature). The Photodentro [12, 13] has free access, it is open to students, teachers, parents, and anyone interested. All of different learning objects are autonomous and reusable digital content units [16]. It is very easy and interesting for users. We can find many useful contents that can change our teaching style and simultaneously make a teaching process more interesting and challenging, since there we can find and use a lot of interactive simulations, visualizations, investigations, images, experiments, educational games, 3D maps, exercises etc. Obviously, the Photodentro can provide to students and teachers an opportunity to avoid and enhance the classic way of teaching and learning. According to official website [12, 13], today this repository includes approximately 9000 learning objects, including 6500 learning objects of enriched interactive school books as well as collections of selected objects developed within the framework of various actions of the Ministry of Education or other bodies.

### 3. CONCLUSION

The modernization of the teaching process with the help of ICT has begun in developed countries. Now the order of the Balkan countries has come. The educational practices in Balkan countries need transformation and modernization. One big step in this direction is the application of the ICT in educational practice. Since we are talking about a slow process, it is time to implement in continuous professional development the specific ICT education (both for in-service and pre-service

teachers). An experimental approach using ICT in everyday practice is an important factor in increasing teachers' pedagogical competence. This is the best way to make them ICT confident. For that reason, it is extremely important to make teachers more active and willing to experiment and prepare them to be able to upgrade their ICT skills and gain more pedagogical knowledge in a more active way.

It is our opinion that the Greek national strategy for the application of digital content in the education is well organized. This new approach is helping us to reorganize the educational process, making the teaching and the learning more creative and flexible. The best proof for the success of the concept is the fact that the official site of Ministry of education with digital educational content has an average of 400,000 unique visitors per month since its launch in 2012 [11]. For modernization and acceleration of creative teaching and learning, we need continuous support of the organizational and institutional context, and a national strategy for ICT in education is sine qua non to achieve this goal.

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# The contribution of information technology in the education of high school students with visual impairment

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**Abstract:** *This paper focuses on the identification of software and information technology programs in the education of high school students with visual impairment. The sample included 32 respondents, 17 females and 15 males, all categories of visual impairment. The aim of the research is to determine which software and programs the high school students with visual impairments commonly use, whether they prefer tactile or voice outputs, as well as the dependence of computer competencies of the schools they attend and their success at school. The obtained results will be discussed in the paper, and it would point out the possibilities of practical implication of the results through the use of information technologies in improving the participation of high school students with visual impairment in educational activities.*

**Keywords:** *information technology, education, student, visual impairment*

## 1. INTRODUCTION

This paper deals with the notion of the possibilities of application of information technologies (IT) that are increasingly present in the education of children with visual impairment. They provide the independence to these students in the educational environment and while learning, enabling them to develop and maximize their potentials.

In accordance with the current teaching and educational-rehabilitation practice, more areas could be distinguished that often require specialized instructions in teaching the students with visual impairments, in order to meet their specific educational needs [1], because certain knowledge and skills of students are expected upon completion of their studies, among which the most important ones are related to the field of information technologies.

Therefore, this research started with the assumption that the respondents would point out in the sample the basic directions of the application of information technologies in learning and secondary education. The aim of this research is concerned with the question of how the availability of information technology and curriculum based on this technology affects the ability of the high school students with visual impairments to learn.

Technology enables a blind learner to quickly access information as well as to receive feedback, whether using Braille alphabet, sound output, or any other medium, allowing them to prepare the materials for personal use in all subjects.

Adaptation of computer technology, input, output, application of computer programs, interaction with computer equipment and its accessories also depends on individual psychophysical, cognitive, and sensory abilities [2]. The type and quantity of children's activities on the computer, in addition to their abilities, depend on the teaching objectives. By the evaluation of access technology, the special technological solutions for every child are determined, performed with persons who are familiar with the unique needs of blind and visually impaired pupils, but who are also well informed about the possibilities of modern technology.

Some software programs could be used in different areas of teaching, helping children of different ages and with different abilities. Some programs are designed to support certain activities, such as programs that train children in mastering cause-effect relationships, telling differences and similarities between individual images, graphic views, and so on.

Adaptation of the existing information technology for persons with visual impairment offers different possibilities: sound output, Braille hard copy, and for visually impaired persons text in capital letters, on the screen or in the printer. The input could be a device such as touch screen, joystick and keyboard. The input could be on a standard keyboard, using 6 selected points in the Braille's dots: (s, d, f - j, k, l), or by special techniques by using Perkins. The first method is cheaper, and the advantage of the second method is that a hard

copy is immediately obtained, because one is typing and the paper is in the machine.

A blind user who is conversant with typewriting can enter data on a classic keyboard, but must have a screen reader to be informed about errors, or through the Braille order (display). The screen reader could read selected images on the screen or images as a whole. The output can be done in various formats: increased printing on the screen or printer, speech synthesis, Braille printer [3]. Devices that a child would use will depend, above all, on their visual abilities, cognitive need, and all other needs they have at home, school, and community [4].

The visually impaired students, in accordance with their needs, use different software that appears on the market. Currently, the following programs are the most widely used: JAWS, Magic 9.50, Open Book Scanning Reader Software, Open Book's, Window - Eyes, et al.

JAWS is a powerful software program designed to work with a speech synthesizer to improve the productivity of visually impaired students. By streamlining keyboard functions, automating commands, and eliminating repetition, JAWS allows the student to learn faster and easier than ever before. Magic 9.50 introduce a new approach to settings files and customization. Just as Windows provides a "My Documents" folder for each user on a computer or serve, Magic now allows each user to have own profile. Open Book Scanning Reader Software allows to convert printed documents or graphic based text into an electronic text format using accurate optical character recognition and quality speech. Window - Eyes is nothing less than the most stable screen reader available on the market today. Featuring Windows 9X, Me, 2000, XP and 2003 compatibility, Window-Eyes is the most powerful screen reading software ever created.

The software in education, enables access to literature through digital textbooks and online sources of knowledge, simplicity of solving tasks in educational institutions, access to global information, and equal communication with the majority of population.

Reviewing the foreign literature, a tendency could be noticed that almost all modern education systems and teaching environments for students with visual impairment are based on modern information technologies [5].

Complaints about inaccessibility were often framed in terms of unequal access for visually impaired and sighted users. The participants expressed their frustration about having to depend on assistance from sighted people [6].

A research indicated that students use various assistive technologies, computer devices and programs / applications. The students used the most laptops and "smart" phones, as much as

90%. From a program on a computer, phone, or other device, most often used is the MS Windows laptop, IOS on the tablet / phone. JAWS was the dominant screen reader on these computers, and Voiceover on the tablet / phone. E-mail is used by 80% of respondents, 70% regularly browsing the Internet, and about 70% download and upload documents [7].

The research has shown that students with visual impairments mainly use certain screen readers, which are the most convenient tools for them, they regularly search the Internet for various purposes: finding information, communication, shopping, socializing, education, listening to music and correspondence. Teacher's opinion (98.8%) also indicates the necessity of using information technology for work in schools for pupils with visual impairment, primarily for reading and writing, as well as for various applications (61.4%) of technology with blind and visually impaired students. The result of a study in which the competences and the level of computer literacy of high school students with visual impairment was examined, showed that screen readers need to have simple access to Web browsers, in terms of easy and quick reading of Web site source codes, as well as that web designers should, in addition to each animation also include a text description, instruction, so that the screen readers successfully pass the information to the blind user [8]. Some research suggests that users of screen readers should be allowed to go right to the main content, to skip peripheral or repeated content, which would save a lot of time to a blind user and would not tire and confuse them. A particular webpage should also be shared, defined, and should indicate exactly what could be found where; for example: the main part, the header, the advertisement, the contact, the announcements, so that a blind person could orient oneself faster and better, and could skip the part that is not needed [9].

The main causes of frustration could be a page layout that causes confusing feedback on the screen reader, badly designed / unmarked forms, no alt texts for images, so the blind users reported a loss of an average of 31% of time due to these frustrating situations [10].

In the study conducted at the Faculty of Special Education and Rehabilitation [11], the importance of acquiring knowledge and competencies in the field of information technologies in special education is emphasized, where almost half (41.6%) of the sample, which included 204 students of basic studies of three study programs (Speech pathology, Oligophrenology and Special Education - with several different modules), points to the importance of classes and the training they receive at the faculty about the information technologies as an adequate preparation for their future professional role,

which would certainly require the application and inclusion of technology in the broader learning and education objectives of persons with special needs.

## 2. METHODOLOGY

The sample included 32 respondents, 15 male and 17 female. Related to the category of visual impairment, there were 37% of blind and 63% of visually impaired students according to the International Classification of the WHO on visual impairment. The age of respondents was between 15 and 19 years for both groups of respondents, 12 visually impaired and 19 blind, the majority of blind respondents is 17, and visually impaired 16 years old. The sample covered blind and visually impaired students from the 1st to the 4th grade, the largest number of blind students is in the 3rd grade (50%), the largest number of visually impaired is in the 2nd grade (35%). In relation to school and departments, 38% of students have physiotherapists, 28% of legal-technical department students, 34% of PTT department, and out of that 37% of blind and 63% of visually impaired. In relation to the success at school, there are respondents from sufficient to excellent success in both groups of respondents, and there is the highest number of students with excellent success (58%). The level of knowledge in the context of using of the internet technology is equated through the attendance of school subjects in which internet technology is applied.

This research applied the Technology Assessment Checklist For Students with Visual Impairments [12] which examines practical effectiveness through understanding and applying commands to computer access in multiple areas of use, such as input (using standard and custom keyboard) and visual output (visual, auditory and tactile), use of the Braille Letters and reading speed on printed material and the Braille displays, motivation, access to printed information through audit mode, and computer competence.

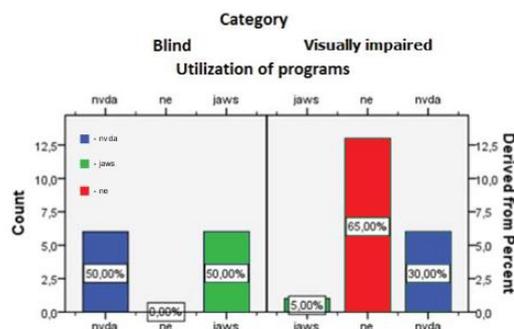
The results are presented by descriptive statistics, frequency analysis, and parametric statistics.

## 3. RESULTS

Screen Readers are software programs that enable visually impaired users to read text using a synthesizer that reads aloud the contents of the entire screen or the active window. New programs are constantly emerging on the market, and the objective was to determine which spoken programs are most used by high school students with visual impairment.

It could be noticed from the graphic that blind responders equally use the software for the blind – screen readers Jaws (Job Access with Speech) and NVDA (NonVisual Desktop Access) software.

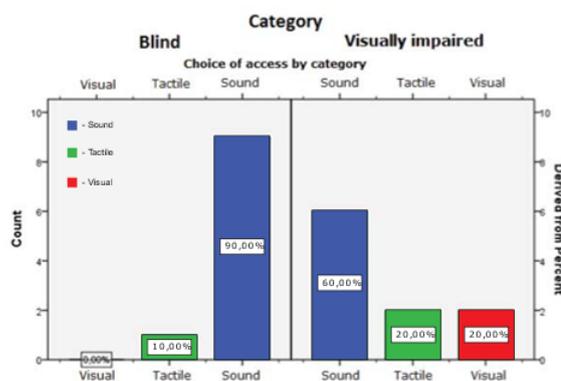
JAWS supports standard Windows and other popular applications; it is the most popular and most used screen reader in the world, so our students have been generally referred to this program in recent years. It gives blind and visually impaired people the ability to access information on the screens of their computers using a speech synthesizer or a Braille order at the output, an interactive voice installation allows installation and settings on an equal footing with users who see.



**Figure 1.** Screen readers used by blind and visually impaired students

The reason for the growing use of the NVDA is that it is a free screen reader that is increasingly used by both blind and visually impaired learners, as could be seen at the chart. The text that is read could be controlled by moving the cursor to the appropriate text area using the mouse or keyboard arrows. It also has the ability to convert text into Braille characters if the computer user has a device called Braille order or Braille display. 49% of respondents perform basic functions without instructions, and 51% of them change the basic font size / items / icons using shortcuts, with instructions. 50% of respondents understand the synthesized speech, and 40.6% move on the screen using shortcuts 41%.

A common dilemma among researchers is whether visually impaired people use sonic or tactile output, and many feel that speech requires greater attention of the user than the tactile text structure and that it provides different characteristics and "feelings" of the program [13].



**Figure 2.** Output information

The majority of blind high school students use the sound output of information, and very few use

tactile output. Screen readers allow students to use the computer independently in a school location, without additional equipment or adaptations, which is why they prefer to use this type of output. Along with that, using a sound card, the voice reads the contents of the entire screen or active window, and contains a set of commands that provide the ability to perform basic actions without the use of a mouse, or a similar device. Another reason why the voice output has the great advantage in relation to the tactile one is the fact that our respondents do not own the Braille order in person, but use this model exclusively at informatics classes or in a resource center, and that reflects on a weaker and slower ability to acquire computer skills. Some authors point out the advantages of speech versus tactile output due to the interaction of a user with visual impairment with a given icon or connection, then if a user types on the screen reader announces each character, and when he hears that he typed the wrong character, he has the ability to reset and delete, and correct [14]. Some other researches point out the objection that screen readers use the voice of the computer speakers, and some visually impaired users consider this extremely boring, and therefore point to the need of improving and working on voice intonation [15]. Screen readers often cannot determine whether content on the web pages is worth listening to if they do not hear at least some of them and as a result, blind users often suffer from overloading with information, but still use speech rather than tactile output. Afterwards, we were dealing with the programs most commonly used by students, as shown in the following figure.

Programs used by male and female students

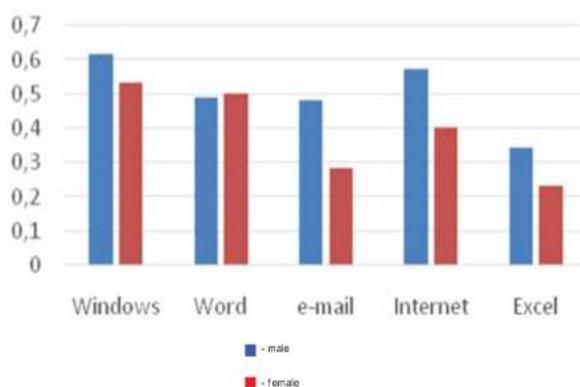


Figure 3. Programs used by students

The respondents (both male and female) use Windows and Word the most in everyday work. The boys use more Internet and e-mail, as well as Excel, and make better use of computers for about 8% than girls. The survey showed that on average, students use only 47% of computer capabilities, which points to the need to further improve the available programs, as well as design

new ones for people with visual impairments. There is also the need to organize training of experts of different profiles, both programmers and special teachers (therapist, special-education teacher) who are well aware of the needs of students with visual impairment, and include them in this training: many commands or terms require knowledge based on visual or spatial concepts, careful verbal instruction, or Braille alphabet to use all available programs in everyday learning and free time. Our findings are similar to the results from a study in which 90 high school students with visual impairment were surveyed on the programs used. The surveyed students emphasized that they use Internet for various purposes: finding information, communication, shopping, socializing, education, listening to music and correspondence. Respondents who were better acquainted with the Internet protection were taking more care and were using Internet less than users with less knowledge in this area. Men were more frequent Internet users than females. E-mail uses 80% of respondents, 70% regularly search the Internet, and about 70% download and upload documents [16].

Computational competencies in relation to the school

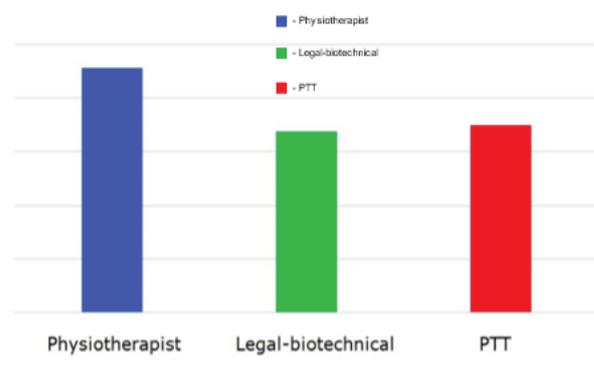
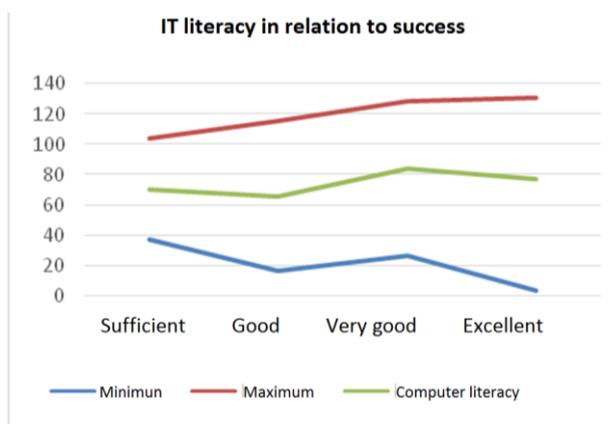


Figure 4. Computer competencies

There is almost no difference in the skills of using computers between students of the legal-technical and the PTT-department, who use computers only for the subject of computer science, whereas students of the medical school of physiotherapy are the most IT literate because they use computers, in addition to computer science in some subjects, such as Anatomy. Of course, this greater experience they have at work and, not only in the use of computers, but also in the organization and coordination of work materials for a larger number of cases, improves efficiency in work. It is possible to improve the teaching process by using computers, but also vice versa, incorporating internet technology into as many teaching subjects as possible would have an impact on increasing the computer competence of students.



**Figure 5.** Computer literacy

IT literacy depends on the success in school. On the average, the most literate are very good students, then the top-grade ones, then the students follow, and finally good ones. Among the top-grade students are the most literate and non-literate students of the whole sample. Motivation is probably the most important factor that school teachers can target in order to improve learning and results in this area. The basic elements impacting student motivation are: student, teacher, content, method/process, and environment. 98% of students expressed a positive attitude towards using computers, and as the most motivating factor they said that they are getting faster information on the availability of computer work by means of programs designed to meet their needs, finding the information they need as well as the increased ability communication and contacts with others because everyone uses the Internet and e-mail, and 86% uses Facebook and has their profile on it. On a scale of 0 to 1, the degree of computer literacy of blind students is on the average 64% (in between 37% and 90%), and for visually impaired students 57% (between 28% and 85%).

#### 4. CONCLUSION

The preliminary results of this survey indicate the significance of the implementation of the information technology in the process of everyday learning and education of high-school students with visual impairment and the research has shown that our students generally use screen readers Jaws and NVDA, which are currently the most widely used throughout the world. The advantages of sound, compared to the tactile output of information were also established. The most commonly used programs are Windows and Word because they are the most accessible for receiving information as well as the Internet. Having access to the Internet and becoming a regular computer user are critical because of their positive impact on literacy, education, employment, and quality of life. However, further research is needed to determine the direction of the causal relationships so as to design

appropriate interventions [17]. The results have also shown that the computer competences increase if the information technology is involved in as many teaching subjects, because numerous teaching contents within many teaching subjects become accessible to blind and visually impaired students exclusively through information technology, which requires the teachers to see the modern technology as important and legitimate learning tool that enables students to master a wide range of academic and practical knowledge. It is necessary to organize and improve training in the use of information technologies where technologists together with special teachers would train directly at a scholastic place. The collaboration between these experts is necessary because technology experts are best acquainted with the capabilities and performance of information technology, and professionals working with these kids know how to train persons with visual impairments. Having in mind the wider importance of information technology in other segments of life of students with visual impairments that needs to be explored, and these are directly related to education, such as orientation and movement in space, environmental control, sports, leisure and other activities, we would like to point out the need for cooperation in science in the field of social sciences, such as special education with technical and technological sciences in the development and modernization of this field on the basis of contemporary challenges of universal design and creation of innovative ideas in this field, in order to accelerate psychological and social integration of people with visual impairment, as the research indicated that still a small percentage of the possibilities of information technologies is implemented in this field. Comprehensive research of this problem is necessary in order to cover all levels and dimensions of this complex system of technology inclusion as an integral part of the education system for persons with visual impairment in our country.

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# Implementation of the Lean concept within Smart School Management

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**Abstract:** *Smart school represents a new educational concept that have dramatically changed education system, not only teaching and learning processes but the management process. In order to overcome the challenges that these changes bring, school managers must to adopt and implement advanced management concepts, such as Lean concept. The implementation of the Lean concept withih smart school management will ensure that all processes, required to support the teaching-learning function, are integrated into a rational entity that purposefully and effectively operates towards achieving objectives. The paper indicates the Lean principles whose implementation within smart school system management will enable improving of education processes.*

**Keywords:** *smart school concept; Lean concept; management*

## 1. INTRODUCTION

The social, economic and political prosperity of the nation depends on the intellectual potential of new generations, traditional educational systems are no longer capable to meet the resulting social need, so it has initiated the development of new forms of education systems that accompany technological development such as smart school platforms. Smart school is education institution that is based on digital education platform which brings a lot of benefits to learning-teaching processes, as it is pointed out by numerous studies [1], [2], [3], [4], [5] and [6].

Those new educational concepts have dramatically changed access to education, not only to teaching and learning processes but to the management process. In order to overcome today's challenges, school managers must to adopt and implement advanced management concepts, such as Lean concept, that will enable them to manage more efficiently and effectively of processes required to support the teaching-learning function in IT environment. Although the Lean concept was initially intended for the production environment, its application has expanded to non-production sector, as it is pointed out by numerous of studies in this area. The article [7] focuses on the applying Lean concept to non-profit organization. Lindenau-Stockfisch [8] introduces Lean management within hospital and indicates the principles and key factors for successful implementation, Di Pietro, Mugion & Renzi [9] presented integrated approach between Lean and customer feedback tool for public sector, Buavaraporn [10] investigates the importance of enablers of Lean implementation in financial

services. This paper will indicate the key Lean principles whose implementation within smart school system will enables improving of education processes.

## 2. THE SMART SCHOOL CONCEPT

The smart school concept implies continuous implementation of the Information and Communication Technologies (ICT) through a comprehensive education system, not only within teaching and learning processes, but in implementing a more efficient education providing process. Smart schools are based on digital education platform which enables growing, adaptation and progress as important environments for learning in nowadays conditions.

To ensure the successful implementation of smart school concept it is necessary to use context and corresponding educational policies, which include continuously empowerment and flexibility of curriculum and upgrading of management and teaching staff's capacity and commitment through the integration of the ICT in strategic planning, teaching and learning methods.

The smart school is taken from the concept of the smart factories, which has given birth by a smart revolution. The Smart revolution or 4. industrial revolution is characterized by self-management, the concept of smart cybernetic-cyber-physical information system. The novelty brought by the industry 4.0 is the integration of the Internet of Things (IoT) into the production environment.

The IoT implies the advance concept of machine-machine interaction provided by network-based

remote sensors and actuators. The IoT system consists of smart devices managed by the user over the Internet. Wireless sensors generate data from different devices that can be stored and analyzed either on site or in the cloud.

The IoT concept can also be integrated into non-production systems, such as educational institutions, which provides the digital platform on which a smart school is based.

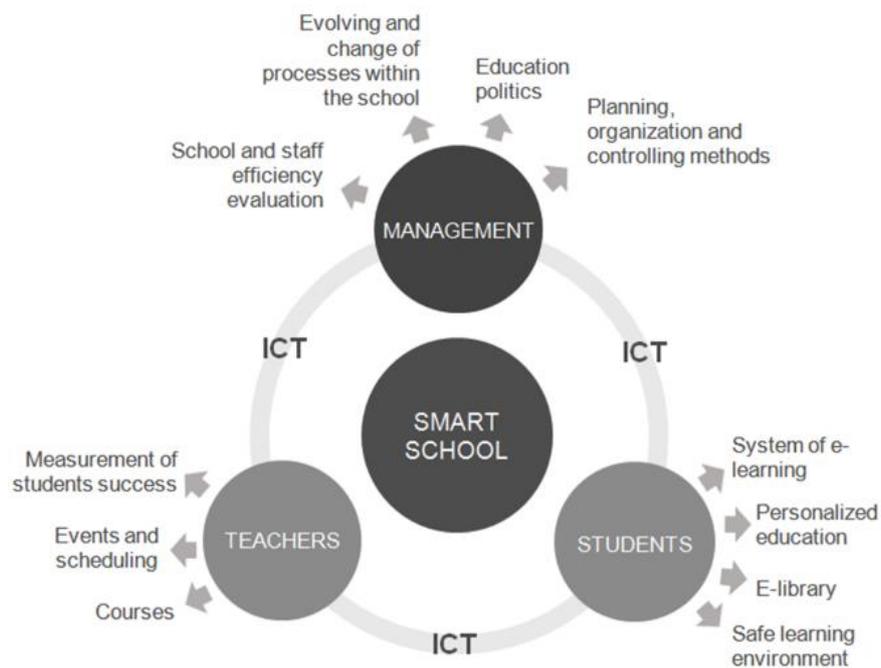
Utilization of the IoT technologies within educational institutions, increase student engagement and commitment, also it provide a safer learning environment. All students' activities can be monitored in real time by using online testing which helps to identify and analyse of student learning patterns and development of adaptive learning systems.

Some of the world's leading educational institutions that have adopted the smart schools concept are: Massachusetts Institute of Technology (MIT), Cambridge, Massachusetts; The California Institute of Technology (CALTECH), Pasadena, California and Eidgenössische Technische Hochschule (ETHZ), Zürich, Switzerland.

Smart school enables the best learning environments by providing the following benefits:

- It stimulates students engagement,
- It takes the benefits of learning in the mobile environment,
- It provides personalized education,
- It makes the learning process more efficiency,
- It achieves cost reduction,
- It improves the process of student success measurement,
- It enhances teacher`s responsiveness and commitment,
- It creates conditions for improving the curriculum,
- It introduces a creative approach in teaching and learning,
- It potentiates the development of adaptive learning systems,
- It fosters student collaboration and encourages creativity.

To achieve smart schools educational objectives, these teaching and learning concepts should be covered: curricular, pedagogy, assessment and teaching-learning materials [2]. The smart school concept is presented in Fig. 1.



**Figure 1.** The smart school concept

As can be seen from Fig. 1, the inseparable component of the smart school concept, in addition to the teaching and learning process, is also a management that plays a key role in creating the conditions for achieving a more effective educational process.

As a main challenges for school management, in making effort to achieve a more effective educational process, are emphasized: developing

the concepts, the processes, structure and how to evolve and change the smart school, application of advanced planning, organization and controlling methods, assessment of the technology, the analysis of the potentials which must be incessant [2], introduction of efficient controlling systems...

In order to respond to these challenges, school managers must to adopt and implement modern management concepts that will enable them to

manage more efficiently and effectively of processes required to support the teaching-learning function in IT environment.

One of these management concepts is the Lean concept, whose implementation within smart school system will ensure that all processes, required to support the teaching-learning function, are integrated into a rational entity that purposefully and effectively operates towards achieving objectives.

More about the Lean concept and the possibilities of its implementation within the smart school system is given below.

### 3. LEAN MANAGEMENT CONCEPT

Lean concept was first introduced by Krafcik [11] and it has its origin in the main principle of the Japanese industry 'increasing output by reducing input'. The Lean concept can be defined as a systematic approach to overall business in the way of using as less resources as possible, in order to achieve the best possible performance and improve business processes. Lean needs to be viewed as a voyage necessitating a strong start and one that never concludes [12] and it is essential to decipher the current state; the current stated ideals and behaviours have to be contrasted with the Lean principles and behaviours [13].

The main elements of Lean concept are: Lean way of thinking, managing and changing of business processes and continuity of introducing improvements.

According to Koenigsaecker [14], Lean is more than a compilation of tools and that its ideology focuses upon a need to reduce three categories of waste, namely Muda (non-value adding work), Muri (overburden), and Mura (unevenness).

The Lean concept today has broader frames, and it is viewed as business improvement strategy that integrates concepts such as Just-in-Time Production (JIT), Total Productive Maintenance (TPM), Total Quality Management (TQM), Six Sigma and Human Resource Management (HRM) practices [15].

Although the Lean concept was initially intended for the production environment, its aim is to increase the efficiency and quality of the system, so Lean principles can easily transfer to non-productive institutions that share the same goals, such as health or financial institutions, service sector, government, as well as in education systems.

### 4. POSSIBILITIES OF IMPLEMENTATION OF THE LEAN CONCEPT WITHIN SMART SCHOOL SYSTEMS

Successful implementation of the LEAN concept in managing smart schools requires respect for some principles such as: optimize the whole, eliminate

time and money waste, create knowledge, build quality in, deliver fast by managing flow and the last, but not the least important, respect people.

The Lean principles that can be implemented successfully in the smart school management process are: Lean way of thinking; continuity improvements and process optimization through the concentration on waste and values; improving personnel policy to increase productivity through employee satisfaction.

#### 2.1 Implementation of Lean thinking within smart school concept

Lean thinking is a methodology which implementation will provide a new way to think about how to organize activities in order to offer more benefits to users through the elimination of waste (worthless activities and processes).

According to [16] there are several postulates of Lean way of thinking: **Purpose:** the Lean concept is based on considering the purpose in a way to ask questions what values for the stakeholders we can create. **Process:** How will the organization analyze each step in order to consider whether the new value for stakeholders are created in every steps, whether there are useless steps, and to consider their interdependence. **People:** It is necessary to ensure that people in organization can create an organization that can produce value and that important process has someone responsible for continually evaluating that value stream in terms of business purpose and lean process. The Lean thinking model is presented in Fig. 2.

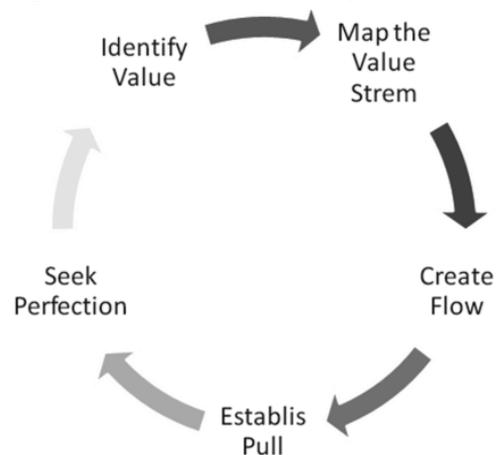


Figure 2. Lean thinking model [16]

The Lean way of thinking includes a several principles:

**Identify Value:** Define value from the user's perspective, and express that value in appropriate terms.

**Map the Value Stream:** Map all of the steps, values, activities and processes which will lead to customer satisfaction.

**Create Flow:** It is necessary to be sure the remaining steps flow smoothly with no interruptions, delays, or bottlenecks.

**Establish Pull:** Pull the value from the next upstream activity.

**Seek Perfection:** Finally, it is necessary to make Lean thinking and process improvement part of your corporate culture.

If this way of thinking would be implemented in the smart school management process, it will bring the following benefits:

- Improvement of employee morale and involvement
- Increasing efficiency,
- Gaining satisfied stakeholders,
- Facilitating the process of change,,
- Improvement of productivity,
- Reducing the risk and increasing achievability of the plans.

'Lean Transformation' is often used to describe the process of moving from an old way of thinking to Lean thinking model. This transformation requires a long term perspective and perseverance that will result in an all-encompassing revolution in managing educational processes.

## **2.2 Continuity improvements and process optimization through the concentration on waste and values**

Lean management concept concentrates on process optimization, waste and value. Therefore, managers in smart schools must involve some Lean tools for waste and value identification and improving, within their practice. Some of them are Kanban, Kaizen, Value Stream Mapping (VSM).

The main purpose of Kanbans is to show which work has to be done at what time to ensure optimal flow, this applies both to teaching and to the learning processes. Also it includes implementation of the Pull concept (does not produce anything until it is needed by the end user), in education system this implies - map market needs for specific professions and accordingly, conceive how many students of which profile will be educated.

A smart school, within the framework of smart education, with the help of a lean concept, will enable students to take the initiative themselves and create their own jobs, in a way to foster self-contemplation, which is contrary to the molded approaches to education that have been countless times proven to be wrong.

Kaizen, or the concept of continual improvement, is aimed at reducing waste. Every day spent in the education system should contribute to creating value for students. Unfortunately, a significant part of the time at faculties is spent on activities that do not contribute to creating values relevant to students. Kaizen concept will enables eliminating

non-value adding activities from education process through continuous improvements.

Value-stream mapping (VSM) is a technique to analyse and measure the flow of information and to value how much each activity or operation, that is part of the value stream, contributes to outcome and total quality. Implementation of this technique within smart school education processes can improve the process of student success measurement, which is of particular importance for monitoring the quality of the entire educational process.

## **2.3 Improving personnel policy to increase productivity through employee satisfaction**

The ideology and concept of Lean is largely successful when pertained to a whole organization, even though the Lean concept has been largely associated with manufacturing and production processes, its principles embrace the entire business, ie to all aspects of the organization both on processes and on human resources.

Within smart schools, by the Lean concept must be covered not only educational processes and activities that relate to providing knowledge to users, but also to employees, as a vital part of these systems.

To achieve main Lean principle - higher outputs while streamlining inputs it is necessary to set the appropriate personnel policy. Lean management includes a reflected interaction with employees, also through employee satisfaction and motivation the Lean contributes to a sound and proper basis for smooth implementation of education processes.

Lean also represents a drastic transformation of the current way of working and thinking, it often creates resistance to employees, in order to eliminate these issues, it is necessary to motivate employees to completely accept and implement Lean way of thinking and operating.

Lean approach to human resources management is especially important in the context of smart school, as this concept requires the teacher to adopt new knowledge concerning the intensive application of ITC technology in teaching processes.

## **5. CONCLUSION**

The paper indicates that it is possible to continuously improve educational institutions through an understanding and applying Lean and smart principles. Smart schools concept provides digital education platform which enables improvement, adaptation and progress as important environments for education processes in nowadays conditions. Also, by integration of smart school concept and Lean principles such as: Lean way of thinking, continuity improvements and process optimization through the concentration on

waste and values and improving personnel policy to increase productivity through employee satisfaction, it is possible to create the conditions for achieving a more effective educational process.

By implementing Lean way of thinking within smart school concept, a new way to think about how to organize activities in order to offer more benefits to users through the elimination of waste will be provide. Also it will bring a lot of benefits for educational processes.

Integration of the Lean concept within smart school management will provide continuity improvements and process optimization through the concentration on waste and values.

To achieve main Lean principle - higher outputs while streamlining inputs it is necessary to set the appropriate personnel policy.

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# Predictive Analytics for Students' Success

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**Abstract:** *We discuss needs and necessary prerequisites to efficiently utilize predictive analytics in the educational environment. Factors, such as data availability and quality and organizational commitment are considered in the predictive analytics framework. Various tasks, both academic and financial, where the predictive analytics can find its use at the institutions of higher education are identified, as well as the technology available to accomplish the analytics process.*

**Keywords:** *Student's success; predictive analytics; statistics; databases; machine learning.*

## 1. INTRODUCTION

Higher education in the 21<sup>st</sup> century is characterized by a number of features determining its development and future [1]. On one side, there are increased requirements for the number and quality of cadre—college graduates, that are the result of the educational process. On another side, the higher education encounters a number of problems and issues that may hinder its development [2]. First, the cost of education increases as determined by exogenous variables that an institution of higher education cannot easily control. Second, the support of governmental entities to higher education stagnates or decreases. Third, the quality of public education in K-12 system oscillates and may not be able to provide sufficient preparation of future university students. Fourth, the traditional public institutions have increasing competition from private for-profit and online programs that frequently compete based on the quality of customer service rather than on the quality of educational programs. These factors, if not addressed properly, may negatively affect the financial future of traditional public institutions and severely limit their ability to provide meaningful, affordable and effective programs.

In order to cope with emerging issues, the institutions of higher education increasingly rely on data in order to better understand educational and financial aspects of their operations. The abundance of various information systems utilized provides an opportunity to collect large amounts of data. On the other hand, the maturity of predictive analytics technologies, starting from conventional descriptive statistics, to advanced machine learning techniques makes it possible to obtain powerful insights on complex relationships among the data. This paper discusses various

challenges that an institution of higher education may encounter during the implementation of data-driven strategies to improve financial stability and students' success.

## 2. DATA

The data routinely collected by the universities differ in granularity (from summary data related to the whole university, to data pertaining to academic departments and units, to students' data) and temporal resolutions (from annual measures such as retention and graduation to students class participation and access logs to a learning management system, as typical extremes). Also, the quality of data generally varies, from high quality data (students' grades and class roster) to data related to admission and financial aid, that are typically provided by students and may have high noise and percentage of incomplete entries. Data cleansing remains the first step prior to utilization of university data in predictive analytics.

The applications and software systems that collect university data range from students' information system [3] to learning management systems (LMS) [4] to assessment software [5]. A number of these systems are designed as comprehensive, using a typical waterfall paradigm, and in addition to a steep learning curve, have a high maintenance cost and limited ability for customization. Albeit the majority of the systems use the relational or object-relational technology, due to legacy reasons, the database designs do not always adhere to principles of relational design. Specifically, normalization is not always systematically implemented, which leads to potential data inconsistencies and problems with updates. The use of data warehousing reduces these problems, at the expense of additional maintenance overhead, which may not be

affordable to small and medium-size institutions with limited budgets. In spite of numerous attempts, the development of an affordable, adaptable and customizable data warehousing software, especially suitable for institutions of higher education remains a daunting task. An ideal system should support seamless data integration from various sources, SQL-free natural language querying and dashboard capabilities, that allow high-level non-technical university management to access, analyze and visualize data at various levels.

### 3. METHODS AND ALGORITHMS

Classic statistics provides a number of techniques for analysis of higher educational data [6, 7]. Descriptive statistics, such as counts and estimates of sample means and standard deviations and percentiles, remain an important tool to assess overall aspects of educational activities. Measures such as graduation rates (per university, department, program, cohort, etc.), retention rates (percentage of freshmen continuing into the sophomore year), persistence (percentage of upper classmen continuing education in the following semester), passing rates (per faculty, course, program), average students' debt, grade point average (GPA), are and will remain the cornerstone of basic reports at universities. Multivariate statistics, ranging from linear regression to principal component analysis provide an ability to determine and quantify relationship among various driving attributes that may influence students' success. Time series analysis can potentially determine long-term relationships in time-variable processes such as admission processes and cash flow management.

Machine learning techniques provide algorithmic engine for data mining and predictive analytics. Classification techniques are an excellent example of power that machine learning can add to statistical techniques. The applications of multi-layer perceptron based classifier, than can be envisioned as generalization of standard logistic regression, provide useful models for predicting discrete outcomes based on a variety of numerical, categorical and ordinal variables. [8]. Support vector machines [9] are theoretically well-founded practical tools that provide high classification accuracy. A drawback of these models, however, is that they provide limited explanatory power; their complex structure is difficult to explain to a non-technical person which may limit their use and understanding. A solution is to utilize decision trees and decision rules [10] that result in graphical or natural language models and are typically appreciated by university administrators. Bayesian models [11] provide probabilistic dependence of outputs vs. input variables and can be a tool of choice for what-if analyses [12]. Further improvement of

classification accuracy is possible through usage of classification ensembles [13], bagging and boosting [14, 15] but such models to a non-technical user also appear as a black-box and thus can predominantly be used embedded in other software. Deep-learning networks [16], demonstrated successful for a variety of artificial intelligence tasks, still await their application in educational domain.

Unsupervised learning technique, such as clustering, association rules and outlier detection analysis, can help identifying structure in unlabeled data. Clustering [17] groups data points based on feature similarity. Starting from relatively simple methods, such as k-means to agglomerative and density-based clustering, it helps to determine subsets of data that may help detect or better understand underlying processes leading to an underlying data structure. Association rules [18] are generalization of standard implications, and are related to fuzzy logic [19]. They introduce important concepts of significance (how frequently a particular rule applies in a data set) and confidence (how accurate is the rule) and can be inferred from large collections of data. Outlier detection, on the other hand, provides an opportunity to detect unusual data, that may require future attention and explanation. They are especially useful in multidimensional data sets, frequent in educational domains, where manual detection may not be practical.

### 4. TASKS

There is a number of processes within an institution of higher education where the utilization of predictive modeling can lead to measurable and substantial improvements. During the admission process, a university's goal is to recruit, admit and enroll high school graduates or other qualified persons according to pre-specified target enrollment numbers, in order to achieve university's vision and mission. Universities with specific missions (including but not limited to minority institutions, universities affiliated with specific religious denominations, etc.) may have additional admission goals. Market segmentation, that can be accomplished using statistical tools and clustering, is essential for efficient admissions. In addition, predictive models that can estimate the probability that an admitted student will enroll at the university help concentrate admission efforts on particular segments of students.

In the process of academic advising, a student is provided information about available majors (programs) at the university. It is demonstrated that appropriate major choice can lead to substantial financial savings to a student, and improve retention and graduation rates. Hence,

development of predictive models that can assist students in providing professional orientation contributes to students' success and readiness for future careers.

One of the most critical periods for students' academic future and accomplishment of their academic goals is the freshmen year. The student, encountered with issues such as monetary, academic in narrow sense, social and psychological, is at serious risk of leaving the university. Utilization of data ranging from demographic, to financial, to academic success data available through a learning management system, provide an opportunity to generate and test an early warning system that can be utilized by academic advisors or students themselves.

Data driven models can improve class scheduling and provide students an interactive tool to assess their progress, perform cases analyses and better manage their time and plan their coursework. At the same time, the models can improve resource management at the universities (time, space, personnel) and contribute to program prioritization and strategic planning. Techniques such as association rules can find application in these tasks.

Analyses of passing rates and average grades (by class, program, and faculty) contribute to better quality control of educational process. It can identify variance due to instructor and help determining the necessary corrective actions and personnel development. Further, it is possible to analyze effects of changing educational practice (placement tests, introduction of lecturers, mandatory usage of clickers or supplemental instruction) on students' success. A potentially interesting application is to investigate correlation between students' success in different classes, which can assist in redesigning curricula, adding or modifying prerequisites, etc.

The ultimate measure of students' success is their placement after the graduation. Analysis of meaningful employment data and their correlation with students' majors and other academic variables help tailoring universities' strategic planning.

Analysis of university financial data is an important segment that substantially contributes to financial stability and future of the institution. One of the key factors is to identify various cost drivers and their influence on fixed and variable cost of education. This is especially important for private (both non-profit and for-profit) institutions, due to their substantial dependence on tuition revenue. Better understanding of variable cost can help making strategic decision about tuition models, discounts through various forms of scholarships and incentives (special pricing for early completers and academically gifted students). Analysis of administrative

processes (maintenance schedule, accounts payable, housing assignment and planning), especially when combined with six-sigma framework [20] improves efficiency and can contribute to reduction and better utilization of personnel and financial resources.

## 5. ORGANIZATIONAL ISSUES

There are several prerequisites that an institution of higher education needs to satisfy in order to fully utilize power of predictive analytics. Data awareness is here defined as understanding of the institution, starting from its management to administrators and educators, that data, when adequately analyzed and utilized, can substantially contribute to achieving the institutional goals. Our society can be defined as data driven and data abundant, resulting in requests to pursue data-supported decision making at higher education.

However, data awareness is only the *first*, albeit necessary condition. An institution of higher education, in order to truly utilize data-driven approach and predictive analytics, needs to make substantial investments in software and human resources. At the current stage of the technology, a team of data scientists, including expertise in databases, machine learning, statistics, data warehouses and visualization is essential to establish necessary data structures and launch predictive analytics systems. This makes usage of predictive analytics technology prohibitively expensive, especially for small to medium-size organizations why would, otherwise, most benefit from launching of the data-driven paradigm. Further efforts are needed to make data analysis less technical and more available to casual non-technical users. An alternative is to establish consortia of institutions of higher education which would share data analytics capabilities, and thus reduce the cost.

The true benefit of launching the data driven approach can be achieved only if the consumers of provided information have basic data literacy, and are capable of making conclusions based on provided information, reports and dashboard. Data literacy of all university constituents need be continuously increased through a series of professional development activities, workshops and hands-on exercises.

## 6. CONCLUSIONS

This paper represents an attempt to provide an insight on various issues and characteristics of application of predictive analytics and data driven modeling paradigm in higher education. We discussed needs, technical environment, potential tasks where the technology can help improving students' success and efficiency, and the organizational prerogatives. The paper is not intended to provide any definitive guidance in this,

still highly emerging field, but to identify potential venues for further development and investigation. While the paper reflects the experience of its authors, it does not necessarily represent the official standpoint of their institutions.

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# Future Belongs to Innovative and ICT Skilled Nations – Is Serbia Ready?

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**Abstract:** *We are witnesses of intensive transformations of society where innovations are everyday business of each company striving to stay on the market. This paper aims to bring the most interesting facts about the characteristics of nowadays business, innovativeness, education in order to clear the connections between business success, innovation and ICT skills of citizens of different countries. It is obvious that growth still belongs to those countries who had the best innovation models implemented in the whole society and with strong economy support. Serbia has potentials, but should reorganize itself.*

**Keywords:** *innovations, ICT skills, economy growth*

## 1. INTRODUCTION

We live in a time of intensive transformation of industrial society into new design- informational society. Activities, that are typical for an industrial society, give way to new activities connected with producing information and due to that, the value system and institutions are changing. This is most evident in highly developed countries. But, these changes are happening much faster than during industrial transformation even in developing economies.

The core of this new economy is made of the global network where investors, using ICT, trade with actions and use informational technology for improving productivity. The new technologies for processing information enable business globalization, and production of information is needed to improve activities and this is followed with directly or indirectly increasing employability of people dealing with information [16].

Rapid changes in doing business were introduced during 1992-2000 because the development of ICT during that period had reached the level that allowed them to have the power to transform all aspects of economy life (as did the steam engine and electricity) [15].

Manuel Castells [1] highlights the difference between *information society* and *informational society*. He notes that the first term highlights the role of information in society and that the second one means specific form of social organization in which production, processing and transmission of information become the fundamental source of productivity and power.

From a different definitions of *informational society* it can be concluded that [11]:

- Information becomes the main strategic resource in industrial and economic development,
- Rapid computerization of economy enables closer connections between regional, national and international economies,
- Globalization depends on informational networks,
- The limits of space are decreasing.

The innovations are recognized as the core for developing economies of all countries. Digital technologies, according to Cortada [3], represent a great possibility for innovations, through upgrading operation efficiency, development and sales of new products and services, through digital means. This can lead to the destruction of some existing industries – it can happen that whole industries, companies or their parts are not needed any more on the market, due to the implementation of ICT innovations. Also, it can happen that new technologies could be implemented in different areas of life with different speeds and that can provide a gap.

Cortada [4] notes that the speed of informatization of a society will depend on investments in infrastructure and interest/capability of wide of users to use potential and benefits from a informational technology. It is evident that Internet development is going to be crucial in future design.

In his work, Daniel Pink [9] predicts that the next phase in social development is the conceptual phase, in which people are going to deal with creative, artwork jobs, and that a lot of attention is going to be focused on:

- Design,
- Stories,

- Symphonies,
- Empathy,
- Gaming and
- Thinking.

Also, Daniel Pink presented his view of civilization development with a picture of a man changing through time from a monkey, as a farmer, skilled engineer in a suit to a casually dressed painter with a spade and a pallet [10].

If we take in consideration that we are living in a time when knowledge has an exponential growth rate and when even food production is supported with ICT (even Serbia has its first digital farm), maybe that new type of society, conceptual society is not so far.

## 2. ROLE OF INTERNET IN DEVELOPING SOCIETY

Since 1775, when Samuel Johanson noted that there are two types of knowledge: knowledge about some theme and knowledge where that information can be found [5], it was clear that information is very important for each segment of life. Finding information about something today, in an era of Internet, seems to be easy. But, on the other hand, people from so many different sides and with different intentions are charging the Internet with data, and still there are no strict rules for creating and connecting data bases.

So, today's education for using new ICT offers, not only knowledge how to use computers and Internet, but also learning a wide range of technologies dealing with multi-functionality, multimedia, multi communication, using data bases, and especially the knowledge about how to use Internet data searching machines [14]. The users of the Internet are *forced* to find their own way how to use the Internet possibilities and to deal with phenomena that endanger their security, habits, market position etc. But, missing ICT skills for the 21<sup>st</sup> century is a lack that can be allowed by the side of each person striving to survive.

Due to this fact, almost all educational systems in the world are changing in a manner to educate students to think, to solve problems based on using data, to be creative. The skill for learning facts is in that way put behind – because on the Internet you can find facts just on time when you need them (Einstein noted that he did not want to remember some data that can be found in each practicum). In this way the interactive learning is changing the face of teachers and students together [15]- new technologies are becoming the integral part of the classroom and they are putting students in the center of the education process. Besides this, new forms of education, such as lifelong learning is spread among countries. The most interesting changes that are noted are:

- learning is a much more nonlinear process (example: less reading books from beginning to end and more and more nonlinear processing information from Internet, TV),
- transition from giving instructions to processes of research and design researches for information,
- students are in the center of the education process, not teaches,
- more teaching about how to learn and how to synthesis everything learned,
- learning is a lifelong, continuous process etc.

It is evident that finding new ways of producing, processing and presenting data using less time is going to be one of the main challenges that we will be facing with in the future. The Internet will here conduct one of the crucial roles as a place where data about everything and everybody can be found.

Some predictions say that in 2050 in the USA 60% of employees will be working in the *info-industry*, 15% in industry and 20% of employees in other services [13].

This leads to the opinion that new ways of organizing companies are going to be more and more network organizations, like Internet is and more similar to marine than spider network. Exchange of knowledge is therefore, going to be faster and faster, so the realization of companies goals are going to be measured in less days, months. Internet will help in choosing right goals: information from the net will provide knowledge about similar situations in closer history and mistakes will be easier to prevent.

## 3. ROLE OF INNOVATION IN NEW SOCIETY

The world is changing very fast and innovations are pronounced for the main *culprit*. It is said that there have been more innovations in the last 50 years that during the whole last known history of civilization. On the global level, competitiveness of economies, regions, industries becomes very important. Somehow the connection between countries development and level of innovation is established. Also, it is assumed that there is a strong relationship between innovativeness and ICT skills of nations and development of the economies. That is why a lot of analysis are conducted every year about the level of national economies innovativeness, citizen ICT skills and competitiveness.

On Fig 1 the ranging countries according to their competitiveness for 2017 is given. On Fig 2 the Innovation Scoreboard ranking of countries for 2017 is shown. Together, figures show that countries that are good in innovations are also good ranked in the table of competitiveness.

Serbia is, on list shown on Fig 1, in 78<sup>th</sup> place.

**GCI Global Competitiveness Index**

Rank/137	Country / Economy	Score	Trend	Distance from best
1	Switzerland	5.9	↗	0
2	United States	5.9	↗	0
3	Singapore	5.7	↗	0.2
4	Netherlands	5.7	↗	0.2
5	Germany	5.7	↗	0.2
6	Hong Kong SAR	5.5	↗	0.4
7	Sweden	5.5	↗	0.4
8	United Kingdom	5.5	↗	0.4
9	Japan	5.5	↗	0.4
10	Finland	5.5	↗	0.4
11	Norway	5.4	↗	0.5
12	Denmark	5.4	↗	0.5
13	New Zealand	5.4	↗	0.5
14	Canada	5.3	↗	0.6
15	Taiwan, China	5.3	↗	0.6
16	Israel	5.3	↗	0.6
17	United Arab Emirates	5.3	↗	0.6
18	Austria	5.2	↗	0.7
19	Luxembourg	5.2	↗	0.7
20	Belgium	5.2	↗	0.7
21	Australia	5.2	↗	0.7
22	France	5.2	↗	0.7
23	Malaysia	5.2	↗	0.7
24	Ireland	5.2	↗	0.7
25	Qatar	5.1	↗	0.8
26	Korea, Rep.	5.1	↗	0.8
27	China	5.0	↗	0.9
28	Iceland	5.0	↗	0.9
29	Estonia	4.8	↗	1.1
30	Saudi Arabia	4.8	↗	1.1
31	Czech Republic	4.8	↗	1.1
32	Thailand	4.7	↗	1.2
33	Chile	4.7	↗	1.2
34	Spain	4.7	↗	1.2
35	Azerbaijan	4.7	↗	1.2
36	Indonesia	4.7	↗	1.2
37	Malta	4.6	↗	1.3
38	Russian Federation	4.6	↗	1.3

Fig.1 Global Competitiveness Index for 2017, [18]

The European Commission follows the data for each year in order to do the fine tuning of its *Strategy for Sustainable, Smart and Inclusive Growth 2020*. Countries are divided into 4 categories, according to innovativeness level: modest innovators, moderate innovators, strong innovators and innovative leaders. For 2017, results show that Sweden remains the innovation leader, while Lithuania, Malta, the Netherlands, Austria and the UK are the fastest growing economies. In global perspective, the EU is catching up with Canada and the US, but South

Korea and Japan are pulling ahead. China shows the fastest progress among international competitors. In the EU, Sweden is followed by Denmark, Finland, the Netherlands, the UK (first time become an innovation leader) and Germany. In selected areas of innovations, the EU leaders are: Denmark – human resources and innovation-friendly environment, Luxemburg- attractive research systems and intellectual assets, Finland – finance and support, Germany- firm investments, Ireland – innovation in SMEs and employment impact, Belgium – innovation linkages and collaboration, UK- sales effects.

The last used methodology for evaluating innovativeness better captures: investments in skills, digital readiness, entrepreneurship, and public-private partnerships.

The parameters that are used to evaluate innovativeness are:

- *category 1* – new doctorate graduates per 1000 people aged 25-34; percentage of population among 25-34 that has finished tertiary education; percentage of population among 25-64 that is participating in lifelong learning; international scientific co-publications per million people, scientific publications among 10% of most cited publications in comparison to the total number of published papers; foreign doctorate students as a percentage of all doctorate students; broadband penetration; opportunity driven entrepreneurship,
- *category 2* – R&D expenditure in a public sector as a percentage of GDP; venture capital investment as a percentage of GDP, R&D expenditure in the business sector as a percentage of GDP; non –R&D innovations expenditure as a percentage of total turnover; enterprises provide training to upgrade ICT skills of workers,

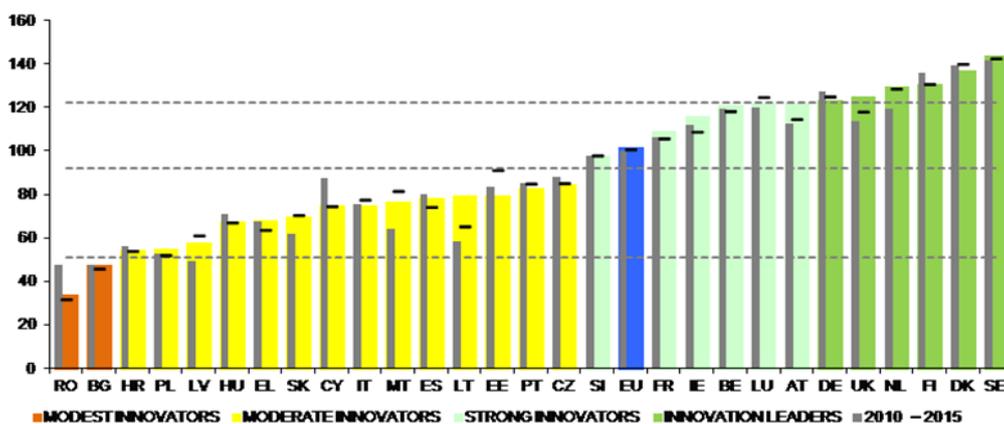


Figure2 : Innovation Scoreboard for 2017 country ranking, [19]

- *category 3* - SMEs introducing product or process innovations; SMEs introducing marketing or organizational innovations; SMEs innovating in-house; innovative SMEs co-operating with others; public-private scientific co-publishing cooperation per million people; private co-funding of public R&D expenditure; PCT patent applications per billion GDP; trademark applications per billion GDP; design applications per billion GDP,
- *category 4*- sales of new-to-market and new-to-firm innovations employment in knowledge-intensive activities as a percentage of total employment; employment in fast growing enterprises; export of medium and high technology products; knowledge intensive services export. [13]

Interesting to note is that there is a correlation between percentage of population that has finished tertiary education and innovation possibilities. It is also interesting to note that about 11% of the EU population has participated during 2017 in lifelong learning activities. In Switzerland, Sweden, Denmark, Finland and Iceland higher than 25% of population among 25-64 has participated in those trainings.

Switzerland and Ireland have the highest percentage of scientific co-publications (more than 2.500 per million citizens), while the lowest level (less than 250) had Ukraine, Turkey, Former Yugoslav Republic of Macedonia, Romania and Bulgaria. The best score in citations have Switzerland, UK and the Netherlands.

In second category, where there is debating about R&D expenditure, the best score have Denmark, Sweden and Finland. They are investing 1% and more in R&D. Investments in business sector is higher than 2% of GDP only in Israel, Sweden, Austria and Switzerland.

When providing trainings among employees for developing ICT skills, in Norway, Austria, Finland and Belgium this share is 34% of all established companies is less than 5%. Over 50% of companies in Switzerland, Luxemburg and Ireland had innovations in the area of marketing and organization, while, for example, Romanian companies have not innovated at all.

When innovations in-house are discussed, once again Switzerland is leader, with 38%, while Romania had 0% of in-house innovations. Best cooperation among the public and private sectors in publishing scientific papers has Switzerland (18%), than Island (17%) and Denmark (13%), with more than 100 co-publications per million of citizens, while 11 countries have less than 5 papers on the same population.

The capacity of companies to develop new products strongly influences their competitiveness. One of indicators is the number of new products among number of patents. Israel, Sweden, Finland and Switzerland have the best scores (8 and more new products per billion GDP).

Knowledge-intensive activities provide services directly to customers, such as telecommunications and they provide inputs for conducting innovative activities in other firms. Leaders in this area are: Israel, Luxemburg, Switzerland, Iceland and Ireland (from 20 to 27% of employment).

Interesting indicator is technological competitiveness – the ability to commercialize the results of research and development (R&D) and innovation in international markets. Export of medium and high technology products is higher than 60% in four countries ( Hungary, Germany, Slovakia, Czech Republic). The exports of knowledge-intensive services are the highest in Ireland, Luxemburg, the UK, the Netherlands, Norway and Sweden (more than 75%). Also, interesting data is the sales of new-to-firm and new-to-the-market innovations. The best scores have the UK, Switzerland, Slovakia, while Ukraine, Malta, Cyprus, Bulgaria and Croatia have less than 5%.

Using broadband connectivity is one of the criteria for evaluating the level of digitalization and digital skills of citizens. In [7,8] the author dealt with the comparisons among EU and Serbia in the area of using ICT, ICT skills and digitalization and it is shown that ICT skilled workforce can provide faster acceptance of changes and innovations in firms.

If we compare list of GCI and this analysis, it is obvious that innovations influence competitiveness.

#### 4. SERBIA IN NUMBERS

The Republic of Serbia (RS) is in 62<sup>nd</sup> place on the Global Innovation Index list (GII) for 2017 among 127 countries. The most innovative countries, according to that list are: Switzerland, Sweden, the Netherlands and the USA. Before the RS on that list is Slovenia (32), Bulgaria (36), Hungary (39), Croatia (41), Romania (42), Montenegro(48), Macedonia (61).

This system of evaluating innovativeness of a society takes into account lot of parameters: institutions (political stability, low legislation, business climate), human capital and research, infrastructure, market sophistication, creativity and technological output, quality of education.

Per criteria, the RS has the next score:

- on the institution level (50/127),
- infrastructure – 52/127,
- human capital and research – 54/127,

- output of technology and knowledge – 53/127
- economy and business- 99/127,
- economical sophistication – 79/127.

The criteria, by which Serbia is evaluated good, is the export of ICT services as a percentage of whole export (23/127), online g-services (24/127), number of researchers per million (35/127), number of graduated in scientific, technological and engineer areas in a relation to a hole number of graduates (22/127).[17]

Looking at the EU Innovation Scoreboard, according to the criteria that had provided the results, Serbia is somewhere among 10 countries with worst results. For example, Serbia did not provide results for lifelong learning, but is very bad (third worst result) according to broadband penetration. If we take into account that the best export results in Serbia for 2017 has export of software solutions, improving this parameter can bring interesting benefits for whole society. The good score is received in returns from equipment investments (4<sup>th</sup> place – category 2- 2.2.2).

Potentials for reaching better scores can be found in strengthening those indicators that the EU support (they are used to foster smart and sustainable growth through innovation). The following data is taken from [6]. One of indicators is the number of new doctorate graduates per 1000 people aged 25-34. On that list, Serbia is among the first half of countries with the lowest level of indicator value (1,2 versus max 3,6). When indicator *completed tertiary education* is discussed, Serbia did not provide results to the EU Commission, so that data could not be compared but potential for improvement can be found here. This situation is also related to the following indicators: percentage of population aged 24-64 that are involved in lifelong learning, PCT patent applications per billion of GDP, employment in fast-growing enterprises.

One interesting indicator of the potential for growth and increasing innovativeness is *international scientific co-publications per million people*. According to this indicator Serbia is in 8<sup>th</sup> place of 36 countries, with 300 papers per million population. If we take the average EU score – 500, but also that Denmark has about 750, Switzerland 2800, this indicator by itself does not mean a lot.

Indicator *Broadband penetration* is interesting in the context of using full e-potential that is being offered on a world bases. Only 3,5% (best score is 32% in Sweden) of companies that have access to broadband internet are using it for electronic commerce. This is a huge potential for fostering business and innovativeness on firm level.

An interesting indicator is the opportunity-driven entrepreneurship. Serbia, above all, chose security of maintaining their income, than to be

driven by opportunity to risk, be independent and earn more. Only 1% of citizens among 25-64 chose entrepreneurship as a chance (EU average score is 3%, Norway is a leader with 13% ).

*Research and Development (R&D) expenditure in the public sector* (as a percentage of GDP) is, for example, in Serbia on the level of 0,60%, while the EU average is 0,7%. This expenditure is very important due to the fact that the public sector provides some services for all industry development. Another indicator – *R&D expenditure in business sector*- captures the formal creation of new knowledge within firms. This is important in the science-based sectors (pharmaceuticals, chemicals, some areas of electronics). Serbia, with 0,3% has much lower score than EU -1,3%. This is one of the very important factors because it is directly connected with developing innovations which can provide products/services that will bring funding for further innovations.

Serbia is, with 1,7% of investments ( which come from total turnover) in equipment and machinery, acquisition of patents and licenses, among 4 countries that are best scored. Taking into account that the Serbian GDP is still low, using licenses can be a way to lower unemployment and raise average GDP. This method was used in Serbia after the Second World War and nowadays Turkey is an example how this is applicable.

In almost all criteria that are connected with trainings of staff (*ICT skills, innovation trainings dealing with all areas of business in companies- new products, services, marketing*), Serbia comes out in the middle of the list. Also, when it comes to *cooperation with other organizations in order to provide innovations*, Serbia is in the middle of the list. Better governmental strategy can provide faster flow of knowledge and services among higher education institutions and economy partners (production companies firstly) in the future.

Two interesting indicators, connected with Serbia export structure are – *knowledge -intensive services export as percentage of total services* and *sales of new-to-market and new-to-firm innovations as a percentage of turnovers*. As a country with huge export of ICT services, investments in infrastructure, retraining and education in ICT skilled workers, Serbia can provide a good base for GDP growth and deliver more knowledge-based services and a higher number of new-to-market and new-to-firm innovations.

## 5. CONCLUSION

Through this work it is shown that there is strong relationship among innovations and economy development of countries and that the level of ICT

skills of citizens can influence GDP growth. A research made under the OECD countries during 2010 whose results were published by Vincenzo Spiezia, [12] concluded that development of ICT skills do not influence an employee capability to innovate, but ICT skills influence capability to adopt innovations in firms. This can be used in Serbia, to foster innovation acceptance on a daily bases. Also, Serbia should force itself to foster education of production staff into using ICT skills in order to foster innovation. These can be reached through improving cooperation among innovation centers and companies, additional education employed staff through lifelong learning trainings or through education in teamwork among companies staff.

Looking on examples from developed countries, who mostly innovate and knowing that innovations in ICT foster innovations in other areas, it is obviously that Serbia should firstly be focused in the area of food production, tourism, chemical industry and software production because Serbia is in those areas well quoted in the world. Missing infrastructure must be the priority of Serbian Government. Focus in sales should be mostly done in developing high technology products and services and some efforts should be done in patents implementations in the field. Money should be invested only in patents that Serbian industry can support at this moment.

Potential lies in using opportunities under the institutions: The Innovation Fund, Development Agency of Serbia, Chamber of Commerce and Industry of Serbia. For example, Chamber of Commerce and Industry of Serbia organizes meetings with important EU companies where it can be found what projects they are running and where Serbian knowledge-based companies can be involved.

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# Professional orientation of secondary school students of economics

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**Abstract:** Professional identification and orientation is an important turning point because it reflects personal opinions on different occupations, affects personal satisfaction of the individual, self-esteem and self-respect, as well as the biological and social progress of the community. The paper presents the results of the research of the professional orientation of students of the fourth grade of the School of Economics in Čačak, conducted in 2017/2018. school year. Choosing a life course at the end of a high school is a major decision that is conditioned by various factors and this choice can be influenced by a multitude of life elements, the current state of the world and the personal attitude and desires of the individual.

**Keywords:** professional orientation; professional determination; professional maturity; professional development.

## 1. INTRODUCTION

Psychology of professional determination studies the conditions and circumstances in which professional decisions are made [1].

### 1.1. Professional development and professional orientation

Vlado Andrić and Mira Čudina [1] determine professional development as a continuous process of maturing a professional decision based on an insight into their own characteristics, knowledge of work tasks and general social conditions; professional maturity and the reality of professional decisions depend on the accuracy of the assessment of these three components of professional decision making. Within the concept of professional development, these authors perceive professional maturation as a development process that encompasses the whole lifetime of the individual and relates to professional behavior and professional decision-making, careful career planning, awareness of personal professional progress, etc. In the course of professional development, different life milestones are distinguished: transition from elementary to secondary school; finishing high school; first profession; additional education; the next profession; middle age crisis; retirement.

Three important information is required for the decision of a high school student on future profession:

1. Real self-image of oneself,
2. Knowledge and experience of different human activities, occupations and jobs,

3. A clear picture of current and future social needs for particular jobs, knowledge and professions. [3]

Making professional decisions encountered at least three levels of difficulty: (a) difficulties in linking knowledge about yourself to the knowledge of the world of work, (b) the problem of developing personal perception or the desire to change the image of oneself based on a professional determination, (c) deep disorder of the individual, meaning that problems of professional development are associated with the symptoms of deeper disorders [1].

The process of professional decision-making takes place in at least three stages:

1. Phase of preference in which decision-making affects the attractiveness of the activity,
2. The stage of the election in which besides the attractive activity have great influence also have expectations of their own abilities,
3. Phase of the decision in which, in addition to the previous factors, the probability of success and opinion of parents and peers is also included [1].

It is important to note that the professional orientation after secondary school is only one of the turning points of modern life, the choice of secondary school plays an important role. The importance of these two choices is also reflected in the years in which such decisions are made, since not every individual is able to make such decisions independently. Through conversation with students of the High School of Economics in Čačak, during the implementation of this research, the financial impact on further choices and decisions is noticeable, as well as the ignorance and lack of interest of the respondents for various reasons that

can't be assessed from the conducted questionnaires. The subject teachers who attended the study pointed to a drastic drop in the interest of most students in schooling, which can be considered as one of the very influential factors of professional orientation in the sense that such an individual will opt for an easier choice, not the one for which he is interested / or competent [3].

### 1.2. Continuous monitoring of the professional identification of students of the School of Economics in Čačak

The School of Economics in Čačak conducts an internal research each year. The first step is to conduct a questionnaire on the professional orientation of students in the first grade of secondary school, in which each student receives a personal code that is re-used in the fourth grade of

secondary school for the same student. The questionnaire is filled in again in the fourth grade, data are processed and the results are compared. Also, the school keeps track of the real situation (where did the students continue their education / work) [2].

In cooperation with class supervisor, a career guidance and professional orientation team at the High School of Economics in Čačak conducted a survey on where students enrolled in college / got a job from the generations who graduated from the school year 2014/15, 2015/16. and 2016/17. (Table 1).

Researching student intentions during the fourth grade shows that students from generation to generation are mainly identified for studies that relate to their secondary education.

Table 1. Comparative overview of the intention of further education and enrollment

University, faculties, college	Wants to attend			Really enrolled 2016/2107
	2014.	2015.	2016.	
Faculty of economics	37	67	36	45
Technical faculties	4	3	5	26
Teachers' faculties	6	7	5	5
Faculty of political science	4	7	3	1
Faculty for security	10	9	8	4
Faculty of law	9	8	8	6
Faculty of organizational Sciences	4	12	19	6
Faculty of philology	11	2	9	4
Faculty of sport and physical education	3	2	1	2
Faculty of natural sciences	/	/	2	2
Faculty of agriculture	/	1	1	2
Faculty of mechanical engineering	/	1	1	/
Medical School	/	/	2	/
Faculty of drama arts	/	/	1	1
Private faculties	/	/	4	8
Faculty of maritime studies	4	4	1	/
Criminalistics	4	1	2	1
High business school	/	9	2	20
Faculty of transportation	1	/	2	3
Undecided	7	10	7	/
<b>Total:</b>	<b>116</b>	<b>155</b>	<b>119</b>	<b>136</b>

Following the explicit wishes of students (Table 1), only a small number of students wants to enroll in the Faculty of Technical Sciences in Čačak (5 students want to enroll), but it seems that in the end, for economic reasons, due to the failure to enroll at the desired faculty or for some other reason, 26 students enrolled at this faculty. Also, greater disagreements between wishes and possibilities, show data for specific faculties for which, besides knowledge, they need special skills, readiness and skill (such as the Faculty of sport and physical education, Academy of criminology) [2].

## 2. EMPIRICAL RESEARCH

Although both researchers and practitioners are looking for answers about the reasons and ways of

professionally identifying students, social changes that reflect on the development of high school students are continually triggering re-examination of motivation for professional choice and education. Current social conditions are an important factor that affects professional attitudes, and the general tendency of students can't be determined at all, as the probability that the next year will be different is very high. This problem is the basis for the further development of this research focusing on determining the reasons, motives for the professional determination of students at the end of high school.

### 2.1. Research organization

Subject of research: This paper examines the motives of graduates (students of the fourth grade

of the High School of Economics in Čačak) for making professional decisions on further education and choice of studies or employment upon completion of secondary education. Different motives (both social motives of professional identification, as well as different information, material motifs, etc.) were examined.

The aim of the research was to determine the degree to which different reasons / motives influence the professional orientation of the graduates, and whether there are differences in the professional orientation of the graduates of different types of secondary education. As far as the secondary vocational school is concerned, this research also determines the diversity in the areas of the desired education.

The basic hypothesis of this research is as follows: Most high school students in the fourth grade of secondary education are determined to continue their education at various higher education institutions, but there are differences between high school students of different school achievements, different occupations or secondary education directions not only in the field of education, but also in the type of studies which are defined.

Specific hypotheses are based on this basic hypothesis: When it comes to the School of Economics in Čačak, an important part of the examination is the variety of choices, i.e. determining compliance with the areas of economics, law, management and business, or the introduction of a change by identifying for another area of education. During the research, the interview found that the majority of pupils are defined with economics, law and management, and that most have a desire to study at the University of Belgrade.

Sample: Students of the fourth grade of the School of Economics in Čačak, professions: economics technician, financial administrator, bank clerk, insurance officer and commercialist, a total of 160 pupils.

A non-experimental method of research is applied. A survey technique was used to collect data. For this research, the POMIS instrument was developed, which was analyzed in the pilot phase in the focus group and on a small sample of the student population. The instrument was developed within the activities of the Department of Educational Sciences and Technology at the Faculty of Technical Sciences in Čačak, University of Kragujevac, in cooperation with the Department of Mathematics and Informatics of the Faculty of Natural Sciences and Mathematics, University of Novi Sad, as a joint research. Students of the fifth year of the IAS Technique and Informatics, who carried out research in secondary schools in Čačak, also participated.

POMIS (Professional definition of graduates and choice of studies, Graduates' professional decision

and selection of tertiary education) is an instrument consisting of two parts:

- The first part is a questionnaire with questions of closed and open form intended for collecting data on educational and demographic variables;
- The second part contains three self-assessment scales (five degrees) designed for determining the degree of motivation for different factors of professional identification (two sub-classes) and self-assessment of IT and technical skills that are in basic IT and technical literacy (one sub-subject).

Variables:

- Demographic variables: gender (female and male).
- Education variables:
  - School achievements at the end of the third grade;
  - Education area of tertiary education: engineering and technology, socio-humanistic field, philological sciences, medical and biomedical field, art, interdisciplinary and multidisciplinary field;
  - Types of tertiary education: bachelor academic level, bachelor vocational level, integrated academic level,
  - Institutions of higher education: faculties and faculties in Serbia, universities and faculties in other countries;
  - Motivational variables - motivation / graduation factors of graduate students and selection of types of higher education institutions: social factors, material-financial factors, professional status, status of educational institutions, personal characteristics of students and their expectation of themselves, etc.

Procedures for descriptive statistical analysis (frequencies and percentages, arithmetic mean, standard deviation) and comparative analysis (ANOVA) using statistical software SPSS were used for data processing. Graphical solutions from the mentioned software were used to display the results [4]. The research was carried out in December 2017.

## 2.2. Research results

In the study in the School of Economics in Čačak, 160 students participated, of which 101 were girls and 56 boys, and 3 students did not indicate half, most of them having achieved very good school success.

After completing a four-year high school, students of the High School of Economics in Čačak intends to:

1. continue education at a faculty in Serbia 127 graduates (79.4%);
2. continue education at a high vocational school in Serbia 8 graduates (5%);

3. get a job 11 graduates (6.9%);  
 4. starts their own job 3 graduates (1.9%);  
 5. continue education at some faculty outside Serbia 8 graduates (5%).

It examined the extent to which different motives, information, opportunities and reasons - which they have about potential studies - are important

graduates for professional identification and choice of type of study and institution in which they will continue their education. The importance of socialized motives for further education is confirmed by numerous studies. The social impact on the definition of further education and type of education was also examined in this study (Table 2.1).

Table 2.1. Social motives and factors of professional decision of secondary school students of economics

Reasons:	Frequency					M	SD
	1	2	3	4	5		
Parents' or family members' recommendations	42	22	37	18	24	2.72	1.436
University programs similarity with the family members' professions	89	28	12	10	5	1.71	1.102
Teachers' recommendations	80	29	20	12	3	1.81	1.090
The same profession is selected by the friends	100	18	11	4	11	1.67	1.212
I like a city where is location of the tertiary education institutions	40	23	26	28	27	2.85	1.486
Positive experience of the older students of the same institutions	11	15	29	44	45	3.67	1.234
Family's opinion about the university curriculum	35	29	36	34	12	2.72	1.285
Family's opinion about the tertiary education institutions	14	15	39	43	34	3.47	1.231
Information about the students' life	18	23	40	38	26	3.21	1.265
Characteristics of the city for the gymnasium graduates' future education	42	22	37	18	24	2.72	1.436

The greatest influence, when it comes to social motives, is the experience of older students ( $M = 3.67$ ), then information on student life and entertainment (3.47) and characteristics of the city in which the student wants to study (3.21). The smallest influence has the choice of friends (1.67).

Today, the importance of material and financial motives in work is emphasized, and the role of these reasons for selecting types of studies and further education in this research (Table 2.2) is examined.

Table 2.2. Material and financial motives for tertiary education (university programs and institutions)

Reasons:	Frequency					M	SD
	1	2	3	4	5		
Starting your own business in that area.	37	28	31	26	22	2.78	1.407
I think that I can easily recruit at the end of the chosen faculty / college.	13	8	37	41	45	3.67	1.228
Possibility to work with a faculty / college degree in different business environments.	7	7	20	40	71	4.11	1.119
The opportunity to get employment in Serbia and other countries with diploma, knowledge and skills you acquire.	5	5	18	36	81	4.26	1.103
N=							

The greatest influence on professional determination, when the material and financial motive is concerned, is having the possibility of employment in Serbia and other countries with acquired diploma (4.26), as well as the possibility

of working in different business environments (4.11)

It was examined how the graduates are affected by the reputation and status of the chosen profession (table 2.3.).

Table 2.3. Characteristics and status of the profession for decision making of graduates from school of economics

Reasons	Frequency					M	SD
	1	2	3	4	5		
I've always been attracted to this area.	2	11	28	48	53	3.98	1.007
I am particularly interested in the study program for which I apply.	5	19	32	56	34	3.65	1.080
Possibility of practice in companies during studies.	10	9	26	51	49	3.83	1.169
The ability to learn about new technologies and apply it in your future work.	12	10	27	35	62	3.86	1.270
Names and contents of the object.	6	2	22	45	71	4.18	1.017
The status of the profession in our country.	3	8	20	42	73	4.19	1.006
Possibility to gain specialized knowledge and skills.	31	34	38	24	19	2.77	1.313
Possibility to acquire widely applicable knowledge and skills.	44	46	35	13	8	2.28	1.149
Studying the latest achievements in IT, IT and computing.	78	40	12	12	4	1.79	1.076
The challenge is to learn the latest achievements of technical engineering disciplines.	31	35	27	26	26	2.87	1.411
The challenge is to study the latest developments in the field of biomedical science.	31	37	38	29	19	2.85	1.329
The challenge is to learn the latest achievements in the socio-humanistic field.	64	36	23	19	3	2.04	1.148
The challenge is to learn the latest achievements in the field of language and literature.	60	37	21	13	14	2.20	1.326
The challenge is to learn the latest achievements in the field of natural sciences.	7	7	34	44	53	3.89	1.106
The challenge is to study the chosen artistic area.	2	16	30	53	44	3.83	1.027
Contents of subjects that you can continue to perfect your skills.	2	9	35	40	60	4.01	1.014
Relation of theoretical and practical knowledge in studies that enables you to acquire good professional knowledge and skills.	7	11	31	44	51	3.84	1.138
The challenge and the interest of the profession for which you will be preparing for the studies.	2	11	28	48	53	3.98	1.007
The opportunity to engage in practice in quality companies or institutions during the course of studies.	5	19	32	56	34	3.65	1.080
N=							

Challenge and interest of the profession they will prepare at studies are very important to the students (4.01), they are very interested in studying the program for which they are enrolling (3.98), and the most important is the possibility of acquiring specialized and widely applicable knowledge and skills (4.18 and 4.19). Students are

least interested in studying biomedical achievements (1.79).

The study included examining the impact of reputation and the status of an educational institution (table 2.4.).

Table 2.4. impact of the educational institution's reputation on studying students of graduates from school of economics in relation to the education course

Reasons	Frequency					M	SD
	1	2	3	4	5		
Weight of the entrance exam.	28	17	39	37	22	3.06	1.336
Good study conditions (classrooms, laboratories).	27	26	41	26	23	2.94	1.331
Professors are overwhelming and cooperative.	28	20	28	30	38	3.21	1.467
Education is free (on the budget).	9	14	33	51	39	3.66	1.152
The reputation of faculty / college.	4	1	16	48	77	4.32	0.902
Quality of the study program.	8	8	26	51	51	3.90	1.120
Study condition Conditions for university education	37	32	29	29	18	2.72	1.368
Possibility of studying at a distance.	20	33	33	36	23	3.06	1.292
Possibility to study in a small study group where it is possible to learn more and cooperate more directly.	10	13	29	33	60	4.04	2.801
Pre-availability and willingness of professors to cooperate.	8	15	45	49	29	3.52	1.091
Faculty / college equipment.	28	17	39	37	22	3.06	1.336
N=							

Quality of the studies and the program for which they are enrolling are the most important to the students (4.32), as well as the readiness of the

professors for cooperation (4.04). Study conditions (3.90) and the reputation of faculty / high school play an important role as well.

Table 2.5. Impact of information accessibility for decision making of graduates from secondary school students of economics

Reasons	Frequency					M	SD
	1	2	3	4	5		
Advertising by faculty / college.	55	40	24	19	6	2.17	1.196
Information at the education fair.	57	33	29	15	10	2.22	1.265
Information on social networks.	44	27	34	19	20	2.61	1.400
Information obtained at college / high school during a visit to the "Open Doors Day"	67	20	25	19	12	2.22	1.265
Presentation of faculty in my school.	72	19	25	20	7	2.10	1.296
Faculty website / high school	34	29	30	26	25	2.85	1.419
Information I got during additional classes, sections or preparations for competitions	73	29	26	11	3	1.89	1.092
Information within courses and workshops outside the school (Petnica Research Station, research camps, tribunes).	82	28	25	6	2	1.73	0.987
The way the university institutions / college advertises and publicizes.	20	28	54	32	12	2.92	1.136
N=							

Students are informed about universities, university departments and colleges in various ways, and most often through the website (2.85)

and social networks (2.61). An important factor in identifying is the way in which the college is advertised and presented in public (2.92)

Table 2.6. Personal characteristics and expectations for decision making of secondary school students of economics

Reasons	Frequency					M	SD
	1	2	3	4	5		
In these studies, I can continue to improve my skills.	10	14	22	52	46	3.76	1,200
Inability to write something else for the success of high school.	93	14	21	6	9	1.77	1.212
Information on which studies your peers choose, friends.	41	34	36	23	11	3.51	1.264
Expectations that others have of you.	49	28	33	27	8	2.43	1.279
Special skills or skills you have for specific studies.	4	18	40	47	35	2.63	1.069
My interest in secondary education is related to the field of further education.	36	27	26	19	34	2.92	1.518
Previous experience and knowledge in the field of future studies.	15	16	36	45	33	3.45	1.247
Connectivity of your high school education with a type of study.	37	21	35	15	36	2.94	1.513
N=							

It is very important for pupils to continue to improve their skills in studies (3.76), the choice of studies of their peers and friends (3.51), as well as personal experiences and knowledge from the area they want to continue to study (3.45). The smallest influence on the choice has achieved success during high school education (1.77).

### 2.3. Educational implications

On the basis of the results obtained, teachers working with secondary school students could explore or contact different universities to recommend them to students. At the School of Economics in Čačak there is very little variety in the choice of further education. Most students choose economics, law, and management, which are areas they have studied during high school. The problem

arises, in this particular case, that most students have a desire to enroll a particular faculty, but do not have the necessary competence or success in high school education.

With this in mind, teachers can direct students to choose the appropriate faculty / college in accordance with the level of knowledge and competencies they have acquired. The general problem that can be noticed through the interview with the respondents of this research is the inability to assess the financial status of the family.

The High School of Economics in Čačak is implementing the internal research mentioned annually, there is a large percentage of students who do not remain consistent with their own wishes

and plans. The way a school can use this internal research is a conversation with students.

The way colleges can contribute to the mature professional decision making of high school students is implementing the promotion of the faculty as mandatory in cooperation with secondary schools. Uninformation is a major obstacle in making professional decisions, so for the beginning such a problem can be removed in the mentioned way.

### 3. CONCLUSION

The survey found that high school students who are studying for occupations in the field of economics work are generally homogeneous when it comes to professional choices. Even 78% of students at the School of Economics in Čačak decided to continue further education in the field of economics and related disciplines.

Professional identification is very important, especially after the completion of high school when there is a big turning point in life. Wrong choices are generally not detrimental to the professional life of an individual, but they certainly cost as much time as it has been spent on the chosen path. In today's time of understanding and realization of professional orientation, it is a very complex, permanent and comprehensive work of numerous institutions. We share the view that modern professional orientation is based on the conception of choice of occupation and workplace as a process consisting of a series of personal choices of a person and making decisions important for his further professional development. Activities in the domain of professional orientation have existed since ancient times as an indispensable segment of educational work, and today professional orientation is recognized as a necessary activity in almost all countries of the world and has become a necessary part of the teaching work and the entire educational system. The importance of investing in and developing the concept of professional orientation in the educational system, that is, in the institutions, as well as in the later professional engagement, work and life of people, is becoming increasingly important in the world [5].

Most students of the High School of Economics in Čačak chose the way when they decided to attend an economic school. There is a possibility for students to feel the pressure of the environment to continue education in the direction of economics, although most students have indicated that they do not care what others think about their choices. It is also possible to emphasize the factor of the unknown. In an economic school, the educational program focuses mostly on economics, which limits the students to change their field of education.

A new generation enrolling economics from 2017 will be attending a new educational plan for economics schools that includes physics, fine arts

and other subjects that they had not previously had or have had in smaller number of classes. Opinions are divided, some believe that it will allow students to acquire knowledge and skills related to the field of economics, while others consider it to provide students with additional knowledge and skills that will reduce fear of changing the field of education.

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# Grammar School Graduates' Professional Decision-Making and Higher Education Orientation

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**Abstract:** *Professional orientation is a continuous lifelong process and is tasked with helping and directing young people to better understand their own aspirations and the opportunities provided. The paper presents an overview of the results from the empirical research in gymnasiums in Čačak and Gornji Milanovac, as well as a review of the motives and reasons that have the biggest influence on the professional decision of the graduates.*

**Keywords:** *professional development; professional/vocational orientation, professional maturity; factors of professional development; grammar school graduates*

## 1. INTRODUCTION

The choice of occupation represents a significant part of the personal development of an individual and is inseparable from other developmental processes. Professional development is a complex and time-consuming process, and the making of a professional decision is only one of the manifestations of this process [1]. Professional development, as a continuous process of maturing professional decisions based on understanding their own characteristics, getting to know the tasks and requirements of various occupations, and the social conditions that determine the possibility of achieving success, is an important area of school functioning.

### 1.1. Professional development

In the course of professional development, an individual brings a number of professional decisions - from those that influence the choice of a school, to those that determine direct work engagement. One of the important professional decisions is made at the end of high school. By enrolling in a secondary vocational school students are already defined for a specific field of activity (which they can change), while students of the gymnasium postpone their explicit professional orientation for the end of high school. Completion of secondary education is a significant turning point in the life of young people who, independently or in cooperation with others, decide on continuing education, choosing a type of study and future occupation. This decision is very important for the future life of an individual. Satisfaction and performance in the workplace greatly affect the general life satisfaction

of the individual, which arises from meeting the need for biological maintenance, recognition of the environment, self-esteem and self-regulation [2] The selection of studies basically determines the further course of graduate development in a professional sense.

Choosing a profession is a decision-making process where the following three components of making a professional decision are different in different stages: knowledge of one's own characteristics, opportunities and constraints, knowledge of the characteristics and demands of different occupations and jobs, familiarity with the objective situation in society - needs for particular occupations, opportunities and availability of education and employment [2].

And of the many factors influencing the choice of occupation, these are especially recognizable [3,4]: intrinsic motivation, behavioral motivation, specific extrinsic motivational factors, among which the possibility of achieving a good social position, then assessment of self-efficacy, probability of success, attraction of activities within a particular profession, the influence of parents and the environment, in the adolescent period, the opinion of parents or peers is particularly emphasized [3], but also the general attitudes of pupils towards school and teaching. On the basis of the perception of self-efficacy, students can create attitudes towards their future work and life, accordingly set goals, direct their behavior and action [5]; By comparing the motivation of pupils of social and technical schools, the results of this research have shown that students of social orientation have a stronger intrinsic motivation, as well as motivation

for the achievement of students in the technical field.

The choice of profession is, according to Super Development Theory [6] the process of realizing the image of oneself. It can be understood as an assessment that, through a preferred choice of faculties and future professions, individuals can achieve important life goals, seen by the individual as essential elements of an ideal image of themselves. Accepting the thesis on professional development as a continuous process of maturing a professional decision based on the understanding of personal and situational factors, this paper examines the connection of these factors with the professional definition of grammar school graduates (with a choice of type of study, study program, faculty or college).

### 1.2. Review of local research

Professional development at the end of high school was examined from different angles, and at least two are of particular significance for this work: examinations of professional development at the end of secondary school as a decision-making process on the choice of field of work and occupation, and examination of professional development as a decision - making process education at higher education institutions.

In the socio - psychological researches of the choice of profession and the choice of further education, the value expectations of young people were also studied. Havelka (1994) started from the thesis that students already have formed values at the end of elementary education and that value expectations play important role in their decision - making on the future profession [7,8].

Gymnasium students defer their decision for occupations rather than students who have selected secondary vocational schools after compulsory primary education. Gymnasium students postpone their more explicit professional definition for the end of high school [9].

In the research of professional orientation and preferences of occupation and education of Grammar School graduates in Čačak, conducted from 2002 to 2017, the effects of social circumstances and values on professional determination were analyzed.

In the research of the professional value orientation of the Grammar School graduates in Čačak and their expectations from future occupations, conducted in 2002 and 2014 [10], it was established that there are some differences between two generations of graduates: the security of employment for every other graduate in 2004. were more significant than their 2002 peers; Graduates from 2004. were more concerned about the possibility of temporary departure abroad than their peers in 2002.

Changes in the direction of the professional orientation of graduates from different generations of the Grammar School in Čačak have been studied in the following years [11]: the highest number of Grammar School graduates in Čačak enrolls basic academic studies of the state faculties within the technical and technological group from Belgrade (Faculty of Transportation, Faculty of Electrical Engineering, Faculty of Electrical Engineering , Faculty of Mechanical Engineering, Faculty of Technology and Metallurgy) and social - humanistic sciences (Faculty of Law and Faculty of Philology); In recent years, state economic faculties are no longer so interesting to graduates, as opposed to 2004, when they were in the group of the most desirable [10]. Differences in study preferences regarding the course in gymnasium were also determined; Defining the direction, the students were somewhat focused on the type of future studies - students from the natural-mathematical direction are more determined for technical-technological faculties, while students from social-linguistic direction are more determined for socio-humanistic sciences.

The monitoring of professional preferences in two different periods - in 2006 and 2016 and 2017 [11,12] showed that the technical faculties are at the price for the graduates of the Gymnasium in Čačak. Graduates of the Gymnasium in Čačak mainly choose state faculties as institutions where they want to continue their education [11,12].

According to the enrollment results at the end of the school year 2016/2017. [13], the highest number of graduates of the Gymnasium in Čačak enrolled the first year of study programs, primarily basic academic, then integrated academic, and basic vocational studies financed from the budget of the Republic of Serbia. Belgrade is a city where the most of the Čačak Grammar School students want to continue their education. In the context of other studies, it has been established that Čačak Grammar School students mostly do not see the future in the city of their birth - as many as 77%, and only 15% would like their future to be in Čačak [14].

Given the general educational character of gymnasium education, students of these schools were allowed to professionally choose at the end of high school, that is, after an important developmental period that entails achieving maturity, but the question is, what impacts the maturity of their choices and the type of further education.

## 2. RESEARCH METHODOLOGY

The topic of the research: factors (motives, reasons and incentives) of the gymnasium graduates' decisions on their future professional engagement and tertiary education.

Research goals: to investigate and describe the gymnasium graduates' reasons and motives of professional orientation and selection of tertiary education, and to compare professional decisions between students from different gymnasium courses.

#### Variables

Sociodemographic variables: gender (female and male).

Educational variables:

- types/courses of general education (grammar school): general course, socio-linguistics course, scientific course (science and mathematics) and bilingual course;
- school achievement at the end of third class;
- the field of tertiary education: technics and technology (engineering), socio - humanistic field, philological sciences, medical and biomedical field, arts, interdisciplinary and multidisciplinary field;
- the types of the tertiary education: bachelor academic level, bachelor vocational level, integrated academic level,
- tertiary education institutions: universities and faculties in Serbia, universities and faculties in the other countries, vocational higher educational institutions in Serbia, the other educational institutions.

Motivational variables – motives/factors of the grammar school graduates' professional decision-making and selection of the types of tertiary education and tertiary education institutions: social factors, material-financial factors, professional status, status of the educational institutions, students' personal characteristics and their expectancy from themselves etc.

The basic hypothesis: Most of the grammar school graduates make decisions to continue their education on the university level, but there are differences between the grammar school graduates based on the types of general education (types of classes).

Specific hypotheses:

- The most of the grammar school graduates make decisions to continue their education on the same field of education (like grammar school departments).
- Most important factors of professional decision-making are material-financial situation, support of the most important persons in private life (family, parents, older brother and sisters, classmates), and students' personal characteristics (abilities, capacities, wishes).

Nonexperimental methodology based on survey is implemented.

Research instrument: POMIS survey consists of the several parts – (a) questionnaire of the demographic and educational variables and information of potential future education, and (b)

two (self)assessment scales on the factors of professional decision (some items are presented in the part Results). POMIS is developed as a part of research project of the Department of education sciences and technology, Faculty of technical sciences in Čačak, University of Kragujevac, and Department of mathematics and computational sciences, Faculty of science, University of Novi Sad. Cronbach's alpha for Likert - type items was 0.89.

Data processing is realized by SPSS; descriptive and comparative statistical procedures are used.

Sample: 257 students of the fourth grade of gymnasium/grammar school from two grammar school: Gymnasium in Čačak and Gymnasium "Takovski ustanak" in Gornji Milanovac, Serbia. The structure of the sample:

- 39 students of general courses/classes (24 female and 15 male),
- 118 students of socio - linguistics courses (88 female and 30 male),
- 92 students of science - mathematics courses (53 female and 39 male),
- 7 students of bilingual class (4 female and 3 male).

The research was realized in December 2017.

### 3. RESULTS

Examination of professional and educational preferences of grammar school graduates shows that most of the high school graduates want to continue their education (add a percentage), which is consistent with their previous school success: at the end of the third year, almost half had excellent school success (48, 9%), very good was 40.8%, and good 10.2%. Natural-mathematical graduates were the most successful in the third grade - they had 58% of excellent students.

The intention of the graduates is to continue their education at a faculty or high school in Serbia after graduation (94.55%), while only a small number of students plan to continue their education at some faculty outside Serbia - 5.05%, and only 0.38 % said he wanted to start his own business. Future students marked the potential areas of study (Table 1). A large number of students are defined for the technical and technological area (about 48%), while a great interest in the socio-humanistic, as well as in the natural-mathematical field of studies is of great interest.

About 42% of students have chosen this area as one of the most attractive ones in the field of information technology, information technology and computing. However, there are a number of undecided graduates (3.89%), who still have not decided what to study. As the first option, as many as 92.07% of the graduates choose to study at the University of Belgrade. In order to enroll in faculties belonging to the University of Kragujevac, 3.52% of respondents defined themselves.

**Table 1.** Grammar school graduates' preferences of the field of tertiary education

The field of the tertiary education	First choice	Second	Third choice
Technics and technology / engineering	15,95%	14,39%	17,89%
Science and mathematics	13,61%	17,50%	16,34%
Socio-humanistic	18,67%	12,06%	9,72%
Medical and biomedical	9,72%	3,50%	3,50%
Information technology, informatics and computer sciences	14,78%	14,39%	12,84%
Management	8,17%	12,06%	11,67%
Philology and linguistics	9,72%	16,34%	7,39%
Arts	5,83%	2,33%	9,72%
Something else	3,11%	0,38%	0,38%

The interest of the governments for the high schools in Belgrade, as well as for the education at universities abroad. Graduation grammar school students mentioned the following faculties (university departments) as the first option: Faculty of Philology, Faculty of Organizational Sciences, Faculty of Electrical Engineering, Faculty of Law and Faculty of Mechanics (in Belgrade). They most often opt for the following study program: information technology, law, management, security and criminology, as well as studies in the field of language learning.

Only 26.8% of respondents listed the third option for studies. There is still interest in mechanical engineering, traffic, psychology, information science and computer science, but also for sociology and Germanism.

As much as 91.4% of the respondents stated that it is more important for them to enroll in appropriate studies, than where they will study,

8.6% of respondents are more important for studying because of the size of the city, the cultural events and the numerous opportunities that the desired city can provide.

The influence of social motives and factors on the making of professional decisions (selection of types of studies), as well as similarities and differences in this among gymnasiums of different gymnasium directions was examined (Table 2).

The young people's decision is largely influenced by the positive experience of older students, and they find important information about student life and the various opportunities that they provide for socializing. The selection of studies selected by their best friend / friend almost no effect on their choice, nor the recommendations of teachers from the school. Their choice is not affected by the similarity of studies with the profession of older family members.

**Table 2.** Comparison of the social motives and factors of professional decision between different grammar school courses

Reasons ...	Courses of grammar school/ gymnasium education					F	Sig.
	All M	G M	SM M	SL M	BL M		
Parents' or family members' recommendations	2.42	2,37	2,58	2,32	2,43	.690	.559
University programmes similarity with the family members' professions	1.70	1,46	1,79	1,68	2,29	1.242	.295
Teachers' recommendations	1.60	1,55	1,70	1,53	1,71	.524	.666
The same profession is selected by the friends	1.31	1,13	1,36	1,35	1,00	1.072	.362
I like a city where is location of the tertiary education institutions	2.70	2,66	2,58	2,79	3,00	.484	.694
Positive experience of the older students of the same institutions	3.91	3,82	3,91	3,92	4,14	.251	.860
Family's opinion about the university curriculum	2.70	2,58	2,75	2,73	2,43	.268	.849
Family's opinion about the tertiary education institutions	2.71	2,74	2,70	2,71	2,57	.036	.991
Information about the students' life	3.26	3,24	3,14	3,34	3,71	.839	.474
Characteristics of the city for the gymnasium graduates' future education	3.04	3,11	3,02	3,03	3,00	.047	.986
	N=	257	F-Fisher coefficient, **p<0.01, *p<0.05				

All – all gymnasium students; G – general gymnasium course; SM – science and mathematics gymnasium course; SL – socio-linguistics course; BL – bilingual course. F – Fisher coefficient, Sig. – significance.

Social motives are almost equally represented in all courses in gymnasium education. Almost all examined courses as the most important social factor highlight the positive experience of older students, as well as information on student life and

socializing opportunities. It is the least important for graduates to choose the profession chosen by their best friend or companion, as well as the recommendation by teachers.

The study examined the influence of material and financial factors on decision-making on the selection of graduation students. Future students expect that they can easily get hired after graduation.

The most important factors are the possibility that

they can work in different business environments with a degree in the faculties and that they acquire diplomas, knowledge and skills to secure employment in Serbia or other countries.

The results of the Comparative Analysis according to the courses are shown in Table 3.

**Table 3.** Comparison of material and financial identification motives for studies, faculty, of graduates in grammar school

Reasons ...	Courses of gymnasium education					F	Sig.
	All M	GM M	SM M	SL M	BL M		
Starting your own business in that area.	3,24	3,29	3,47	3,07	2,71	1.770	.154
I think that I can easily recruit at the end of the chosen faculty.	3,93	4,24	4,10	3,75	3,14	3.433	.018**
Possibility to work with a faculty / college degree in different business environments.	4,41	4,37	4,42	4,38	4,71	.337	.799
The opportunity is to get employment in Serbia and other countries with diploma, knowledge and skills you acquire.	4,62	4,65	4,62	4,61	4,71	.056	.982
N=257 F-Fisher coefficient, **p<0.01, *p<0.05							
All – all gymnasium students; G – general gymnasium course; SM – science and mathematics gymnasium course; SL – socio-linguistics course; BL – bilingual course. F – Fisher coefficient, Sig. – significance.							

**Table 4** Comparison of the characteristics and reputation / status of the profession for decision making of graduates from grammar schools in relation to the education course

Reasons ...	Courses of gymnasium education					F	Sig.
	All M	GM M	SM M	SL M	BL M		
I've always been attracted to this area.	4.19	4,16	4,16	4,22	4,29	.102	.959
I am particularly interested in the study program for which I apply.	4.16	3,97	4,10	4,26	4,29	1.103	.348
Possibility of practice in companies during studies.	3.34	3,78	3,63	3,00	3,00	5.660	.001**
The ability to learn about new technologies and apply it in your future work.	4.14	4,21	4,45	3,88	4,14	5.066	.002**
Names and contents of the object.	3.93	3,92	3,82	4,03	4,00	.763	.516
The status of the profession in our country.	4.11	4,03	4,11	4,13	4,29	.154	.927
Possibility to gain specialized knowledge and skills.	4.54	4,53	4,64	4,47	4,57	.866	.459
Possibility to acquire widely applicable knowledge and skills.	4.53	4,58	4,53	4,51	4,57	.076	.973
Studying the latest achievements in IT, IT and computing.	3.00	2,92	3,51	2,62	2,86	7.716	.000**
The challenge is to learn the latest achievements of technical engineering disciplines.	2.80	3,08	3,40	2,20	3,57	15.768	.000**
The challenge is to study the latest developments in the field of biomedical science.	2.35	2,66	2,74	1,91	3,14	8.386	.000**
The challenge is to learn the latest achievements in the socio-humanistic field.	2.89	2,97	2,25	3,38	2,57	12.415	.000**
The challenge is to learn the latest achievements in the field of language and literature.	2.81	2,82	2,10	3,38	2,57	14.859	.000**
The challenge is to learn the latest achievements in the field of natural sciences.	2.96	3,34	3,80	2,16	3,29	27.561	.000**
The challenge is to study the chosen artistic area.	2.27	2,66	1,88	2,38	3,29	4.903	.003
Contents of subjects that you can continue to perfect your skills.	4.18	4,11	4,21	4,15	4,71	1.014	.387
Relation of theoretical and practical knowledge in studies that enables you to acquire good prof. knowledge and skills.	4.24	4,13	4,36	4,16	4,57	1.360	.256
The challenge and the interest of the profession for which you will be preparing for the studies.	4.33	4,16	4,30	4,39	4,71	1.090	.354
The opportunity to engage in practice in quality companies or institutions during the course of studies.	4.16	4,34	4,17	4,09	4,14	.587	.624
N= 257 F-Fisher coefficient, **p<0.01, *p<0.05							
All – all gymnasium students; G – general gymnasium course; SM – science and mathematics gymnasium course; SL – socio-linguistics course; BL – bilingual course. F – Fisher coefficient, Sig. – significance.							

The graduates of the general, natural and mathematical and socio-linguistic course, as the most important material and financial factor, indicate the possibility to employ graduates, knowledge and skills acquired by attending specific studies in Serbia and other countries. As a less important factor, the graduates of these three

courses singled out the start of their own work in the area they are studying, which also applies to the bidding classes. In them, the most important material and financial motives are the possibility of employment in Serbia and other countries, as well as the opportunity to work in different business environments, equally represented.

It was examined how the graduates are affected by the reputation and status of the chosen profession (Table 4.).

A large number of students said that is important for them to be attracted to the area they would study, as well as the interest in a particular study program they are applying for. It is important for graduates to acquire specialized and applicable knowledge and skills, as well as the opportunity to practice in quality companies through education. As motives for choosing the future profession, the least important were the challenges for them to study the chosen artistic area, the latest achievements in the field of natural sciences and in the field of biomedical science. The results of the comparisons by courses are shown in Table 4.

On the basis of the data processed, results that graduates who attend bilingual teaching as very important reasons for the selection of certain studies emphasize the challenges of studying the latest achievements of technical engineering disciplines and biomedical sciences, while the students of social-linguistic direction marked it as less important reasons. Students attending socially-linguistic direction as important reasons cite challenges to study the latest achievements in the socio-humanistic field and in the field of language and literature science, which are equally

represented. Graduates of the general and natural-mathematical course as an important reason for the selection of studies emphasize the possibility to learn about new technologies and apply them in their future work. Graduates of natural-mathematical orientation have singled out the study of the latest achievements in the field of IT, informatics and computing as an important reason for choosing future studies. Also, they are challenged with achievements in the field of natural sciences, which is not the case in students of social-language course, which is negligible for this reason. The possibility of practice in companies during study is equally represented among pupils of socio-linguistic and bilingual direction.

The study included examining the impact of reputation and the status of an educational institution. It is extremely important for graduates that the selected study program is of high quality and that the professors are kind and ready to cooperate with students. Graduates point out as a very important factor conditions for studying at a particular faculty / high school. For graduates less important is to study at distance, as well as the weight of the entrance examination. These factors are compared to existing courses in gymnasiums. The results are shown in Table 5.

**Table 5.** Comparison of the impact of the educational institution's reputation on studying students of grammar school in relation to the education course

Reasons ...	Courses of gymnasium education					F	Sig.
	All M	GM M	SM M	SL M	BL M		
Weight of the entrance exam.	2.70	3.19	2.62	2.59	3.00	1.903	.130
Good study conditions (classrooms, laboratories).	3.31	3.34	3.41	3.19	3.86	1.050	.371
Professors are overwhelming and cooperative.	3.12	3.29	3.16	3.03	3.14	.424	.736
Education is free (on the budget).	3.06	3.24	3.21	2.88	3.00	1.096	.352
The reputation of faculty / college.	3.87	3.55	4.01	3.86	4.00	1.878	.134
Quality of the study program.	4.62	4.47	4.73	4.58	4.86	1.898	.130
Study conditions.	4.02	4.03	3.99	4.02	4.29	.158	.952
Possibility of studying at a distance.	2.70	2.47	2.85	2.68	2.14	.992	.397
Possibility to study in a small study group where it is possible to learn more and cooperate more directly.	3.38	3.08	3.45	3.46	2.86	1.342	.261
Pre-availability and willingness of professors to cooperate.	3.98	3.84	4.02	3.98	4.00	.232	.874
Faculty / college equipment.	3.64	3.74	3.64	3.61	3.43	.221	.882
	N=	257		F-Fisher coefficient, **p<0.01, *p<0.05			

All – all gymnasium students; G – general gymnasium course; SM – science and mathematics gymnasium course; SL – socio-linguistics course; BL – bilingual course. F – Fisher coefficient, Sig. – significance.

Based on the data analysis it can be concluded that the obtained results are similar regardless of direction and that there are no major deviations. The graduates were the kindness of the professor. Students of bilingual education, in addition to the above mentioned important conditions of study, as well as the reputation of the educational institution, for which the graduates of natural and mathematical orientation decided to a great extent. The least important factor for students in general direction is the possibility of distance studies. Graduates of social-language and natural-

mathematical direction are least concerned about the weight of the entrance examination.

By examining the availability of information on studies, it was found that graduates are primarily informed on social networks and from faculty web sites, and less in other ways. Data processing has led to the conclusion that any of the ways in which college / high school is presented to the public or information at fairs and the Internet is almost irrelevant to most of the students who participated in this research. The results of the comparative analysis are shown in Table 6.

**Table 6.** Comparison of the influence of information accessibility for decision-making of graduates from grammar School in relation to the education course

Reasons ...	Courses of gymnasium education					F	Sig.
	All M	GM M	SM M	SL M	BL M		
Advertising by faculty / college.	1.83	1.66	1.74	1.97	1.43	1.510	.212
Information at the education fair.	1.94	1.87	1.82	2.06	1.71	.952	.416
Information on social networks.	2.09	1.82	1.99	2.22	2.71	2.220	.086
Information obtained at college / high school during a visit to the "Open Doors Day"	2.03	1.89	2.07	2.03	2.43	.365	.776
Presentation of faculty in my school.	1.94	1.87	2.04	1.90	1.86	.308	.819
Faculty website / high school	2.63	3.00	2.38	2.74	2.00	2.826	.039
Information I got during additional classes, sections or preparations for competitions	2.13	2.08	2.21	2.09	2.29	.210	.890
Information within courses and workshops outside the school (Petnica Research Station, research camps, tribunets).	1.81	1.89	2.05	1.59	1.86	2.654	.047
The way the college / college advertises and publicizes.	2.91	2.71	2.98	2.93	2.71	.532	.661
	N= 257		F-Fisher coefficient, **p<0.01, *p<0.05				

All – all gymnasium students; G – general gymnasium course; SM – science and mathematics gymnasium course; SL – socio-linguistics course; BL – bilingual course. F – Fisher coefficient, Sig. – significance.

The main influence of graduates on the general course is the website of the faculty / college, while the graduates of the natural-mathematical course find important the way in which the educational institution is presented to the public, as well as the social-language course. Graduates who attend bilingual education find important information on social networks, as well as public presentation of faculties. However, the smallest impression on high school graduates leaves faculty advertisements.

It was examined how the personal characteristics of graduates and the expectations they have in their professional orientation are influenced. The obtained data show that it is most important for

graduates to continue to improve their skills in selected studies. It is important for them to develop the skills they possess for certain types of studies, as well as previous experience and knowledge in the field of future studies. As for the slightest influence on the decision making process, the graduates listed the inability to enroll something else because of school success and the impact of information on which studies are chosen by their friends and peers. It is interesting that for most of them expectations that others have from them are not important. In the following table, a comparison of these factors according to existing courses in gymnasiums is presented (Table 7).

**Table 7.** Comparison of personal characteristics and expectations for decision making on of grammar school graduates in relation to the education course

Reasons ...	Courses of gymnasium education					F	Sig.
	All M	GM M	SM M	SL M	BL M		
In these studies, I can continue to improve my skills.	4.12	4.24	4.02	4.12	4.86	1.763	.155
Inability to write something else for the success of high school.	1.43	1.66	1.34	1.44	1.00	1.516	.211
Information on which studies your peers choose, friends.	2.16	1.89	2.22	2.21	2.14	.770	.512
Expectations that others have of you.	2.39	2.08	2.45	2.48	2.00	1.200	.310
Special skills or skills you have for specific studies.	3.88	3.74	3.86	3.94	3.86	.385	.764
My interest in secondary education is related to the field of further education.	2.94	3.00	3.01	2.87	2.71	.298	.827
Previous experience and knowledge in the field of future studies.	3.69	3.66	3.72	3.63	4.29	.898	.443
Connectivity of your high school education with a type of study.	3.14	2.89	3.34	3.09	2.71	1.310	.272
	N= 257		F-Fisher coefficient, **p<0.01, *p<0.05				

All – all gymnasium students; G – general gymnasium course; SM – science and mathematics gymnasium course; SL – socio-linguistics course; BL – bilingual course. F – Fisher coefficient, Sig. – significance.

Based on the analysis of the results in Table 7, it can be concluded that it is important for graduates to improve their skills at the studies, and to use previous experience and knowledge in the field of future studies. There is almost no doubt that they will enroll in the desired studies for their achievements in schooling, and they do not have exceptional information about the choice of friends and peer studies.

#### 4. DISCUSSION AND EDUCATIONAL IMPLICATION

On the basis of the obtained results, teachers and professional associates who work with high school students should achieve their advisory role through informal meetings with students, discussing future profession and exchanging critical opinions and

attitudes. In this way, mutual trust is created, teacher learns the students' interests and they are teaching each other.

The school should more often organize presentations of various occupations needed by the economy, promote them through educational visits to companies or organized practices. By organizing creative workshops or virtual businesses, they can also further interest students. Students should be informed about available free trainings organized by highly educated institutions or firms, also recommending them going to fairs or indicating when the Open Doors Day is planned is a good way to inform them. One of the creative ways to inform students about the demands of different professions is organizing a costume ball of professional orientation, which has found application in some schools. The school has a great role to guide students to make the right decision, to introduce them to less popular occupations that students have not heard and to encourage them to make a decision more mature.

The counselor should be familiar with the basic principles of using professional information and integrating them into a comprehensive advisory process, with a special emphasis on creating the opportunity for a candidate to express his or her views and opinions. Teaching and extracurricular activities in the school and contacts with parents can significantly contribute to professional development [6].

A large percentage of high school students (94.55%) chooses to continue their education and enrollment at faculties or colleges. This result is not surprising, since students at the end of high school education in gymnasiums prefer to continue their education. The areas of interest are different, as well as the choice of a particular type of study according to gender.

Also, we can conclude that the great interest is for the enrollment of faculties belonging to the University of Belgrade. The capital attracts them because of numerous cultural events. However, the higher the number of students, on the question of whether they find more important the place of study or study itself, decided on the importance of the study.

The reasons why a large number of students are still interested in the technical and technological area can be numerous, starting from the constant technical and technological progress, innovations and inventions in this area. A great deal of interest in technical faculties has also been shown in the results of the previous study [12]. Taking into account the courses that exist in gymnasiums, the results obtained are not surprising, especially the existence of great interest in the areas of natural-mathematical and social-language disciplines. This leads to the conclusion that when they were enrolled in the appropriate course in gymnasium,

they were aware of their knowledge and abilities and are directed further towards their affinities.

The evidence of this is the previous study which showed the differences in the professional preferences of gymnasiums of different orientations, with a clear orientation towards social and natural sciences depending on the course in the gymnasium [11].

Their teachers, class officers, professional associates, as well as their family play a major role in their decision-making and direction.

## 5. CONCLUSION

According to a survey conducted in gymnasiums, regarding the professional orientation of graduates and the degree of representation of factors influencing the final decision on the selection of future studies, the result is that most students plan to continue their education at faculties and colleges, as well as that the majority is defined for studies in the technical and technological field. We can assume that this is due to the increasing popularity of this area, as well as the rapid development of the past years. Also, we can conclude that the great interest is for the enrollment of faculties belonging to the University of Belgrade. The capital attracts them because of numerous cultural events. However, the higher the number of students on the question of whether they have a more important place of study or study have just identified the importance of the study. Of all the factors examined, it turned out that the students most emphasize their personal preferences, the most important thing is that they enter what they want without the material and financial situation being over-influenced. Study conditions are important for them, as well as the possibilities for employment after graduation. Graduates are not so much interested in studies related to their high school course. The reason may be the nature of their age, when they are prone to changing the decision. The need for improving skills in a particular area, as a motive, strongly influences graduates when choosing a course. The results confirmed the assumption that the key motives of graduates in selecting studies are desire, possibilities and abilities, but the availability of study information as a factor is not absolutely negligible.

The development of a professional orientation should follow a step with modern science and knowledge, it should be ensured that it is adaptable to constant changes and monitors socio-economic changes. The choice of profession is the development process, so it is expected that professional orientation and counseling follow the developmental path of the society. The development of professional orientation has a lot of positive effects on society in general. It also has a significant impact on the reduction of the positive

and negative professions in the labor market, as well as on future employment. Therefore, the role and responsibility of parents, teachers, pedagogues and psychologists, as well as other institutions and institutions dealing with this issue, is of great importance.

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# Application of statistics for the analysis of results achieved in primary education

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**Abstract:** - *Statistics is one of the most applicable mathematical disciplines dealing with data collecting and processing as well as the analysis of the achieved results. Statistical packages enable quick processing of these data and performing statistical analyses. In this paper, the application of Statistica software package enabled processing of the data that included 80 pupils. The achievements of pupils from the subject of technical and informatics education were examined by tests. Descriptive statistical procedures were used in data processing. Appropriate statistics were used to carry out the analysis and adequate interpretations of the obtained results were provided. The test results indicate a normal distribution of data as well as gender independence relative to the area being tested by testing.*

**Keywords:** *statistics, descriptive statistics, hypothesis of testing, statistical analysis.*

## 1. INTRODUCTION

The aim of the examination is to indicate the possibility of applying statistics in the education process to students. Systematic application of such analyzes could lead to important conclusions regarding the improvement of the teaching process in schools.

In this paper the analysis of the success of pupils of the sixth grade, within the subject of Technical and Informatics Education was carried out. The random sample was founded on 80 pupils of an elementary school and sample elements by observing the following categories: gender, class and obtained grades to each of four examinations carried out within this subject. The used data are more or less similar and the results of some future tests cannot be accurately predicted.

By monitoring these available data in their entirety, they reveal that the medium results manifest certain pattern and stability that serve as the basis of the mathematical theory of statistics and statistical prediction.

## 2. CONCEPT AND IMPORTANCE OF STATISTICS

One of the basic problems in mathematical statistics is that on the basis of a sample from a certain population, the distribution of the very character of the population occurs, that is, the theoretical distribution is based on the sample distribution. Of course, information on the theoretical distribution function is obtained with a certain accuracy, or with a certain level of confidence. This accuracy and precision of the

conclusions reached can be increased by selecting a sample of sufficiently large volumes. However, we are not always able to get a sample of the desired volume, so our capabilities in terms of accuracy are limited [1].

Since the statistical distribution of a certain feature is precisely determined by the parameters of this distribution, the first problem we face in relation to the observed feature is: an assessment of the unknown parameters of the observed samples.

Basically, our goal is to find the best mark for the parameter, based on the sample. The specification of these values is carried out using statistical hypotheses, and deciding on the acceptability of these values based on the observed sample is done using criteria called statistical tests.

Therefore, if we want to test the hypothesis of a certain value of the mathematical expectation for a particular feature  $X$  ( $H_0: m = m_0$ ), then we first need to evaluate the mathematical expectation for that characteristic  $X$ . We use statistics for this assessment

$$\bar{X}_{n=} = \frac{1}{n} \sum_{k=1}^n X_k$$

(the medium value of the sample), which represents a centered (unbiased) assessment of the mathematical expectation of that feature  $X$ .

In other words, the sample average value serves as the starting point for all tests. Through testing, we only determine how far we can deviate from this average value, and that the starting hypothesis  $H_0$  remains effective. We do this for a certain significance threshold  $\alpha$ , usually  $\alpha = 0.05$ , i.e. we give certain guarantees for our conclusions.

Our research and the results that follow, fully agree with the reasoned methodology [1], [2].

### 3. DESCRIPTIVE STATISTICS

Descriptive statistical analysis is a set of methods for calculating, displaying and describing the basic characteristics of statistical series [8], [2].

Descriptive statistical analysis has the following tasks:

- grouping and compiling statistical data,
- displaying statistical data,
- determination of basic indicators of statistical series.

Grouping data is done according to the values or modalities of the observed features. The final result is the statistical series.

The statistical series is a set of variations of the characteristics of the observed statistical mass. The statistical series is presented in the form of a table, in at least two rows and two columns, where the qualitative side of the statistical mass is shown in the first column, and in the second quantitative (numerical) side.

Descriptive statistics include calculating:

- counting measure (frequency and percentage),
- measure of central tendency (mode, median and arithmetic mean) and
- measure of variability (range and standard deviation).

Graphical data representations are called diagrams or charts, and we can divide them into dot, line and surface.

### 4. METODOLOGY OF RESEARCH

In this paper both descriptive and inferential statistics were used as methods of research. By the method of descriptive statistical analysis, testing of statistical hypotheses, using the Pirson  $\chi^2$ -test, the contingency table, determining the confidence interval of the expected value, as well as the procedure for creation of a sub-sample, the main results of this paper have been reached.

The data on which the analysis was carried out were taken from the primary school "Sveti Sava" in Čačak, and represent the grades from the subject "Technical and informatics education". The sample consists of 80 pupils on which the six values observed are registered: gender, class (as attribute features) and grades on Test1, Test2, Test3 and Test4 (as numerical features).

The analysis was carried out in the program package *Statistica*, which offers the most comprehensible range of data analysis, data management, data visualization and data extraction procedures. Her arsenal includes the most comprehensible selection of techniques of prognostic modeling, grouping, classification and research methods in the same software platform.

### 5. APPLICATION OF DESCRIPTIVE STATISTICS IN THE BASIC EDUCATION

This paper analyzes the success of pupils of the sixth grade of "Sveti Sava" elementary school in the field of Technical and informatics education. The sample consists of 80 pupils of this school and for each of these pupils 6 values are registered: gender, class and grades on each of the 4 test. Part of this table is shown in Figure 1 [3], [4], [5], [7]. We can say that pupils' grades are in the maximum interval, or from 1 to 5.

	1 Pol	2 Odeljenje	3 Test 1	4 Test 2	5 Test 3	6 Test 4
1	Muski	6/1	5	4	5	5
2	Muski	6/1	5	1	5	4
3	Muski	6/1	3	1	2	4
4	Muski	6/1	3	2	2	4
5	Muski	6/1	3	2	2	4
6	Muski	6/1	4	3	2	5
7	Muski	6/1	5	4	1	5
8	Muski	6/1	5	4	4	5
9	Zenski	6/1	3	5	4	2
10	Zenski	6/1	5	1	4	5
11	Zenski	6/1	5	5	4	5
12	Zenski	6/1	3	4	4	5
13	Zenski	6/1	3	2	4	2
14	Zenski	6/1	2	4	4	5
15	Zenski	6/1	1	2	4	5
16	Zenski	6/1	4	2	5	5
17	Muski	6/1	5	5	5	3
18	Muski	6/1	3	4	5	3
19	Muski	6/1	3	5	2	3
20	Muski	6/1	4	5	2	3
21	Muski	6/1	2	4	2	3
22	Muski	6/1	1	3	1	3
23	Zenski	6/1	4	3	3	3
24	Zenski	6/1	5	2	3	3
25	Muski	6/1	3	2	3	3
26	Zenski	6/2	2	1	3	3
27	Zenski	6/2	1	4	3	3
28	Zenski	6/2	4	4	3	3
29	Zenski	6/2	5	5	3	3
30	Zenski	6/2	3	5	5	2

Figure 1. Part of the sample with the values of the observed variables

As already mentioned, data can be displayed in different ways depending on the tool selection - tabular or graphic (diagram). Summary Statistics provides the possibility of tabular display of the number of individuals in the sample (in this case, the number of pupils in the sixth grade), then medium, minimum and maximum values, as well as the summarized value of the observed sample mark (in this case, the test on the subjects Technical and Informatics Education).

Also, the values of mode, medium and standard deviation are tabulated. In Figure 2, a summary of the *Summary Statistics* for the numerical value of the Test 1 - mark from the first test in the Technical and Informatics course is shown.

Variable	Valid N	Mean	Geometric Mean	Harmonic Mean	Median	Mode	Frequency of Mode	Sum	Minimum	Maximum	Std. Dev.
Test 1	80	3.112500	2.782170	2.407222	3.000000	3.000000	25	249.0000	1.000000	5.000000	1.321619

Figure 2. Summary Statistics part of numerical variables - Test 1

In all four tests, the minimum score is 1 (inadequate grade), and the maximum score is 5 (excellent). The average marks for the tests are: Test 1 (3.11), Test 2 (3.38), Test 3 (3.34), Test 4 (3.46) from Technical and Informatics Education (Figure 3).

Variable	Valid N	Mean	Geometric Mean	Harmonic Mean	Median	Mode	Frequency of Mode	Sum	Minimum	Maximum	Std.Dev.
Test 1	80	3.112500	2.782170	2.407222	3.000000	3.000000	25	249.0000	1.000000	5.000000	1.321619
Test 2	80	3.387500	3.067065	2.687570	3.000000	5.000000	23	271.0000	1.000000	5.000000	1.335969
Test 3	80	3.337500	3.057065	2.724177	3.000000	3.000000	26	267.0000	1.000000	5.000000	1.262344
Test 4	80	3.482500	3.305865	3.151674	3.000000	3.000000	34	277.0000	2.000000	5.000000	1.042891

Figure 3. Summary Statistics for all numerical variables

The absolute frequency histogram for Test 1 provides a graphical representation of the values of the observed random variables (in this case, Test 1). A histogram is a type of surface diagram showing the values of a random variable. This diagram consists of a column, where the width of the column is the width of the class interval, and the height of the column represents the absolute frequency. By connecting the center of the column, a polygonal line is obtained.

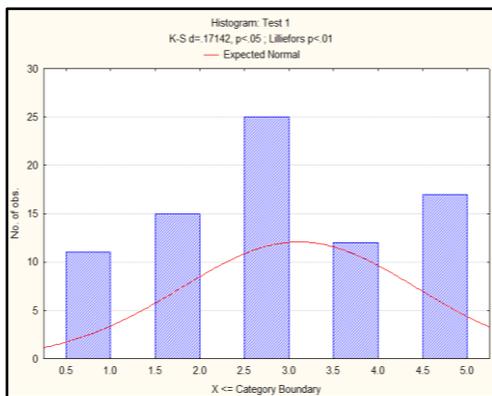


Figure 4. Absolute frequency histogram for Test 1

The shape of this polygonal line would change when a new sample of pupils from the same school was formed, but these changes would probably not be statistically significant. The theoretical density function, shown in Figure 4, represents an approximate function for all these polygonal lines. It is obvious that she points to Gauss's (normal) distribution. This assumption is confirmed or denied by the Pearson  $\chi^2$ -test, the results of which will be presented in the next section.

To mark - a test on Test 1 give another display. This is a Box & Whisker Plot (Figure 5).

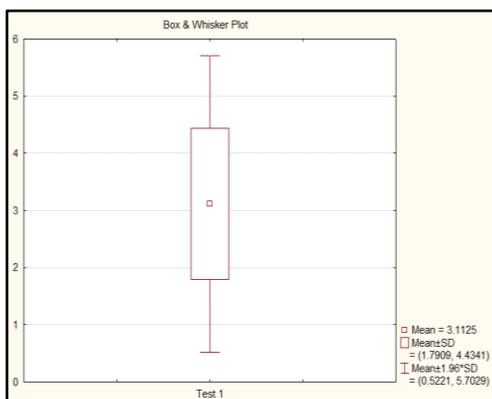


Figure 5. Box diagram for variables Test 1

Box & Whisker Plot Diagram (Figure 5) consists of three parts: the middle square - showing the average grade on Test 1 (Mean = 3.1125), box frame - extending to the mean value  $\pm$  deviation (Mean + SD) and "Whisker" - which reach the mean value of  $\pm 1.96 * \text{standard deviation}$  (Mean  $\pm 1.96 * \text{SD}$ ), which represents the confidence interval for the mathematical expectation of the random variable of this feature.

The small square represents the mean value of the marks obtained in the first test (Mean = 3.1125). The rectangle represents the minimum and maximum deviation from the mean value for the standard deviation value of 1.101710. The ends of the mustache show extreme values that represent values that are outside of the deviation framework. In fact, this is the maximum value of the interval value of this feature.

### 5.1 Testing statistical hypotheses

#### 5.1.1 Test $H_0 (m = m_0)$ against $H_1 (m \neq m_0)$ with unknown $\sigma^2$

The test relates to a random variable Test 1, which presents the grades that pupils achieved at the first test in the subject Technical and Informatics Education. The  $H_0$  hypothesis is tested (assumption) that the mean or the average grade for this test per student is equal to 3, i.e.  $H_0(m_0 = 3)$ . The value 3 ( $m_0 = 3$ ) is entered in the field Test all means against. Then the minimum value of the probability of occurrence of the error of the first type ( $\alpha$  minimum) is to be assigned, i.e. the value  $\alpha = 0.05$  ( $\alpha$ -level for highlighting) is fixed. After this setting, it is necessary to confirm the Summary button, and then the table shown in Figure 6 is obtained.

Variable	Mean	Std.Dev.	N	Std.Err.	Reference Constant	t-value	df	p
Test 1	3.112500	1.321619	80	0.147762	3.000000	0.761362	79	0.448708

Figure 6. Values T-test-a for variables Test 1

Since  $p = 0.448708 > 0.05$  we have no reason to reject the zero hypothesis and we can consider that the success of the pupils on this test is characterized by a score of 3.

#### 5.1.2 Testing $H_0 (m_1 = m_2)$ against $H_1 (m_1 \neq m_2)$ when unknown $\sigma_1^2, \sigma_2^2$

From the Statistics menu, the Basic Statistics / Tables option is selected, and t-test is independent by Variables.

Sampling values of values on Test 1 and Test 2 are different  $\bar{x}_1 = 3.1125$  and  $\bar{x}_2 = 3.3875$ .

The question arises: Is this difference statistically significant, with confidence level of 0.95, or significance threshold  $\alpha = 0.05$ ? This is expressed through a hypothesis,  $H_0(m_1 = m_2)$  against an alternative  $H_1(m_1 \neq m_2)$ .

For this we use the t - test (Figure 7).

Group 1 vs. Group 2	Mean Group 1	Mean Group 2	t-value	df	p	Valid N Group 1	Valid N Group 2	Std Dev Group 1	Std Dev Group 2	F-ratio	p
Test 1 vs. Test 2	3.112500	3.387500	-1.30891	158	0.192467	80	80	1.321619	1.335909	1.021741	0.924091

Figure 7. Table showing the results of the test for independent random variables Test 1 and Test 2

From the table in Figure 7 it can be noticed that the hypothesis  $H_0$  is not accepted, since the value  $p = 0.192467$  (less than 0.05). This test can also be illustrated by a diagram of the boxes, shown in Figure 8, and from which it is also noted that the variables Test1 and Test2 are different. This means that with a confidence of 95% we reject a zero hypothesis  $H_0(m_1 = m_2)$  against the alternative  $H_1(m_1 \neq m_2)$ .

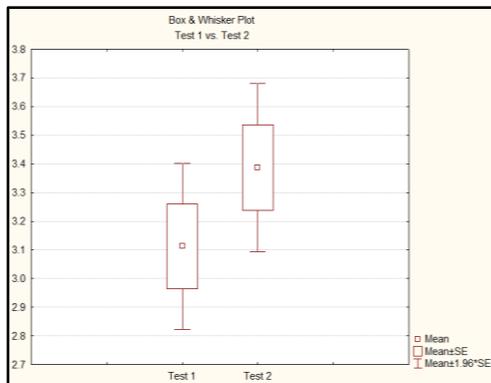


Figure 8. Box plot for variables Test 1, Test 2

### 5.2 Pirson $\chi^2$ -test

The Pirson test in the Statistica software package shows which types of distribution are supported for a particular pattern [6], [8]. Based on histograms, we can assume the distribution of the observed features. Is this so checked by Pirson's  $\chi^2$ -test? We test the hypothesis that the data on Test1 should be arranged according to normal distribution.

Upper Boundary	Observed Frequency	Cumulative Observed	Percent Observed	Cumul. % Expected	Expected Frequency	Cumulative Expected	Percent Expected	Cumul. % Observed-Expected
<= 1.00000	11	11	13.75000	13.75000	4.39800	4.39800	5.49750	6.60200
1.50000	0	11	0.00000	13.75000	4.49917	8.89717	5.62396	-4.49920
2.00000	15	26	18.75000	32.50000	7.09949	15.99666	8.87437	7.90050
2.50000	0	26	0.00000	32.50000	9.72511	25.72177	12.15639	-9.72511
3.00000	25	51	31.25000	63.75000	11.56478	37.28655	14.45597	13.43622
3.50000	0	51	0.00000	63.75000	11.93871	49.22526	14.92339	-11.93871
4.00000	12	63	15.00000	78.75000	10.69929	59.92455	13.37411	1.30070
4.50000	0	63	0.00000	78.75000	8.32394	68.24849	10.40493	-8.32394
5.00000	17	80	21.25000	100.00000	5.62182	73.87031	7.02727	11.37822
< Infinity	0	80	0.00000	100.00000	6.12969	80.00000	7.66211	-6.12970

Figure 9. Table of absolute functions Test 1 variables and the results of testing their compliance with the normal distribution

On the basis of the table shown in Figure 9, the absolute frequency histogram is shown in Figure 4 and can be concluded on the basis of the value  $p$  of 0, which is less than 0.05 that the data, in this case the estimates, are not distributed by the normal distribution.

Let's examine the possible agreement with Puason's distribution for the same significance threshold  $\alpha = 0.05$ .

Category	Observed Frequency	Cumulative Observed	Percent Observed	Cumul. % Expected	Expected Frequency	Cumulative Expected	Percent Expected	Cumul. % Observed-Expected
<= 0.00000	0	0	0.00000	0.00000	3.55917	3.55917	4.44896	-4.44896
1.00000	11	11	13.75000	13.75000	11.07791	14.63708	13.84739	-0.77911
2.00000	15	26	18.75000	32.50000	17.24000	31.87707	21.55000	9.84630
3.00000	25	51	31.25000	63.75000	17.88649	49.76357	22.35812	27.40545
4.00000	12	63	15.00000	78.75000	13.91793	63.68150	17.39741	45.28359
< Infinity	17	80	21.25000	100.00000	16.31850	80.00000	20.39813	-16.31850

Figure 10. Frequencygroup table for Puason distribution

From the table of grouped frequencies in Figure 10 it can be seen that the value  $p = 0.22924 > 0.05$ . On the basis of this, it can be concluded that the estimates on Test1 were calculated according to Puason's law. The same conclusion applies to Test2, where  $p = 0.45624 > 0.05$ . However, this does not apply to Test3 and Test4.

Using the  $\chi^2$ -test of independence, we will test the test results of half of the pupils. First, we will create a contiguity table for the half-marker marks and the results on Test1 (Figure 11).

Pol	Test 1 1	Test 1 2	Test 1 3	Test 1 4	Test 1 5	Row Totals
Muski	7	8	14	6	7	42
Zenski	4	7	11	6	10	38
All Grps	11	15	25	12	17	80

Statistic	Chi-square	df	p
Pearson Chi-square	1.578206	df=4	p=0.81270
M-L Chi-square	1.588335	df=4	p=0.81089

Figure 11. Contingency table and independence test

The results of the test show that Test 1 has a high degree of independence of the test results from half of the pupils because  $p = 0.81270 > 0.05$ . A similar conclusion applies to Tests 2 and 4, but this independence is less exposed. However, this does not apply to Test 3. This shows which group is more interested in this segment of teaching material, boys or girls. Which gender is exactly the issue depends on who has a higher average grade, boys or girls.

In the end, the independence of the results on the observed tests was investigated by methods of factor analysis, [6], [8] (Figure 12). The results of these analyses have shown that the results in the tests are largely independent ( $p = 0.27410 > 0.05$ ). The only dependence was recorded between the results on Test 1 and Test 4. The reason for this dependence could be subsequently analyzed, but what we need is further information.

Test 2; Unweighted Means (Spreadsheet3)						
Current effect: F(4, 75)=1.3098, p=.27410						
Effective hypothesis decomposition						
Cell No.	Test 2	Test 1 Mean	Test 1 Std.Err.	Test 1 -95.00%	Test 1 +95.00%	N
1	1	3.142857	0.495652	2.155467	4.130247	7
2	2	2.882353	0.318055	2.248756	3.515950	17
3	3	3.705882	0.318055	3.072285	4.339480	17
4	4	2.750000	0.327843	2.096903	3.403097	16
5	5	3.086957	0.273440	2.542236	3.631677	23

Figure 12. Factor analysis test table

## 6. CONCLUSION

Without computers and statistical programs, processing large amounts of data would be a slow and time-consuming process. Application of statistical packages, such as *Statistica*, enables easier data processing and analysis of results.

The test results mostly do not depend on half of total number of all the pupils. More importantly, the results in the tests are mutually independent. This points to the fact that these results do not depend much on pupil's knowledge on the particular subject, which somehow points to the structure of the subject.

From the results of the analysis we conclude that the results of the test do not depend on half the students. More importantly, the results in the tests are mutually independent.

This points to the fact that these results do not depend much on the knowledge of students on the subject, which somewhat points to the structure of the subject.

For more reliable conclusions, we would need more information and more repeated student testing. Systematic application of such analyzes could lead to important conclusions regarding the improvement of the teaching process in schools.

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# Language of the Internet – change or decline?

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**Abstract:** *Language constantly evolves and technology accelerates that change dramatically. Over the past three decades, the development of communication technologies has recorded the fastest rate in history and has made remarkable impact on the English language. This language 'revolution' has been met with apprehension by the community in much the same way as every new technology in history did. The objective of this paper is to present actual technology-induced language changes in the English language, especially the language of texting and instant messaging, and analyse the objectivity of increasing debate among community concerning the changes. The paper also attempts to provide predictions about possible future development of the English language in the environment of fast-paced developing communication technology and potential areas of investigation of 'netspeak' in the ELT context.*

**Keywords:** *language; technology; texting; instant messaging; future*

## 1. INTRODUCTION

The English language, much the same as any other language, is ever-changing, evolving all the time, as words fall out of use or acquire new meanings. We only need to look back at the works of great writers like Shakespeare, Austen and Dickens to see how the English language has changed over time [1]. Societal change and education were often the dominant factors that led to language evolving in times past, but doubtless it is technology that has had the greatest impact on how we speak in recent years. Emoji, LOL, ROFL, selfie, blogging – these words meant little or nothing just a few short years ago but now are part of our everyday lexicon. The entire communication on the internet, be it text messaging, instant messaging or any other electronic communication form has generated what we call 'netspeak' [2], a new language made up of abbreviations, portmanteau words, acronyms, non-standard punctuation, etc.

In view of the fact that the English language has undergone enormous changes particularly over the past two to three decades, the apprehension voiced in different tones and fashions that the English language is being uncontrollably modified for the worse, appears to be justified. However, literature suggests that instead of 'decay' of the language, 'change' is probably a more appropriate word to define what the language is undergoing. In the continuation of the paper, some of the major aspects of the changes in the English language effected by the technology development over the past three decades will be presented. The paper also includes the historical survey of

different technologies introduced into society and their reception in contemporary time. Predictions about future evolution of technologies and their possible influence on the language will be briefly considered in the closing of the paper as well as possible areas of study of the language of the internet in the ELT environment.

## 2. HISTORICAL SURVEY

'Time and the world are ever in flight' – *William Butler Yeats*

All through the history of humanity, poets and philosophers spoke of the inevitability of fluctuation of life. Language also joins this fluctuating mode and gradually transforms itself over time. English of several hundred years ago, e.g. the language of Shakespeare, sounded remarkably strange to the English of the XIX century, let alone the English of modern time. Thus, there is nothing surprising in the fact that language, being at the core of human expression, cannot escape this universal law. In spite of this, a large number of intelligent people condemn and resent language change. As Aitchison in [3] puts it: 'All through the past century and even before, letters were written and indignant articles published, all deploring the fact that words acquire new meanings and new pronunciations'.

From the time of the Industrial revolution and by the first technological inventions, it was the societal factors and education that were major enablers of language changes. With the introduction of the 'second machine age' [4] or the beginning of computer age, the blame was

shifted on fast-pace evolving technology – and has never ceased since.

A brief look back on the major technological inventions that triggered a faster pace of language change shows that the anxieties about the emergence of new technologies have been with us for quite some time – unjustifiably though, as history has proven. As Crystal in [5] aptly puts it, in the fifteenth century, the arrival of printing was widely perceived by the Church as an invention of Satan, the hierarchy fearing that the dissemination of uncensored ideas would lead to a breakdown of social order. Around 400 years later, similar concerns about censorship and control were widespread when society began to cope with the political consequences of the arrival of the telegraph, the telephone, and broadcasting technology. The telegraph would destroy the family and promote crime, they said. The telephone would undermine society. Broadcasting would be the voice of propaganda. In each case, the anxiety generated specifically linguistic controversy. Printing enabled vernacular translations of the Bible to be placed before thousands. And, when broadcasting enabled selected voices to be heard by millions, there was an immediate debate over which norms to use as correct pronunciation, how to achieve clarity and intelligibility, and whether to permit local accents and dialects, which remains as lively a debate in the twenty-first century as it was in the twentieth. And then came the Internet – the global voice with communication at the core, and its suite. 'Join the communication', 'share information' is the imperative of today. With the arrival of the mobile phone and its synergy with the Web, 'the number of people involved in the communication revolution has skyrocketed' [6] as the entire planet has come right under our thumbs.

Before making any assertions about positive or negative impact of technology, we need to take a closer look into the actual linguistic properties of the language yielded by the so-called 'electronic revolution' [5]. In doing so, we need to point up actual changes that have occurred and produced this new 'revolutionised' language so as to obtain a reasonable and as objective as possible insight into what the 'revolution' has yielded. In that vein, the most common misconceptions or myths that inevitably accompany every emerging technology need also to be addressed.

### 3. INTERNET LANGUAGE - NETSPEAK

It is only some twenty years ago or so that the world encountered electronically mediated communication. The World Wide Web was invented in 1991, first emails were sent in mid-90's, weblog (web+log) came into existence in 1997 although blogging was actually introduced in early 2000's, Google search was available in 1999,

mobile phones accompanied by texting facility were widely introduced in late 90's. Instant messaging, Facebook and Twitter introduced us into the new millennium. Each of these have their own distinctive features, however all of the technologies above rely on the written language highlighting a single goal: sharing information. In doing so, these internet outputs apply their own linguistic conceptions. Besides already traditional but still in use email, probably the most utilized of all communication forms are texting, introduced with mobile telephony, and instant messaging (IM), more common in recent time. Language conceptions of texting and IM have been adopted by a great number of social networks, such as Facebook, Twitter, Instagram, Viber, Whatsapp, etc.

#### 3.1. What has the netspeak given us?

It goes without saying that texting and IM abound in abbreviations which are generally blamed for 'ruining' the language however a deeper insight into the frame of operation of these internet 'platforms' is needed.

For the purpose of illustration, here is the list of common Internet abbreviations, and chat acronyms that make up what is called netspeak, also sometimes called 'chatspeak'.

AAMOF	As a matter of fact
AFK	Away from keyboard
BC (B/C)	Because
BFF	Best friends forever
BRB	Be right back
BTW	By the way
CU	See you
DIY	Do it yourself
FYEO (4YEO)	For your eyes only
GR8	Great
IDK	I don't know
IMO	In my opinion
JK	Just kidding
LMHO	Laughing my head off
L8R	Later
LOL	Laughing out loud
NOYB	None of your business
NP	No problem
OMG	Oh my god
OT	Off topic
OTOH	On the other hand
ROFL	Rolling on the floor laughing
TIA	Thanks in advance
TMI	Too much information
TTYL	Talk to you later
ATM	At the moment
TY	Thank you
SMH	Shaking my head [7]

Besides the wide use of abbreviations, the internet language has introduced an array of novelties, both lexical and grammatical. Some words have been re-appropriated and given new meaning, e.g.

- HOTSPOTS were locations in travel guides described as 'hotspots for nightlife' or 'dining hotspots', whereas in the netspeak the primary association is 'a WiFi'.
- DRONE meant an irritating noise, now it is a small, pilotless aircraft generally used for video recording in hard-to-reach places.
- CLOUD is a formation in the sky, however the netspeak recognizes it as a model where data is maintained, stored and backed-up remotely and made available to its users over a network.
- TROL is not only an ugly cave-dwelling creature, but also an individual who makes intentionally offensive posts online to gain a reaction.
- COOKIES we enjoy eating, but the internet ones – small pieces of data sent from a web browser and stored while you browse – do not boast of delicious taste.
- The net BUG, an unwanted piece of code that stops the execution of a program, is as much irritating as little creepy, crawly insects.

And the list is by no means exhaustive. Generally speaking, network is a medium where conveying information is in the focus, as mentioned above, hence no wonder that some economical solutions were implemented in the language of the 'global village' medium. In this respect, many noun forms are also used as verbs, e.g. the noun FRIEND has somehow unnoticeably slipped into the verb, so you can 'friend' or 'unfriend' people you meet in cyber space. The meaning of the noun FRIEND has also changed because only a decade ago a 'friend' used to be a person you enjoyed talking to and spent time with, and now you actually do not need to like the person or even know them in cyber environment. Technology has also made additions to vocabulary in other areas, thus nouns like Google, Instagram, Tweeter derived verbs to google, to tweet, and they have become a part of common real world speech. Some new conventions have also been established, e.g. words in uppercase means 'the person is shouting' [8].

Additionally, social media speech tends to shorten the sentences, bringing us the portmanteau or word merge, thus we encounter words like BLAUDIENCE (blog+audience), MOCKUMENTARY (mock+documentary), STAYCATION (stay+vacation), FRENEMY (friend+enemy), COSTPLAY (costume+play) [9], etc.

### 3.2. The speech for defence

"Go back ten or fifteen years and you would have found endless articles about how our use of the internet, messenger and texting was ruining everyone's vocabulary and we would soon be able to speak in nothing but grunts and emojis" [10]: 'Texting is penmanship for illiterates' (Sunday Telegraph, July 11, 2004), 'The English language is being beaten up, civilization is in danger of

crumbling' (Observer, March 7, 2004); electronically-mediated communication is contagious, polluting traditional writing: '[T]he changes we see taking place today in the language will be a prelude to the dying use of good English' (Sun, April 24, 2001). However, distinguishing between language change and language decline is very tricky business since yesterday's change is often today's norm. We may simply need to wait long enough before an innovation stops being treated with opprobrium by language elites [6].

It cannot be denied that the greatest share of changes laid out above does not make an impression of a move forward in the quality of the language. None of the introductions of this new language shares the sophistication of style, complexity of the discourse and depth of thought. And it is exactly the reason why the questions on the quality of this new linguistic expression surfaces in debates among language professionals. However, a question needs to be put: Is the language of texting and instant messaging supposed to be the language of poetry or prose where the writing conventions are expected to be applied? Is it writing at all? Might it be that this novel language is not expected to have anything in common with writing? Would anyone expect to write a regular daily message to a close friend observing the rules of written conventions?

In his talk named 'Txtng is killing the language... JK!!!', the renown linguist John McWhorter refutes this statement – regardless of the possible misinterpretation on part of those not familiar with the language of texting, as JK in the abbreviation language reads: Just Kidding. McWhorter illustrates that texting is not writing at all. Writing comes along as a kind of artifice, a form with a complex structure, reflective, whereas speech is much looser, more telegraphic, lacking concern with rules [11]. In her book titled *Always on*, Naomi S. Baron extends this description of the written language observing that with writing, you are supposed to be on your best behavior, because someone could re-read what you had inscribed. Grammatical or orthographic errors might come back to haunt you. Electronically-mediated communication is written, though we tend to think of it as more like transient speech. Most messages we read and delete; like speech, they're gone [6]. And here is the point of agreement between the majority of linguists: Despite the fact that texting involves the brute mechanics of something that we *call* writing it is no more than fingered speech [11]. Whenever we need to convey information we tend to use as few words as possible. Regardless of the style, we do not bother to leave the impression of an eloquent person, but simply follow the linguistic pattern needed for the purpose which has nothing in

common with complexity. This is probably how abbreviations made their way into texting being unintentionally more or less subtly introduced. To sum up, texting is only a medium for sharing information in written form uttered in spoken language. And 'spoken language is inherently evanescent' [6]. Hence, is it sensible to conclude that something so ephemeral has the power to change the grand structure of the language corpus developed and modelled through centuries?

The obvious lack of favour of critics for the language of netspeak voiced in prejudices about the adverse impact of texting on young generation was the subject of study of the renown linguist, David Crystal who challenges these prejudices, or the so-called 'myths' about the regressive and degrading impact of texting on the English language. The myths proposed by 'language defenders' are as follows: 1) text messages are full of abbreviations 2) the abbreviations are newfangled by the youth of today, 3) abbreviations promote misspelling 4) abbreviations are common in students' tests and exams [12]. In his research on the accuracy of the myths above, Crystal reports that abbreviations account for only 10% of the entire language corpus used in texting, remarking that this phenomenon is hardly a new one. For the purpose of illustration, the Victorian fascination with language games was amazing; from Royal family down, people played language games: ICUR2WS4M (I see you are too wise for me) [12]. Victorians or people of any other era were not technologically supported for their own exploration of language. They would have probably been texting in the same fashion as we do today if only they had had what we do. Each time has its own frame, and technology is our frame. As for the third myth, Crystal points up that according to the studies performed, the best texters are always the best spellers – 'you need to know where letters are to leave them out' [12]. The final myth relies on very rare exceptions – students are perfectly aware what distinction is between the language of texting and the one they write in their tests and exams. Moreover, given the fact that young people do not use the language of texting in places where it is not expected, but write in an ordinary way, observing conventions of the written language, it is sensible to conclude that young people develop simultaneously bilingual and bidialectal writing skills and 'being bilingual is cognitively beneficial' [11]. Their capacity to adopt and utilize these writing concepts is the 'evidence of a balancing act, expansion of their linguistic repertoire' [11].

Finally, when defying myths of supposedly profound, dramatic and lasting impact of newly developed lexical forms in the language of texting and instant messaging, LOL and SLASH are among words that evolved as the part of new

language structure. Initially, in texting, LOL stood for Laughing Out Loud which both young people and adults used when they wanted to indicate laughing. SLASH (/) was commonly used for providing alternatives, e.g. *and/or*, or to show that something has two uses. In modern texting language, these words represent 'pragmatic particles' as linguists call them, i.e. LOL is a marker of empathy, accommodation, while SLASH is a marker of topic change [11]. Hence the only dramatic phenomenon about these two words, and undoubtedly a raft of others, is only the speed at which their meaning has changed over only a short period of time, let alone their long-term influence on such a magnificent structure of the English language. And this goes for a great number of words whose development on the internet could also be tracked and described in detail. However, it is not the subject of this paper.

### 3.3. 'You ain't seen nothing yet' [9]

The consensus exists as to the emergence of distinctive varieties of language closely related to the fast-pace evolving technology, the Internet in particular, however the future developments will certainly widen this scope of technological innovation which will multiply the impact not on language only, but on all segments of society. 'Many new technologies are anticipated, which will integrate the Internet with other communication situations, and these will provide the matrix within which further language varieties will develop [5].

As for the language yet to come, predicting the future depends on understanding the present. The majority of self-proclaimed 'experts' who argue that language is disintegrating have not considered the complexity of the factors inducing language change. They are giving voice to a purely emotional expression of their hopes and fears [3]. A closer look at language change has indicated that it is natural, inevitable and continuous, and involves interwoven sociolinguistic and psycholinguistic factors which cannot easily be disentangled from one another. There is no evidence that languages are moving in any particular direction from the point of view of language structure. It is always possible that language is developing in some mysterious fashion that linguists have not yet identified. Only time and further research will tell. There is much more to be discovered [3].

Although the application of the language of the Internet in the ELT environment has not been the subject of this paper, this topic, still in infancy, will doubtless find its niche in the realm of ELT in years to come. The language of instant communication media is certainly not applicable in either general ELT or academic contexts, however the fact that this novel, abbreviated language is used by the majority of non-native speakers of English suggests material for potential areas of

investigation of the 'netspeak' phenomenon, e.g. the extent to which English language learners are acquainted with the remarkable corpus of the language of instant messaging or their sensitivity to linguistic contrasts of standard language of tests and exams and non-standard language of instant communication media.

#### 4. CONCLUSION

Accelerating evolution of technology has had a marked impact on all varieties of the English language. By the rule which reads that technologically-induced changes inflicted on language are always met with apprehension by the community and often depicted as regressive and degradable, current language modifications and emergence of varieties of language have commonly been the subject of language debates. In their research of phenomena of modern Internet language forms, the leading language professionals have attempted to illustrate that changes the language is undergoing are often misinterpreted, stating that they are part of a natural process which is far from being damaging to the complex corpus of the English language.

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Technics and Informatics in Education**  
Faculty of Technical Sciences, Čačak, Serbia, 25-27<sup>th</sup> May 2018

# **Session 2: IT Education and Practice**

**Notes:**

# Cloud Services in Higher Education

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**Abstract:** *This paper presents analysis of using Cloud Services in an educational institution in Serbia, as well as some background information on the contemporary trends in Cloud Computing and Cloud Services. Cloud Services offer great possibilities for improvement of education processes in Serbia, especially bearing in mind lack of funds to properly equip computer classrooms with computer configurations required by modern desktop software. Also, collaboration in teaching and research is much easier with using Cloud Services than traditional desktop-oriented computing.*

**Keywords:** *cloud services, higher education; collaboration; integration; e-learning*

## 1. INTRODUCTION

The first idea of Cloud computing [1], [2], [3], [5] was introduced as a proposal for creating "intergalactic computer network" in 1960s by JCR Licklider, who later was one of the key people responsible for the development of Advanced Research Project Agency Network (ARPANET) in 1969, the precursor to the modern Internet. This proposal promoted the idea of all people on Earth being interconnected by using computers and accessing information everywhere. In 1963 MIT developed technology for Project MAC, proposed by the Defence Advanced Research Projects Agency (DARPA), which required that two or more people can use one computer simultaneously. The word *virtualization* was used to describe this situation and the computer that was used acted as a primitive cloud service [1], [4]. During 1970s the term virtualization described creation of virtual machines that act as real computers with fully functional operating system. This concept has evolved with the Internet, firstly as some companies began to offer *virtual private networks* as a rentable service.

During the 1990s cloud services became more popular as companies understood better the use and usefulness of such services. In 1997 Professor Ramnath Chellapa of Emory University defined *Cloud Computing* as the new "computer paradigm, where boundaries of computing will be determined by economic rationale, rather than technical limits alone". From today's point of view, this couldn't be more true [4].

*Salesforce* became one of the first examples of successful use of Cloud Computing in 1999, offering purchase and download of software by anyone with Internet access. This provided cost-effective way for businesses to buy software without leaving the office.

During the early 2000s Amazon introduced its web-based retail services [6]. They had enough server capacity to accommodate peak number of visitors and buyers during days like Christmas, Thanksgiving Day, etc. But, for the remaining time of the year, only 10% of their capacity was used. Amazon was the first major company to think of solving this 10% usage as a problem, while at that time it was considered normal and acceptable to any business to use only 10% of their server capacity on average [6].

Amazon Web Services appeared in 2006 as online services available to other websites and clients, while Amazon Mechanical Turk provided various cloud-based services to their clients, like storage, computation and human intelligence. The most prominent Amazon cloud-based service was Elastic Compute Cloud (EC2), which allowed others to rent virtual computers and used their own software on those virtual machines [7].

IBM, Google and several universities joined forces in 2007 to develop a server farm for research projects that needed high CPU power and huge data sets. The first university to join the project was the University of Washington, followed by the University of California at Berkeley, MIT, Stanford University, Carnegie Mellon University and the University of Maryland [5].

The same year Netflix launched streaming video service based on Cloud, while Eucalyptus was the first to offer AWS API compatible platform to distribute private Clouds in 2008. At the same time, NASA started OpenNebula, the first open-source project for deploying private and Hybrid Clouds [5].

In 2011 IBM introduced IBM SmartCloud framework, Apple launched iCloud, and Microsoft began to advertise the Cloud on television.

In 2012, Oracle introduced Oracle Cloud, offering three different *aromas* of Cloud Services: IaaS (Infrastructure-as-a-Service), PaaS (Platform-as-a-Service) and SaaS (Software-as-a-Service) [8].

**2. BACKGROUND**

Contemporary trend in business is to use Cloud Services for more reasons, just a few of them being the lower costs of IT departments, faster adaptation to new requirements and technologies and more options for integration of processes and sharing of data between different departments [4].

Although some software companies invested lots of effort to make potential and existing customers to use their *on-premise* software (which is installed on the user’s computer or local server), the last 10 years saw the opposite situation, the same companies trying to persuade users and business clients to move to their Cloud Services.

On the other side, the development of Internet redefined the way people learn, collaborate and exchange knowledge, while at the same time, educational institutions are making efforts to adopt new teaching and learning methods supported by the latest IT advancements [9]. While in the developed countries universities, both government and non-government, put much effort into providing their students and staff with the latest technologies, universities in Serbia lack not only funding, but also staff with enough knowledge and experience to introduce such technologies.

The concept of Cloud Services usually depends on the needs of users and the level of control they have (Figure 1).

Traditional systems provide the user with full

control over hardware (computers, servers, network equipment, etc.) and software (Operating System, applications), since the user have full physical and software access.

The next level in Cloud hierarchy is Software-as-a-Service (SaaS), like Google Apps, Microsoft Office 365, Cisco WebEx, etc. This is the most common kind of Cloud Services, representing the largest Cloud market, where everything is managed by service provider, while users only have access to the applications by using the web browser. Some applications may also require a plugin for browser to be installed.

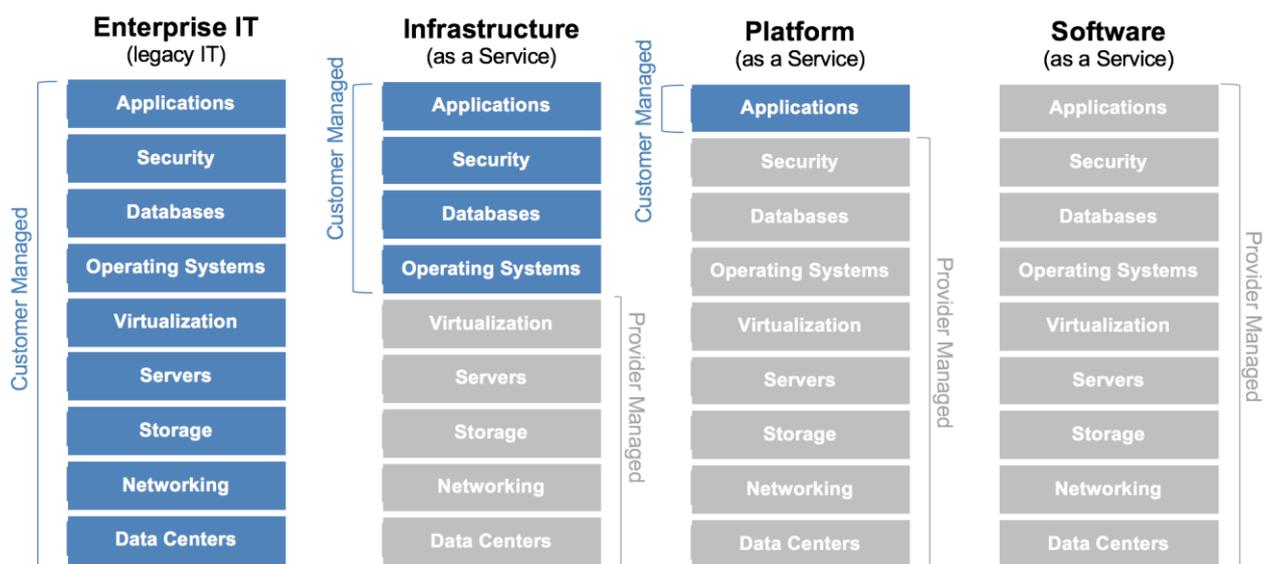
Platform-as-a-Service (PaaS) is a kind of Cloud service where clients manage only applications (e.g., develop and deploy or just customize existing applications). By using this kind of Cloud services, developing, testing and deployment of applications is quick and simple, as well as cost-effective.

Infrastructure-as-a-Service (IaaS) gives users additional control over operating system and related software functions, like databases.

Latest addition to this scheme is Enterprise IT (or legacy IT), where users manage everything, from data center to applications. This is practically a kind of Private Cloud, where users don’t share any hardware with other Cloud users, e.g., they have dedicated servers within data center for their storage and processing power. Examples of IaaS are Amazon Web Services (AWS), Microsoft Azure, Google Compute Engine (GCE), etc.

**3. CLOUD SERVICES IN EDUCATION**

In the last 10 years Cloud Computing saw tremendous expansion and development, offering



**Figure 1.** Cloud Service provider and Customer roles for different levels of Cloud Services. Image source: [The Enterprise Cloud Blog](#).

wide range of different services and integrations of services for the purpose of various businesses, research and education [5].

Cloud-based services can provide teachers and students with opportunity to improve the process of teaching, collaboration, communication, creating and sharing new course materials, as well as better coordination and team work on research and student projects [21].

When educational institutions apply to the Cloud services providers, they are given a tenant account, which is managed by a member of the institution with proficient knowledge and experience in administration of Cloud-based services. Then, this person can create accounts for other institution staff and students, and provide some of them with certain administration-level rights, so that they can create accounts for other staff and students and manage certain resources (e.g. creating new groups, subject pages, etc.) and providing access to them for other users.

The first universities to use Cloud services were, as expected, in USA, which is not a surprise due to the fact that the first global Cloud services providers are companies from USA, which also donate substantial resources to universities. Nowadays, even the most conservative countries have adopted Cloud services in education [22].

In Serbia, these trends are yet to become popular in educational institutions, especially in primary and schools, where the lack of properly equipped computer classrooms is more than evident due to economic situation. Academic institutions are in a better position, not only thanks to the joint projects with universities from EU countries financed by EU academic and education projects, through which advanced computer equipment can be obtained, but also due to the larger sums in their yearly budgets intended for computer equipment and software.

Present situation in Serbia is that most of users in education still dominantly use desktop-oriented applications, and in most cases little care is given to the data security and safety. Also, Learning Management Systems (LMS) are used on local servers, although Cloud hosted LMS would prove to be convenient [11].

Besides the use of LMS for providing course materials to the students, universities in Serbia have agreements with global software companies to provide free student versions of commercial software packages for their students (e.g. Microsoft DreamSpark/Imagine, Oracle Academy, etc.), with both Standard and Premium options, depending on the faculty needs and service provider [19].

While higher education institutions in developed countries are moving to open courses (MIT Open Courseware – OCW, Massive Open Online Courses

- MOOC, Free EdX courses, etc.) and using Cloud services to lower the cost of IT departments, universities in Serbia are still a bit slow to embrace such new trends.

During the last few years, since some global software companies began to offer Cloud services for free of charge to educational institutions [20], but only a few institutions in Serbia adopted this as an opportunity to offer the latest technologies to their students and staff.

At present, all educational institutions are eligible to offer educational services provided by global software companies, like Microsoft (Office 365 Education), Google (Google for Education), Apple (Apple for Education), Amazon (Amazon Education) free of charge to their students and staff. Also, these companies offer some advanced services to educational institutions for a small fee per month per user.

A few faculties in Serbia have already adopted the use of Cloud Services and their experience may be of great use for others to follow the same path.

Two of these institutions, Faculty of Sciences in Kragujevac and Faculty of Technical Sciences in Čačak (FTN), both members of the University of Kragujevac, were among the first academic institutions in Serbia to adopt the use of Cloud services. Thus, we can say that the University of Kragujevac is not much behind the top world universities in using the latest computer and IT technologies in the process of education.

At FTN Čačak the importance of using all the advantages of the latest IT technologies is of great importance due to the three important graduate and postgraduate study programs:

- Professor of Technics and Informatics
- Information Technologies
- Computer Engineering

For future Professors of Technics and Informatics knowledge and experience with the latest IT technologies is important due to the fact that they will teach informatics at primary and secondary schools, thus, providing future students with better knowledge of technologies that even today is dominant choice for not only advanced users, but also for companies involved in the processes of software development, testing and deployment.

Future Information Technologies and Computer Engineering graduates will be more competitive on the job market if they possess good knowledge of Cloud computing concepts, whether from the point of development, testing and deployment of apps for Cloud-based services, or from the point of using Cloud services for research and cooperation with other developers or researchers.

#### 4. CLOUD SERVICE IN EDUCATION AT FTN

In this section we give a case study of using Cloud services at Faculty of Technical Sciences in Čačak (FTN), University of Kragujevac. FTN is a registered tenant of Microsoft Cloud Service [14]. Microsoft Cloud services consist of Microsoft Office 365 applications and Microsoft Azure. More details on Microsoft Cloud Services and Platform Options can be seen in [15], as well as other technical documentation related to Microsoft Cloud services [16]. As a matter of fact, Office 365 is SaaS that uses Azure Active Directory to manage users and Identity Management.

##### 4.1. Microsoft Office 365 Education (A1 plan)

Office 365 A1 plan include "Completely free online version of Office with email, video conferencing, voicemail integration, customized hub for class teamwork with Microsoft Teams, compliance tools, and information protection" [12]. This plan does not include off-line version of Microsoft Office applications (Word, Excel, PowerPoint, etc.).

If only a few users require non-free Education plans (A3 or A5), faculty can provide only their accounts with one of A3 or A5 plans for insignificant price per user per month, which is an affordable solution to provide just a few staff with needed services that are beyond A1 plan, which, besides other options, include off-line version of some Office 365 apps, like Word, Excel and PowerPoint. In this paper we show only a case study of using A1 plan, which is completely free of charge.

In Microsoft Office 365 Education A1 plan each user is provided with Web versions of Word, PowerPoint, Excel, OneNote, and Outlook apps, Desktop version of OneNote, Microsoft Teams – "a digital hub that integrates the conversations, content, and apps your school needs to be more collaborative and engage" [12] – Class and Staff notebooks, Self-grading quizzes with Forms app, Digital storytelling with Sway, Compliance solutions with a unified eDiscovery center, Rights management, data loss prevention and encryption, Enterprise video service for creating, managing, and sharing videos securely across an organization, e-mail with 50 GB box, 1 TB of space on OneDrive, video conferencing in HD quality, etc.

The maximum number of users is not limited, so, in effect, it is possible to create accounts for all faculty students and staff for free of charge, each user having 50 GB e-mail box and 1 TB of storage on One Drive. This means that all communication and correspondence, as well as sharing of course and other materials between teachers, students and administration staff, would hardly hit any storage limit problems, which often is the case with classical use of computers, not to mention problems with security and safety of data.

Microsoft is responsible for backup and safety of all data, as well as security in compliance with requirements specified in ISO 27001, European Union (EU) Model Clauses, the Health Insurance Portability and Accountability Act Business Associate Agreement (HIPAA BAA), and the Federal Information Security Management Act (FISMA) [13]. Microsoft was the first cloud provider to adhere to the ISO/IEC 27018 code of practice, which covers privacy protection for the processing of personal information by cloud service providers. Also, Office 365 obtained some national or regional certificates from certain countries and regional organizations, e.g., UK G-Cloud and ENISA IAF (The European Network and Information Security Agency Information Assurance Framework).

Office 365 Education A1 plan service is available to all faculty staff and students at FTN Čačak [14] free of charge. Teachers can be provided with administration account (Figure 2) with more options to create and control resources, e.g. creating new Outlook groups, Sharepoint pages, Yammer groups, etc. Besides personal details, users can add other contact information, like phone number and private e-mail address, which can be used for sign-in with 2-step verification or password reset [21].

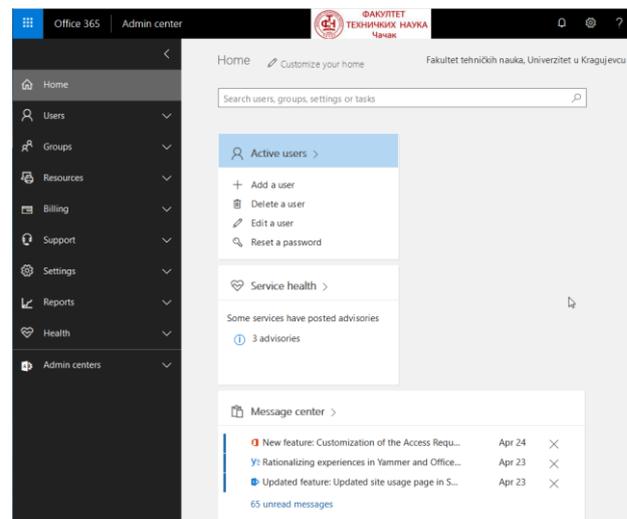


Figure 2. Admin center in Office 365

##### 4.2. Microsoft Office 365 apps

The most used Office 365 application is Outlook (Figure 3), with 50 GB e-mail box and options for advanced management of e-mail communication by using Outlook groups (Figure 4), creating categories or dedicated folders and rules for managing large quantities of e-mails, etc. Outlook also provides Calendar (Figure 5) for creating, changing, deleting and sharing calendar events, and also importing events from other calendars.

Here we mention a few other Office 365 apps, which can be of great use in improving the process of teaching, communication, collaboration,

management of student projects, research and other processes in higher education.

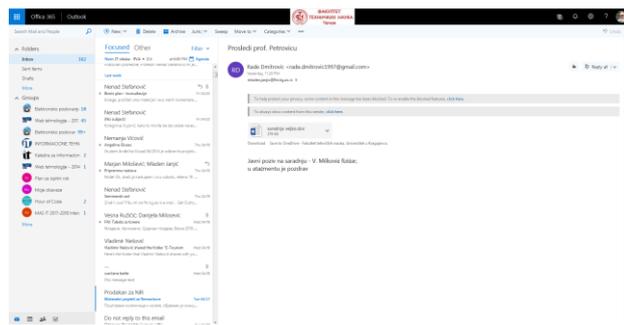


Figure 3. Office 365 Outlook

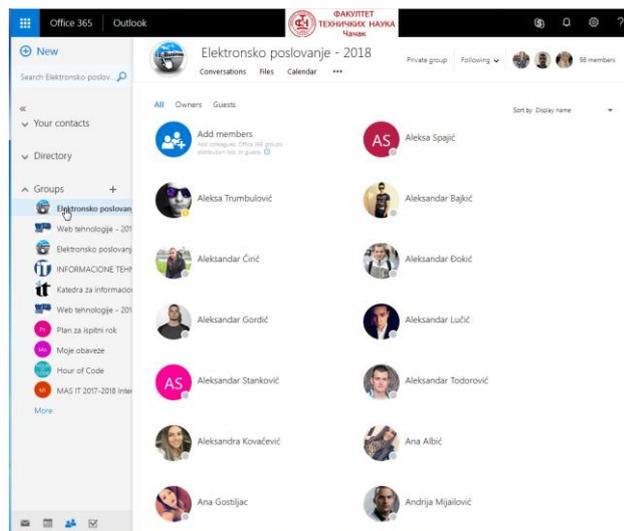


Figure 4. Office 365 Outlook groups

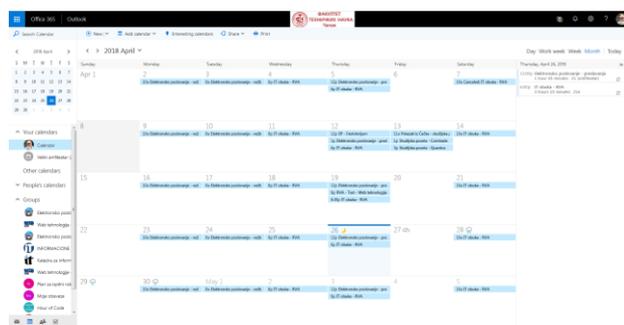


Figure 5. Office 365 Calendar

Teachers can manage preparation and sharing of teaching material with less effort, access and edit all material from any location on-line by using computer or smartphone, manage communication with students and colleagues and benefit from integration with other services used in education (Moodle plugins for Single-Sign-On and OneNote, possibility of integration with Student office information system by using appropriate APIs or custom-developed plugins, etc.).

All apps are available from the Office 365 home page (Figure 6), which is shown to the user by default after successful sign-in. This, as well as many other features, can be customized to the user needs, e.g., user can change the start page

to open any other Office 365 app instead of the home page. For example, user might want Outlook app to be opened after successful sign-in.

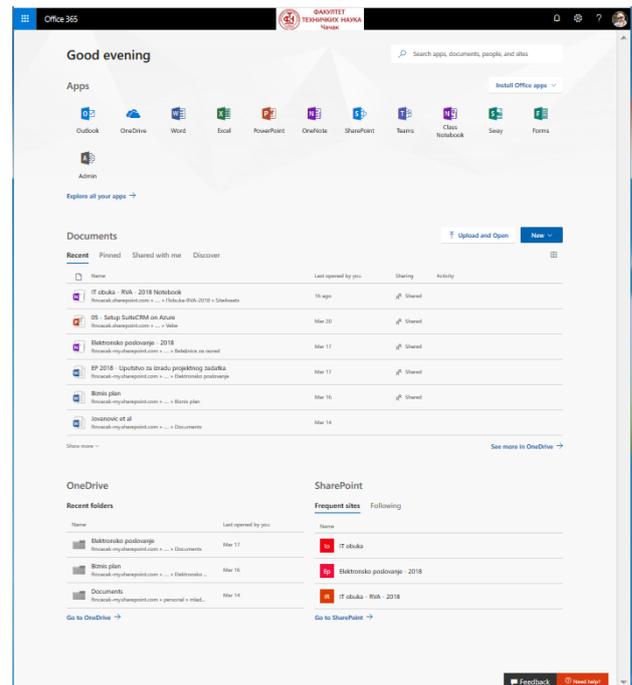


Figure 6. Office 365 home page

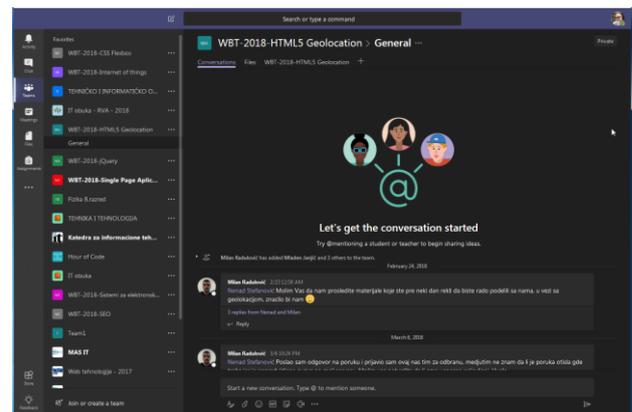


Figure 7. Office 365 Teams

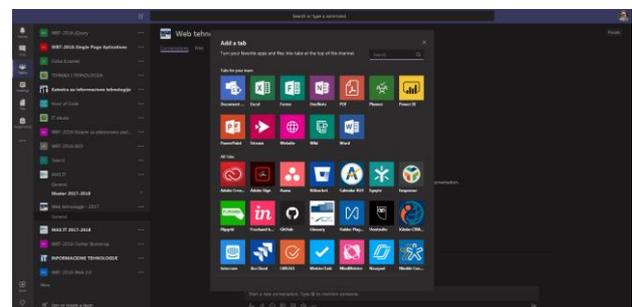


Figure 8. Teams "Add a tab" screen

Teams (Figure 7) is "hub for teamwork", an app that provides a place for cooperation on certain subject, be it a university course for student or a research project, or any other type of team activity at educational institution that can benefit from the use of on-line meetings, live streaming, conference calls. Besides all built-in features,

Teams offer an option to add tabs with other Office 365 features and apps (Figure 8), like Assignments, OneNote, etc.

Office 365 also integrates Business Social Network, known as Yammer (Figure 9), which can be used in education for chat, private and group messaging and sending important information to users in certain groups or everyone within institution. These messages and other posted content is also sent to users' emails and shown on users' mobile version of the app.

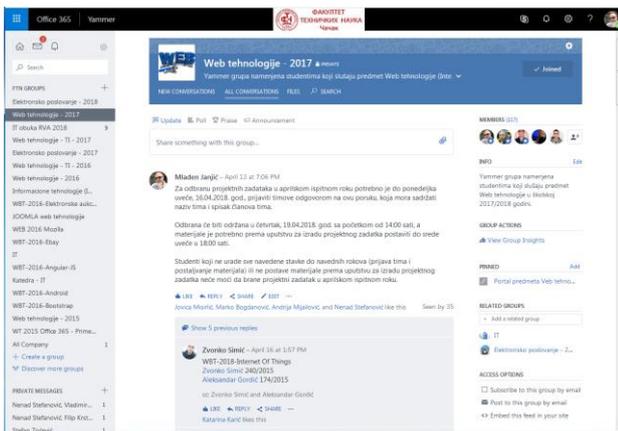


Figure 9. Office 365 Social Network app

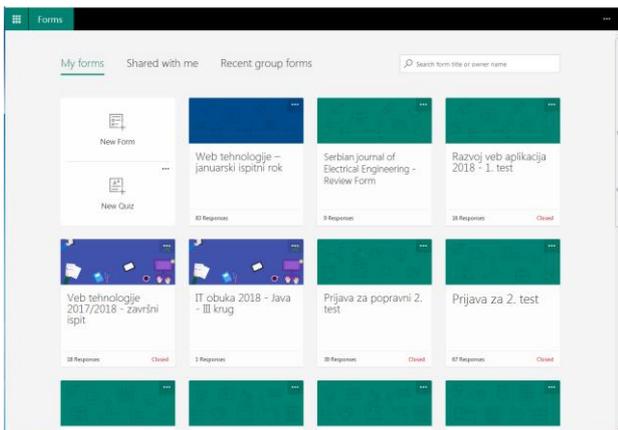


Figure 10. Office 365 Forms app

Forms, shown in Figure 10, is another very useful Office 365 app, which provides one place for creating and sharing of forms and quizzes. Making a new quiz for students is easy even for users with moderate knowledge of using computers, correct answers can be marked, which is very useful with "Show results automatically" option, which shows the result of the quiz to the user after submission. Also, Forms is supported by "Take a Test app", which can lock student computers so that nothing else can be done on the computers before the Forms quiz is submitted.

Class Notebook is OneNote for teachers, with separate personal workspace for each student, a content library for handouts and a collaboration space for lesson material and other activities related to the class.

Other useful Office 365 apps include Delve, app to "discover and organize the information that's likely to be most interesting to the user now – across Office 365", Stream for uploading and sharing videos, Tasks for managing tasks and to-do events, and many other tools to connect more services and exchange information between them.

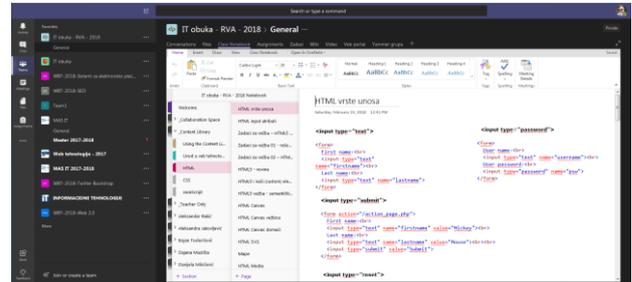


Figure 11. An example of Class Notebook integrated with Teams service.

Class Notebook [18] is (officially OneNote Class Notebook) is special kind of OneNote service that have a personal workspace for each student, a content library for handouts and collaboration space for lessons and creative activities.

Microsoft OneNote also supports integration with numerous LMS by using Learning Tools Interoperability (LTI) standard, to name a few: Blackboard, Brightspace, Canvas, Haiku Learning, LoveMySchool, Moodle, Sakai, School Bytes, Schoology, etc. Students enrolled in LMS, e.g. Moodle, can access the notebook automatically without having to add their names. This provide teachers and students using LMS with possibility to try OneNote as a service integrated into their LMS, with an option to include some services not available in LMS in their workflow, e.g., e-mail service, business social network, Sharepoint pages, OneDrive storage, etc.

#### 4.3. Benefits from using Office 365 at FTN

One of the main problems with communication with students at FTN is their use of private e-mail addresses in official communication with teachers and for registering at student services. One solution is to provide students with FTN e-mail server accounts, which would require space for storage and backup.

The other problem for FTN staff, both teachers and administration, is in keeping of emails on their work computers, without any measures applied for data security and safety (e.g., limiting access, employing backup, etc.). Any solution of these problems require substantial financial investment into hardware (additional servers and storage), software and training of staff.

With the use of Office 365 e-mail service (Outlook online), each FTN employee and student get 50GB of space for e-mail box, as well as 1TB of storage on OneDrive, which can be used for storing documents and sending larger e-mail attachments.

#### 4.3.1. Comparison of Cloud and on-premise FTN e-mail accounts

Suppose that FTN provides its staff and students with e-mail accounts on local e-mail server. The current e-mail box size is limited to 200MB, which means that around 120 accounts (teaching staff and administration) require only 24GB of server space. Obviously, this is not an issue, and one 300GB server hard drive for the system and mail boxes would suffice, with an additional one for backup, which, according to the current prices is between 200€ and 300€, depending on the model. If backup of all documents created and used by teachers and administrations is required, probably terabytes of hard drive space is needed, but let us limit to mail server storage.

If FTN decides to provide students with e-mail accounts on local mail server, that decision would, consequently, bring two problems:

- Mail server storage problem;
- Accessing e-mail by different devices;

The first problem is obvious – if each student is granted with 200MB of mail box, for around 1500 students that would mean around 300GB of storage plus 300GB more for backup. That is another 200€ to 300€. Seems not to be an issue.

The second problem is directly related to the first problem. The first problem can be solved in the mentioned way, by providing students with 200MB mail boxes, but that would discourage students to use FTN e-mails for official communication with teachers, since they would have problems with exceeding e-mail box limit too often. Not to mention that students still wouldn't have a way of sending or receiving larger e-mail attachments, but would have to use services like WeeTransfer. Also, accessing e-mail accounts from different devices (e.g., home computer, laptop, phone) would still be a problem, as currently Faculty staff can access their e-mail boxes by using Round Cube web service, but if they don't delete older e-mails regularly, the mail box limit might be exceeded.

Since we cannot expect students to download their e-mails to all devices they use for checking for new e-mails, it is obvious that a Cloud e-mail service with appropriate storage for mail boxes would solve the problem. That would mean at least a few GBs of space for each student's mail box, meaning, a few TBs of drives for e-mails and backup.

The other solution is to use Microsoft Office 365 for Education, for which FTN is already a tenant. That means 50GB of mailbox storage for each FTN teacher, administration and student. This solution is not just very cost-effective, but also helps in improving the user experience and quality of e-mail messaging. Also, FTN staff and students are not provided with free version of basic Office

applications (Word, Excel, PowerPoint) with Microsoft Imagine accounts. Office 365 Education offers free online versions to all users (A1), with an option to obtain A3 or A5 licenses with offline versions for up to 5 devices per user for as little as 3.25\$ (A3) or 8\$ (A5) per user per month. This means that a user with higher-demanding work can get full Office 365 offline for less than 40\$ per year. Student licenses cost even less, 2.50\$ for A3 and 6\$ for A5, which can be used for students who also work as teaching fellows. This is way less than having to pay around 400\$ for Microsoft Office Professional 2016 for each user. Even if the Office would be renewed only after 10 years, there is much additional cost involved in local storage and administration.

This solution has the following advantages:

- 50GB of e-mail box free of charge;
- E-mail attachments up to 150MB, with an option to limit certain users or groups of users to a lower limit;
- Accessing e-mails from all supported devices (desktop and laptop computers, tablets, phones, Outlook app for most popular desktop and mobile operating systems);
- 1TB of space on OneDrive, which can be also used for larger e-mail attachments, accessible with Single-Sign-On (SSO).
- Large e-mail attachments are automatically put on OneDrive and attached as links.
- Automatic backup of data provided by Microsoft Office 365 services.

**Table 1.** Cost comparison of providing FTN staff and students with on-premise and Office 365 services

Service	On premise (on-time fee)	Office 365 (per year)
Mail box 200 MB	200 - 300 €	0
Mail box 500 MB	300 - 750 €	0
Mail box 1 GB	2000 - 3000 €	0
Mail box 50 GB	/	0
Cloud storage 1 TB	/	0
Online Office apps: Word, Excel, PowerPoint (per user)	/	0
Mobile apps for Outlook, Word, Excel, PowerPoint, Yammer, Teams	/	0
Offline Office apps: Word, Excel, PowerPoint (per user)	399.99\$	39\$ (A3) 96\$ (A5)

## 5. CONCLUSION

On the basis of presented facts and current situation with the use of on-premise Office applications and e-mail servers, it is obvious that educational institutions should embrace the given

opportunity of using Cloud services for free and use them to provide better knowledge and experience for future graduates, thus, making them more competitive on the employment market.

Office 365 Education, with its Classroom app, make virtual classroom system (or LMS 3.0), but additionally with the integrated word processing, spreadsheet, slideshow presentation and cloud storage. Practically, teachers are provided a suite of online tools for easier working with students and colleagues than with classical LMS, or with an option to combine the two worlds as needed for each of the courses.

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# Shifting Education to Cloud: A Reference to Maritime Studies

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**Abstract:** *The basic hypothesis posed in this paper is that in the future education and professional training will be increasingly blended into the Cloud domain. The reasons are above all of the economic nature. They are reflected in space, time, teaching and administrative staff savings, since the education is mostly treated as a cost, and less frequent as an investment. This applies more and more to the developed parts of the world, and especially to those who are conditionally in development or in transition. In support of this hypothesis in the paper we have provided some useful examples of how off- and on-line computer assisted video tutorials from sea-navigation can be used in Cloud based education and training for (future) seafarers at maritime studies departments.*

**Keywords:** *Cloud; education and training; seafarers*

## 1. INTRODUCTION

Cloud can be described as a set of clusters of distributed computers with farms of servers, as enormous centers for data collection and processing, which provide resources and services via network medium, or Internet. Customers had deployed applications installed on their own (physical) computers or company (local) servers in the past, while today these applications are mostly moved to Cloud. For instance, when users check their g-mail account, bank account status, or update their Facebook status - they are in Cloud.

The question is: Why is such a large number of activities, including education moved into Cloud? – The literature sources say that this is in order to increase the flexibility and scalability of the users needs, to free the users of capital investments in infrastructure and software, to allow them "pay as you go" services, as well as automatic software updates, increasing the possibilities of collaboration, the ability to access resources from any place, more efficient group work on the same projects, increasing competitiveness [1], etc.

In fact, we are all faced with an expansive and less controllable growth of technical forms of material culture, which we are in a certain way forced to adopt. It is a kind of imperative of the new digital era. When it comes to the education in this context, it is to be said that the education is mostly treated as an expense, rather than an investment (and not only in developing countries, but also in developed ones). So, this is one of the additional reasons for moving, shifting or blended education into Cloud.

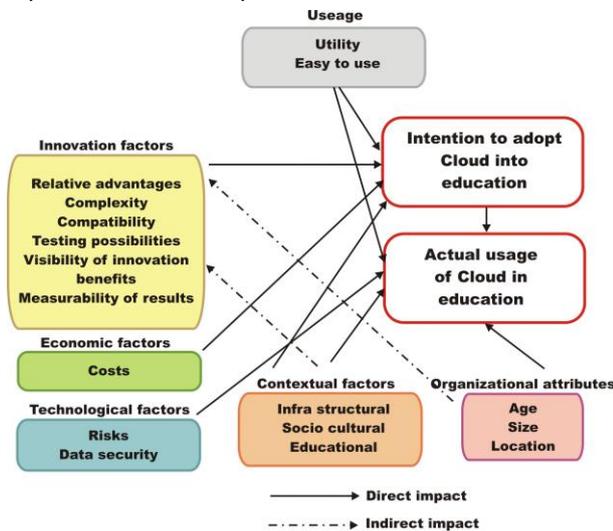
If we start off with the assumption that the increase in the adoption of Cloud services will be present in the field of education (especially higher, lifelong one, including professional trainings) in developed countries, indisputably, new opportunities in this domain will arise for developing countries, as well. For these countries, small capital investments and flexibility in the use of resources are of particular importance. By opening Cloud capabilities, developing countries should be able to use the same infrastructure and resources as technologically highly developed countries [2].

## 2. THE MODEL FOR ADOPTING CLOUD

There is a scarcity of literature resources and little preliminary research on the adaptation of Cloud sources in education and training, in so-called developing countries. The model proposed in [3] has been inspired by a study which had been carried out in sub-Saharan Africa [4]. This model represents the basis for designing a questionnaire, by means of which the readiness of the high education institutions in the developing country (Montenegro) to implement this type of education could be analyzed. The model is based on triangulation (reconciliation) of three theories of adoption and expansion of ICTs: theory of a technologically acceptable model [5], theory of diffusion of innovations [6], and theory of intelligent ICT user [7,8].

The model proposed includes one *dependent* variable: intention to adopt Cloud into education and professional training. The *independent* variables in the model are organized in several

subgroups: innovative, economic, technical, contextual and organizational factors or attributes. The last, but not the least, is the independent variable: actual use of Cloud in high education. In Figure 1, direct and indirect links between dependent and independent variables are shown.



**Figure 1.** Adopting Cloud educational model in a developing environment (Source: Adapted from [3])

The main hypothesis on which the model is based, are as follows:

*h1:* Innovation factors are in positive correlation with tendency of introducing Cloud computing into higher education;

*h2:* Economic factors (costs and unpredictable return of investments) are in negative correlation with the introduction of Cloud;

*h3:* Technological factors (data security, system flexibility and scalability) are positively correlated with adaptation of Cloud computing in this domain;

*h4:* Technological factor related to obsolescence risks, on the other side, is negatively correlated with the introduction of Cloud;

*h5:* Simplicity of use, easy to create new content, and self-evaluation possibilities are positively correlated with the adoption of Cloud;

*h6:* The availability of ICT infrastructure, developed socio-cultural and educational factors are positively correlated with the introduction of this new concept into education;

*h7:* The age of the user is in a negative correlation with the Cloud adaptation. In other words, young people are usually pro innovation unlike elderly generation;

*h8:* The size of organization is in positive correlation with the adoption, i.e., a larger higher education organization will easily adopt the Cloud;

*h9:* Organizational culture is in positive correlation with the adoption;

*h10:* The level of actual using of the Cloud in educational purposes is in positive correlation with its future more extensive use.

The proposed model and afore given hypotheses are to show, to what extent considered factors influences the intent to adopt Cloud services in transfer of knowledge, with emphasize to the developing environment.

### 3. THE SURVEY AND OBTAINED RESULTS

The survey based on the above presented model has been realized by designing and delivering the questionnaires to the selected students, which have above average marks and high level of logical thinking at the Maritime Faculty Kotor (University of Montenegro). In total, 40 students at both Maritime Studies (academic level) and Nautical (applied level) departments have been interviewed. Preliminary version of the questionnaire has been sent to the experts so that they could give their recommendations, and by doing so, improve clarity and avoid ambiguity of the questions. The respondents use a five-point Likert type scale (range: 1-strongly disagree to 5-strongly agree) in answering the questions, which were created in accordance with afore set hypothesis. Then, the SPSS-Statistical Package for Social Science (ver.17) has been used in analysis of the responds [9,10]. The responds show statistically relevant positive or negative correlations between dependent and independent variables in the model (Table 1).

**Table 1.** Strong correlations between dependent and independent variables in the model

Correlations in the overall sample (N=40)	
Ind. Var. / Dep. Var.	Adopting Cloud
Actual use of Cloud	0.759**
Younger users	0.694**
Easy to use	0.648**
Data security	0.633**
Organizational culture	0.582**
Innovative factors	0.476**
Small organization	-0.602**
Technology obsolesce risk	-0.570**
Unpredictable return of investments	-0.483**

#Pearson: \*\*Correlation is significant at the 0.01 level#

Consequently, in accordance to the conducted statistical analysis through the pilot study realized at the Maritime Faculty Kotor (University of Montenegro), in the summer semester of the past academic year, the following might be concluded:

(a) There is strong **positive** correlation between dependent variable *intention to adopt Cloud*

services in higher education, and the following independent variables:

- Actual use of Cloud services;
- Organizational attribute: younger users;
- Usage factors: easy to use, easy to create new content and self-evaluation possibilities;
- Technical factor: data security;
- Organizational attribute: organizational culture;
- Innovation factors: compatibility with previous systems, advantages in comparison to previous systems and measurability of achieved results.

(b) There is strong **negative** correlation between the dependent variable *intention to adopt Cloud services* in higher education, and the following independent variables:

- Organizational attribute: small organization;
- Technological factor: technology obsolescence risk;
- Economic factor: unpredictable return of investments.

Though, it becomes clear that there is a strong positive correlation between dependent variable *intention to adopt Cloud* into education and independent variables: innovation, technical (data security), usage, organizational (organizational size-big and organizational culture) attributes, and actual usage of Cloud. Further, there is positive correlation between *intention to adopt Cloud* and system flexibility, scalability, and contextual factors. This confirms the hypothesis: h1, h3, h5, h6, h8, h9 and h10. On the other side, the dependent variable *intention to adopt Cloud* is in negative correlation with the independent variables: economic (unpredictable return of investments), technical (technology obsolescence risks), and organizational (older users) attributes. This is in accordance to the hypothesis: h2, h4 and h7. Some more detail can be found in [3].

#### 4. TOWARDS ADOPTING CLOUD

Some of the teachers at Maritime Faculty Kotor use multimedia-instructional materials, which support the previously assessed constructs in the model: the users (learners) are mostly young people, i.e., students, the materials are easy to use, they allow students' self-evaluation and cherish organizational and innovative culture at the Faculty. In this regard, below shall be briefly described three off- and one on-line computer assisted instructional resource(s) used in teaching and learning processes at Maritime Faculty. The off-line ones are Seagull products and the on-line one is produced by the cap. Marina Martic. Usages of such instructional materials lead us smoothly towards upcoming shifting of education into Cloud realm.

##### 4.1. The RADAR multimedia materials

These Seagull's video materials include the following topics:

- Fundamental theory;
- Setting up RADAR display;
- Marine RADAR performance specification;
- Plotting;
- The use of RADAR in navigation;
- RADAR and COLREG.

The multimedia off-line instructional materials on RADAR provide self-evaluation tools after each sub-section, which allow the students to self-assess the acquired knowledge. Figures 2 and 3 show plotting basis in terms of target aspect - its R (red-portside) and G (green-starboard) side, and target aspect in relation to the own vessel. The speaker's narration follows these slides.

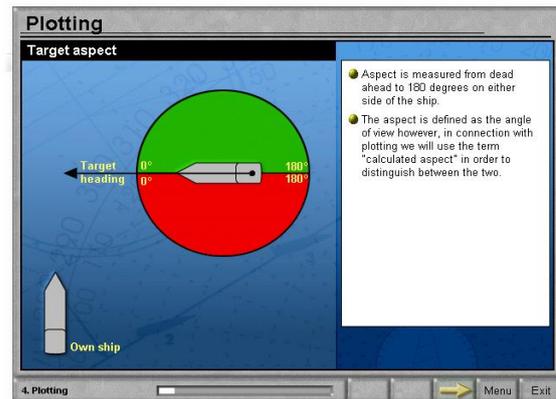


Figure 2. Plotting: Target aspect and its R and G side (Source: Seagull)

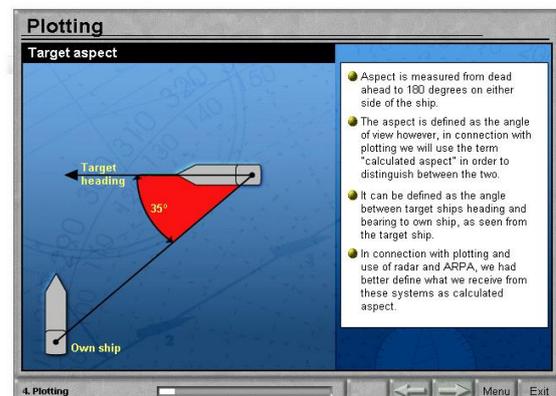


Figure 3. Plotting: Target aspect in relation to the own ship (Source: Seagull)

##### 4.2. The ARPA multimedia materials

This instructional material covers the following topics:

- Review of plotting;
- Principal ARPA systems;
- IMO performance standards;
- Theory of ARPA tracking systems;
- Setting up and maintaining displays;
- Risks of over-reliance on ARPA;
- Standard ARPA system;
- Application of COLREG.

Figures 4 and 5 are extracted as the illustration from these video tutorials and they are all followed by the narrator's talk, i.e., by the appropriate descriptions.

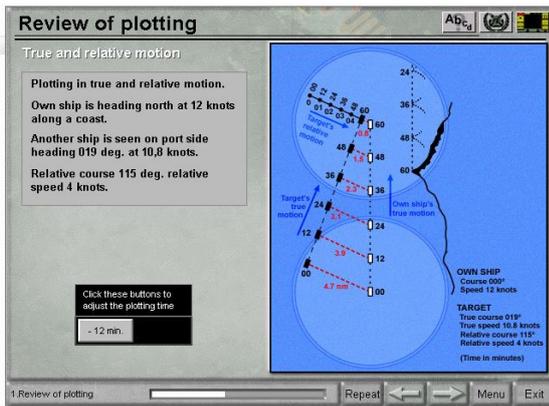


Figure 4. Relative and true motion plotting simulation (Source: Seagull)

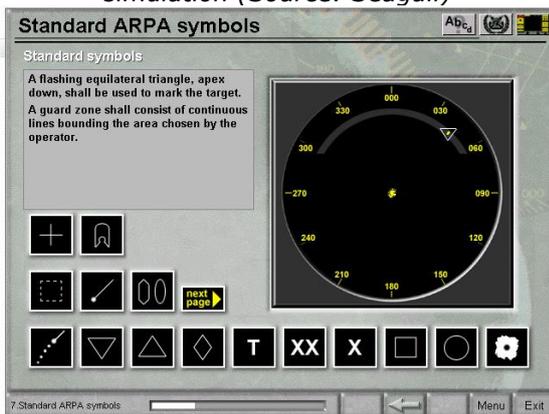


Figure 5. Palette of standard ARPA symbols (Source: Seagull)

4.3. The COLREG multimedia materials

These COLREG multimedia aids help understanding the topics:

- General;
- Lights shapes and sound signals;
- Vessels in any visibility;
- Conduct of vessels;
- Distress signals;
- Cases: 1, 2, and 3.

This module also includes self-assessment section. Figures 6 and 7 illustrate: how to avoid collision in the last minute and validation of the rule of the road, respectively.

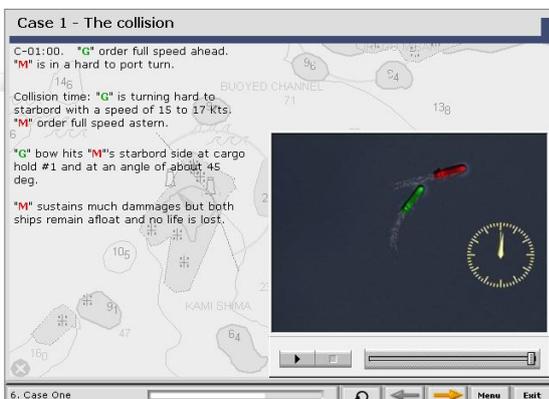


Figure 6. Avoiding collision in the last minute (Source: Seagull)

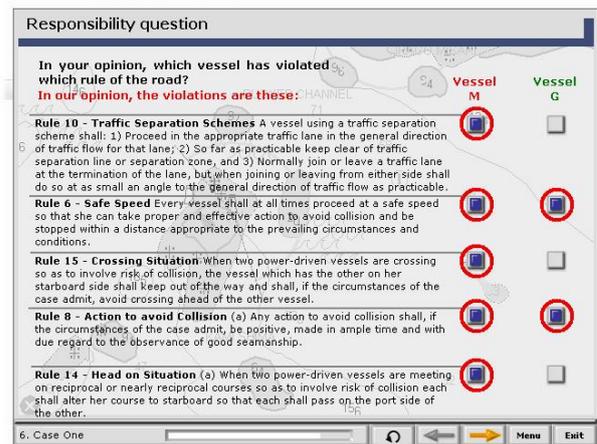


Figure 7. The rule of the road – An exercise (Source: Seagull)

5. 4.4. The Web multimedia materials

These materials are created by cap. Marina Martić and available at the web (URL: <http://www.marinapomorac.com/>; last access on 1<sup>st</sup> May, 2018). These tutorials are very comprehensive and contain textual, audio and video records on astronomical, terrestrial and electronic navigation, including maritime meteorology and safety communications. Cap. Marina Martić has rich experience as a navigator and as a trainer, as well. Therefore these materials should be recommended at maritime education and training institutions and centers within Serbo-Croatian speaking community. Besides, the students can use these materials when they are at home or at sea. This is an additional positive dimension or asset in comparison to previously shortly presented off-line multimedia instructional RADAR, ARPA and COLREG materials, which are in possession of the teachers.

6. CONCLUSION

The paper points out the trend of shifting education and professional training into Cloud. The model for adopting Cloud in education in the developing environment at the exemplar of Maritime Faculty Kotor (University of Montenegro) is proposed. The survey has been conducted among the students of afore mentioned Faculty, which identified the proposed constructs that are in positive or in negative correlation with adopting Cloud in education and training of the seafarers. Since usage of multimedia instructional materials in teaching and learning processes is in favor of the idea of moving education to Cloud, the paper additionally describes the four multimedia instructional aids developed for the needs of maritime studies students. These materials are of a great help, but it is necessary to use additional literature, e.g. [11,12], as well as guidance provided by the teachers. Accordingly, Lee [13] said: "There will always be a small percentage of

students with the necessary background, motivation and self-discipline to learn from self-paced workbooks or computer assisted instruction. For the majority of students, however, the presence of live instructor will continue to be far more effective than a computer assisted counterpart in facilitating positive educational outcome." Or, in other words, the students need to be informed about additional relevant literature references and above all motivated to learn by the teachers in the real world classroom and/or lab.

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# The Correlation Between International E-Learning Standards and National Standards of Serbia and Nearby Countries

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**Abstract:** *The paper presents the status of e-learning standards published during the period from 2004 to 2017, focusing on international standards (ISO) on the one hand and national standards of Serbia and nearby countries such as Bosnia and Herzegovina, Croatia, Macedonia, Montenegro, Albania, Hungary, Romania and Slovenia on the other hand. The development trends of the national sets of standards are analyzed and compared with the development trend of international standards regarding both the number of published standards and their prices. The analysis of the data obtained using statistical methods reveals the current status of the national standards in relation to international ones, as well as their interrelationship. The data are also grouped into price ranges, and their relative and cumulative frequencies are determined. The results of the comparison indicate significant differences between the analyzed sets of standards, especially between national and international ones.*

**Keywords:** *correlation, statistical analysis, standards, e-learning.*

## 1. INTRODUCTION

Knowledge bases (KB) play a significant role in optimizing the use of tools, technology and knowledge in the field of e-learning. The standardized ISO/IEC 2382:2015 (en) dictionary (Information technology – Vocabulary) [1] (i.e. ISO/IEC 2382-1:1993(en) [2]), explains the meaning of the term “knowledge base”<sup>1</sup> as a “database that contains inference rules and information about human experience and expertise in a domain”.

Generally speaking, a knowledge base represents a centralized repository of information, or a library of information relating to a certain field, problem or topic [3]. In IT domain, a knowledge base is almost always created in an electronic format and posted at a certain Internet address. It serves as a source providing individuals or organizations with knowledge of a specific problem. This is why a knowledge base is commonly regarded as a collection of useful information helping the users to improve the job they are doing or make it perfect, and therefore it is rightly believed to save companies both time and money [3, 4].

According to [5], from a knowledge provider’s point of view, the e-learning process includes two key phases: designing e-learning materials and delivering and reviewing them.

Both phases (as well as all subphases) must be governed by standards, whose development and updating play a vital role in establishing an e-learning system and ensuring its proper functioning. Consequently, standardization organizations, both national and international, develop new standards almost on a daily basis in order to ensure the optimal use of all resources, and synchronization of all the elements involved in the e-learning process.

The aim of this paper is to examine the development trends of standards both at international and national levels. Apart from international (ISO) standards and Serbian (SRPS) standards, the standards published by standardization organizations in countries close to Serbia (Bosnia and Herzegovina, Croatia, Macedonia, Bulgaria, Montenegro, Albania, Hungary, Romania, Slovenia) are also analyzed. In addition to analyzing the trend of publishing standards at the national level of each of these countries, their comparison with international standards and their trends regarding both the number of published standards and their prices is performed as well. The analysis of the data obtained using statistical methods reveals the current status of national standards in relation to international ones, as well as their interrelationship.

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<sup>1</sup> ISO/IEC 2382:2015(en): 2121399 (or: ISO/IEC 2382-1:1993(en): 01.06.18) - knowledge base

## 2. LITERATURE REVIEW

E-learning standards have been developed by the International Standardization Organization (ISO) and International Electrotechnical Commission (IEC). Besides these two, there are numerous other organizations, such as AICC, IMS, DCMI, ADL-SCORM, ALIC, IEEE LTSC, ADRIADNE, CEN/ISSS WS-LT, CEN/ISSS CDFS, CEN/ISSS WS on Privacy, W3C, etc. [6].

Standardization has covered 40 fields. Out of the total number of standardized fields, 30 fields belong to the domain of technical and technological sciences [7]. Of all the fields, the 35<sup>th</sup> one – Information technology and its sub-fields (Level 1 – ICS 1) [7, 8] has recorded the highest increase in the number of modernized standards (sources of knowledge). One of the groups within the Information technology field is 35.240 Applications of information technology (Level 2 – ICS 2). The next level, Level 3, comprises sub-groups, one of which is 35.240.90 IT applications in education, including e-learning.

### 2.1. OVERVIEW OF NATIONAL AND ISO STANDARDS

This paper presents the status of e-learning standards published during the period from 2004 to 2017 at international and national levels. According to the international classification [9], ISO standards belong to the ICS 3=35.240.90 group (IT applications in education - Including e-learning), and so do HRN, BDS, MSZ and ASRO standards, whereas MKS standards relate both to 35.240.90 and 35.240.99. As to other national sets of standards (SRPS, BAS, MEST and SITS), their e-learning standards belong to ICS 3=35.240.99. A great number of these standards also relate to the ICS group 03.100.30 Management of human resources (e-learning from a human resource management point of view).

During the abovementioned period, a total of 122 standards were published (denoted by  $\Sigma lqp$ ), and they are worth EUR 7,810.52 (denoted by  $\Sigma lv$ ). The prices of all standards are expressed in euros for the purpose of easier comparison.

The following chapters provide a brief overview of the analyzed sets of standards during the period from 2004 to 2017.

#### 2.1.1. Serbian –SRPS standards

During the period from 2004 to 2017, only six SRPS standards were published ( $\Sigma lqp=6$ ), belonging to the field 35 (ICS 1), group 240 (ISC 2), sub-group 99 (ICS 3). They all were published in 2013 and 2014. The total worth of these standards ( $\Sigma lv$ ) is EUR 149.34, and they are published on 286 pages [10].

#### 2.1.2. Croatian – HRN standards

In Croatia, there are 9 HRN standards ( $\Sigma lqp=9$ ) in the field of e-learning (35.240.90), all published in

2014. The total worth of these standards ( $\Sigma lv$ ) is EUR 319.65, and they are published on 360 pages [11].

#### 2.1.3. Bosnian – BAS standards

In Bosnia, there are 22 BAS standards ( $\Sigma lqp=22$ ) in the field of e-learning (35.240.99), all published in the period from 2010 to 2017. The total worth of these standards ( $\Sigma lv$ ) is EUR 804.73, and they are published on 933 pages [12].

#### 2.1.4. Macedonian – MKS standards

In Macedonia, there are 6 MKS standards ( $\Sigma lqp=6$ ) in the field of e-learning (35.240.90 and 35.240.99), all published in the period from 2010 to 2015. The total worth of these standards ( $\Sigma lv$ ) is EUR 77.72, and they are published on 118 pages [13].

#### 2.1.5. Bulgarian – BDS standards

In Bulgaria, there are 6 BDS standards ( $\Sigma lqp=6$ ) in the field of e-learning (35.240.90). The total worth of these standards ( $\Sigma lv$ ) is EUR 294.66, and they are published on 335 pages [14]. No standards had been published there before 2009.

#### 2.1.6. Montenegrin – MEST standards

In Montenegro, there is only one MEST standard ( $\Sigma lqp=1$ ) in the field of e-learning (35.240.99), published in 2011. It is worth EUR 54.00 ( $\Sigma lv$ ), and published on 136 pages [15].

#### 2.1.7. Albanian – SSH standards

In Albania, there are 3 SSH standards ( $\Sigma lqp=3$ ) in the field of e-learning (35.240.99), all published in 2012 and 2013. The total worth of these standards ( $\Sigma lv$ ) is EUR 110.02, and they are published on 144 pages [16].

#### 2.1.8. Hungarian – MSZ standards

In Hungary, there are 8 MSZ standards ( $\Sigma lqp=8$ ) in the field of e-learning (35.240.90), none of which had been published before 2009. The total worth of these standards ( $\Sigma lv$ ) is EUR 237.83, and they are published on 367 pages [17].

#### 2.1.9. Romanian – ASRO standards

In Romania, there are 11 ASRO standards ( $\Sigma lqp=11$ ) in the field of e-learning (35.240.90), none of which had been published before 2009. The total worth of these standards ( $\Sigma lv$ ) is EUR 141.16, and they are published on 475 pages [18].

#### 2.1.10. Slovenian SIST standards

In Slovenia, there are 8 SIST standards ( $\Sigma lqp=8$ ) in the field of e-learning (35.240.99), the first of which was published in 2009. The total worth of these standards ( $\Sigma lv$ ) is EUR 600.00, and they are published on 456 pages [19].

#### 2.1.11. International – ISO standards

There are 42 international ISO standards ( $\Sigma lqp=42$ ) in the field of e-learning (35.240.90). As

to the analyzed period, only in 2005, 2006 and 2010, no ISO standards were published. The total worth of the published standards ( $\Sigma v$ ) is EUR 5,021.40, and they are published on 2,256 pages [20].

### 3. RESEARCH METHODOLOGY

The aim of this paper is to examine the development trends of standards belonging to the ICS 3 - 35.240.90(99) subgroup – IT applications in education/IT applications in other fields, Including e-learning at national levels, as well as to compare them with international standards, and determine the correlation between them. The data obtained using statistical methods are analyzed in order to determine the current status of national standards in relation to international ones, as well as their interrelationship, placing special emphasis on the status of Serbian SRPS standards in relation to standards in nearby countries and international ones.

First, the basic statistical values, such as the lowest and highest price, mean price, standard deviation, mode, median, etc. are determined within each individual set of standards and within the total number of standards. Special attention is given to the correlation between national and ISO standards regarding the number of standards and their prices. Then the data are grouped by price, and all the prices are expressed in euros for the purpose of easier comparison. As to these data, cumulative and relative frequencies are calculated for each individual set of standards, and then collectively. Some of the obtained results are also presented graphically, using lines and columns.

### 4. RESULTS AND DISCUSSION

#### 4.1. Comparison of published standards

According to [10-19], the analysis of ICS 3 subgroup of standards in the field of e-learning clearly shows that none of the analyzed countries had published standards in this field before 2009, whereas the first ISO standard [20] in the same field was published in 2004. The relationship between the number of published national and international standards is graphically illustrated in Figure 1.

A graph can also be used to compare the prices of standards (Figure 2).

Figure 1 and Figure 2 clearly illustrate the difference between ISO standards on the one hand and all other analyzed sets of standards on the other hand regarding both their number and prices. According to these graphs, ISO standards are far more expensive than those published at national levels.

According to Figure 1, 9 HRN standards were published in 2014 and as many ISO standards were published in 2015, but their prices in these two years reached considerably different peaks (Figure

2). The price of 9 HRN standards published in 2014 was EUR 319.65, whereas the price of the same number of ISO standards published in 2015 was EUR 928.38. These data are sufficient to indicate significant differences between national and international sets of standards.

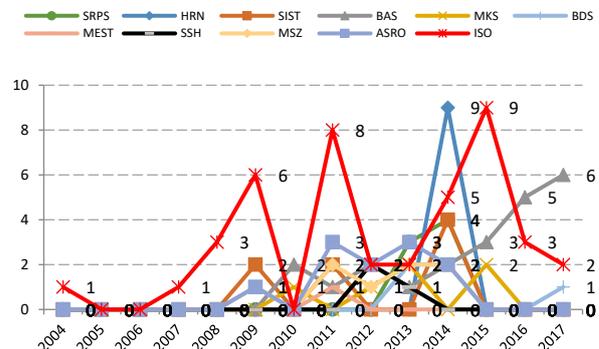


Figure 1. An overview of all published standards (during the period from 2004 to 2017)

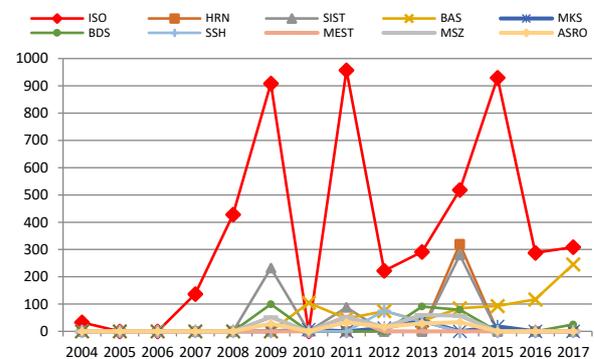


Figure 2. An overview of the prices of all published standards (during the period from 2004 to 2017)

For each of the analyzed years, the mean number of standards published both at international and national levels can be calculated, as well as the mean prices. These data are given in Table 1.

Table 1. The mean number and price of standards for each year

YEAR	Mean number	Mean price
2004	0.09	2.99
2005	0.00	0.00
2006	0.00	0.00
2007	0.09	12.45
2008	0.27	38.93
2009	1.00	120.07
2010	0.27	10.09
2011	1.55	111.94
2012	0.91	37.88
2013	1.36	53.41
2014	2.73	125.16
2015	1.27	94.62
2016	0.73	36.81
2017	0.82	52.66

According to Table 1, the mean number of published standards was the highest in 2014 (2.73), which is also the year when the mean price of published standards reached the peak (EUR

125.16). The data from the table are graphically illustrated in Figures 3 and 4.

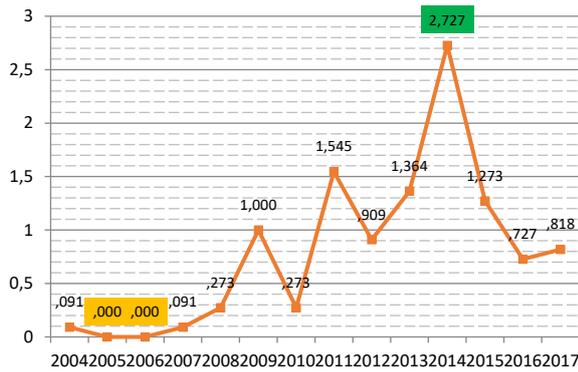


Figure 3 The mean number of all national and international standards for each year

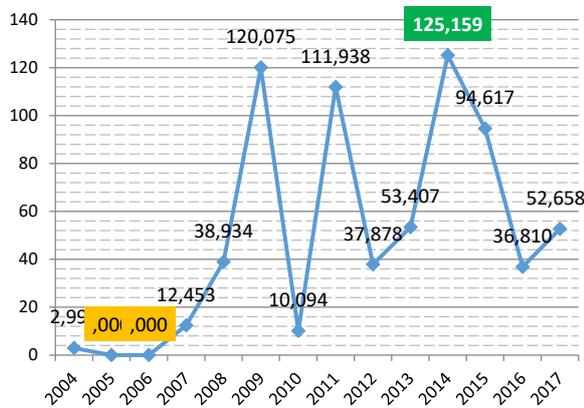


Figure 4 The mean price of all national and international standards for each year

#### 4.2. Correlations between individual sets of standards

There are, obviously, certain correlations between national and international standards. They can be noticed both between the number of pages of the published standards and between their prices. These correlations can be further analyzed regarding the number of published standards and their prices during the entire period covered by this research (2004-2017).

##### 4.2.1. The correlation between national and international standards regarding the number of published standards

The correlation obtained by the comparison of the number of standards published at national levels and the number of standards published at the international level is shown in Table 2.

Table 2. The correlation between national and ISO standards regarding the number of published standards

Designation of standards	SRPS	HRN	SIST	BAS	MKS
Number of standards	6	8	8	21	5
Correlation	0.1358	0.1961	0.5145	0.1613	0.2080

Designation of standards	BDS	MEST	SSH	MSZ	ASRO	ISO
Number of standards	6	1	3	8	11	42
Correlation	0.1387	0.4903	-0.1358	0.4308	0.3749	

##### 4.2.2. The correlation between national and international standards regarding the price of published standards

The correlation obtained by the comparison between the prices of standards published at national levels and the price of international standards is given in Table 3.

As to the prices of published standards for each year, according to the data presented in Table 3, the correlation between ISO and ASRO standards is the highest, whereas the correlation between ISO and SSH standards is the lowest.

Table 3. The correlation between national and international standards regarding the prices of published standards

Designation of standards	SRPS	HRN	SIST	SST	BAS	MKS
Price	149.318	319.645	8	600	804.716	77.7162
Correlation	0.0572	0.4677	0.5145	0.5160	0.0131	0.0844

Designation of standards	BDS	MEST	SSH	SSH	MSZ	ASRO	ISO
Price	294.659	54	3	110.02	237.836	141.155	5021.43
Correlation	0.3196	0.4915	-0.1358	-0.1644	0.5150	0.5300	

The correlation between national and international standards regarding both the number and prices of published standards can also be graphically illustrated, as shown in Figure 5.

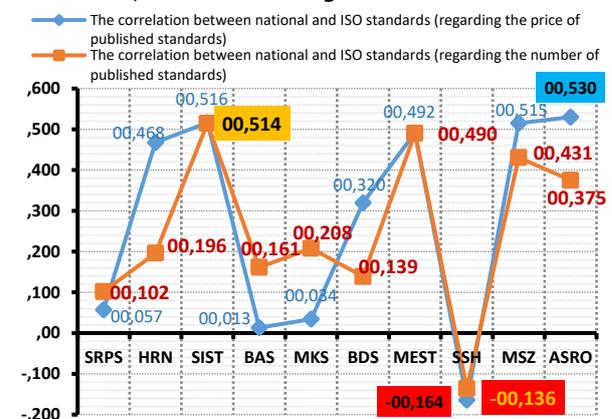


Figure 5. Graphical illustration of the correlation between national and ISO standards

### 4.2.3. The correlation between the number of pages and price within individual sets of standards

In a similar manner, the relationship between the number of pages and the price of published standards can be analyzed for each set of standards (Table 4).

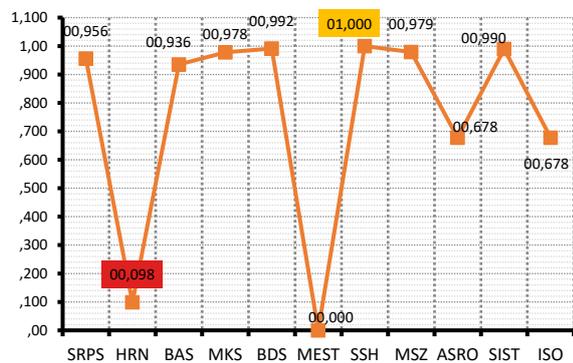
**Table 4.** The correlation between the number of pages and price of published standards

Designation of standards	SRPS	HRN	SIST	BAS	MKS
Number of standards	6	8	8	21	5
Price	149.34	319.65	600	804.72	77.716
Correlation	0.9559	0.0984	0.9889	0.9355	0.9782

Designation of standards	BDS	MEST	SSH	MSZ	ASRO	ISO
Number of standards	6	1	3	8	11	42
Price	294.66	54	110.02	237.84	141.16	5021.43
Correlation	0.9916	-	0.9998	0.9788	0.6777	0.6777

In this case, however, SSH standards have the highest correlation between the number of pages and the price of standards, whereas this correlation is the lowest in MEST and HRN sets of standards. As there is only one MEST standard, the correlation is 0 and therefore cannot be taken into consideration. These data can be graphically illustrated, as shown in Figure 6.



**Figure 6.** Graphical illustration of the number of pages and prices of published standards

### 4.3. The analysis of the sets of standards using the measure of central tendency and measure of variability

Table 5 provides an overview of the basic statistical analyses performed with each set of standards (national and international). It shows the total number of standards (in the given period of time), the highest and lowest price of standards per set, the arithmetic-geometric mean of the prices, mode, median, standard deviation, variance and the sum of prices for each analyzed set of standards.

From Table 5 it can be seen that SSH standards have the smallest standard deviation (the measure of spread from the mean price of standards), whereas the largest standard deviation is calculated within the set of ISO standards. The

relationship between the arithmetic mean and median of prices (the highest and lowest price) can also be analyzed and illustrated graphically, as shown in Figure 7.

Figure 7 shows that ISO standards have the highest mean price, reaching even EUR 119.56, whereas at national levels, Slovenian SSH standards are the most expensive, with the mean price of EUR 75.00. As to the countries bordering Serbia, MEST standards in Montenegro and BDS standards in Bulgaria have the highest mean price, which is EUR 49.11 in each country. The mean price of SRPR standards, is EUR 24.89, which is significantly lower than the mean prices of standards in most of the countries in the region, but not the lowest. The mean price of e-learning standards is the lowest in Romania, where ASRO standards can be bought at a mean price of EUR 12.83.

### 4.4. Grouping data

The analysis of the prices of standards [10-20] clearly shows that they can be grouped into price ranges, and then further statistically analyzed in order to calculate the cumulative and relative frequency distribution.

The price range for each set of standards is defined using the already determined highest and lowest prices and the number of standards in each set. For example, as there are 6 SRPS standards (N=6), the number of ranges (K) is obtained using the following equation:

$$K = 1 + 3,3 * \log N. \tag{1}$$

Using the equation (1), the following number of ranges (K) is obtained:  $K=3,568 \approx 4$  (almost 4 ranges), whereas their width is calculated using the following equation:

$$\frac{X_{max} - X_{min}}{K}, \tag{2}$$

where  $X_{max}$  and  $X_{min}$  denote the highest and the lowest price, respectively, within the analyzed set of standards.

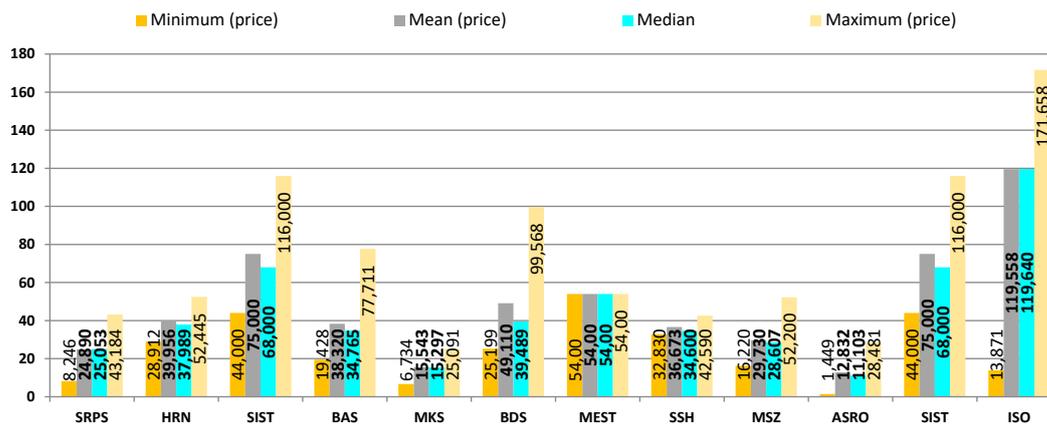
Using this equation, the following range width is obtained:  $8.7345 \approx 9$ . Based on the obtained ranges, the following can be calculated: arithmetic mean, frequency (the number of standards in the analyzed range), cumulative and relative frequency (expressed in %), and the diagram of the cumulant can be created (Table 6).

**Table 6.** Grouping SRPS standards

Interval	Arithmetic mean of the interval	Frequency	Cumulative frequency	Decreasing cumulant	Relative frequency %	Cumulative frequency %
8	17.99	12.995	2	2	6	33
18	27.99	22.995	1	3	4	50
28	37.99	32.995	2	5	3	83
38	47.99	42.995	1	6	1	100
			6			100

**Table 5.** Statistical analyses

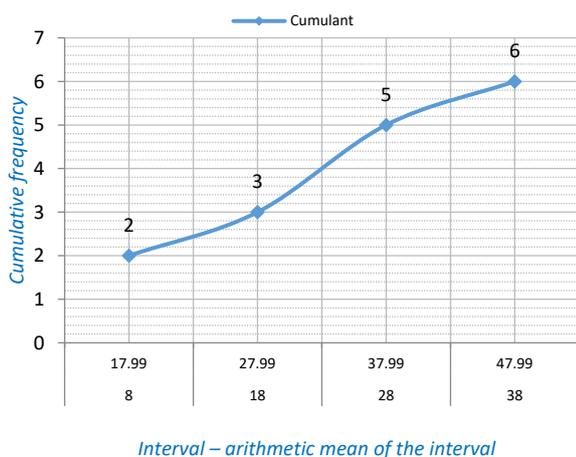
	SRPS	HRN	SIST	BAS	MKS	BDS	MEST	SSH	MSZ	ASRO	SIST	ISO
Number of standards	6	8	8	21	5	6	1	3	8	11	8	42
Maximum (price)	43.18	52.44	116.00	77.71	25.09	99.57	54.0	42.59	52.20	28.48	116.00	171.66
Minimum (price)	8.25	28.91	44.00	19.43	6.73	25.20	54.0	32.83	16.22	1.45	44.00	13.87
Mean price	24.89	39.96	75.00	38.32	15.54	49.11	54.0	36.67	29.73	12.83	75.00	119.56
Geometric mean	21.83	39.24	70.44	36.21	14.22	43.58	54.0	36.44	28.08	10.57	70.44	108.14
Mode	-	34.96	44.00	34.77	-	-	-	-	30.54	-	44.00	119.64
Median	25.05	37.99	68.00	34.77	15.30	39.49	54.0	34.60	28.61	11.10	68.00	119.64
Variance	158.37	66.17	815.14	194.90	46.91	791.85	-	27.04	124.18	51.93	815.14	1550.31
Standard deviation	12.58	8.13	28.55	13.96	6.85	28.14	-	5.20	11.14	7.21	28.55	39.37
Sum	149.34	319.65	600.00	804.72	77.72	294.66	54.0	110.02	237.84	141.16	600.00	5021.43



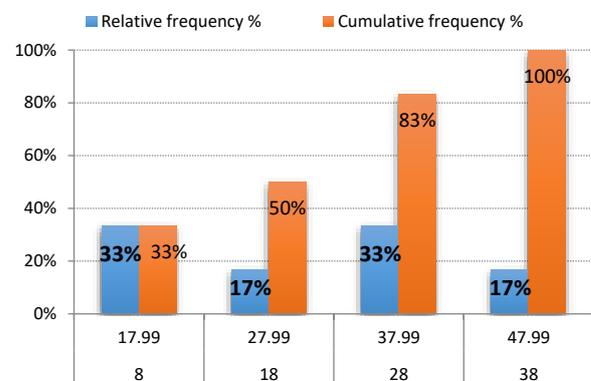
**Figure 7.** Graphical illustration of the lowest, mean, and highest price of standards and the median

Using the obtained data, the following diagram of the cumulant is created for SRPS standards (Figure 8).

Using the data presented in Table 6, the diagram of the relationship between cumulative and relative frequency (%) can also be created, as shown in Figure 9.



**Figure 8.** Graphical illustration of the cumulant for SRPS standards



**Figure 9.** Graphical illustration of the relationship between cumulative and relative frequency of SRPS standards

As to SRPS standards, Figures 8 and 9 show that the greatest number of the standards (33%) belong to the first price range (8-17.99), and the same percentage of standards belong to the third range (28-37.99), which means that most SRPS standards can be bought at prices ranging from EUR 8.00 to EUR 18.00, i.e. from EUR 28.00 to EUR 38.00.

The same procedure is used to obtain data for other sets of standards, as described below:

- most HRN standards can be bought at prices ranging from EUR 12.00 to EUR 24.00, as even 33% of the standards published in the analyzed period belong to this very price range;

- most BAS standards can be bought at prices ranging from EUR 24.00 to EUR 36.00, this being the range to which 41% of the published standards belong;
- most MKS standards are grouped in two ranges. The first range (0-7.99) and the third one (8-15.99) include 33% of standards each, which leads to the conclusion that most MKS standards published in the analyzed period can be bought at less than EUR 16.00;
- most BDS standards, 67% precisely, belong to the first price range (25-44.99), which means that most BDS standards can be bought at less than EUR 45.00;
- as to MEST standards, as there is only one standard published in the field of e-learning, no further statistical analyses can be performed;
- most SSH standards, 67% precisely, belong to the first price range (32-36.99), which means that most SSH standards published in the analyzed period can be bought at less than EUR 37.00;
- as to MSZ standards, the first price range (16-25.99) and the second one (26-35.99) include the greatest percentage of standards, i.e. 38% each, and therefore they can be bought at less than EUR 36.00;
- the prices of most ASRO standards published during the analyzed period, 55% precisely, belong to the second price range (7-12.99), which means that most ASRO standards can be bought at prices ranging from EUR 7.00 to EUR 13.00;
- as to SIST standards published during the analyzed period, most of the standards, i.e. 38%, belong to the first price range (43-61.99), and therefore most SIST standards can be bought at prices ranging from EUR 43.00 to EUR 62.00;
- as to ISO set of standards, which has the greatest number of standards published in the analyzed period, most standards belong to two price ranges. Namely, 26% of those standards belong to the following range: 105-127.99, and the same percentage of standards belong to the last price range (151-173.99). This means that most international standards in the field of e-learning can be bought at the prices ranging from EUR 82.00 to EUR 128.00, i.e. from EUR 151.00 to EUR 174.00.

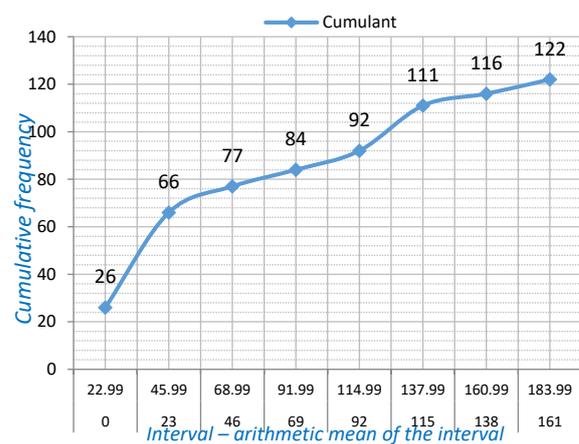
In the same manner, the prices of all standards published at both national and international levels can be grouped. This implies the creation of group price ranges, which would include all sets of standards, taking into consideration the highest price of standards ( $x_{max}$  = EUR 171.66, which is the price of an ISO standard) and the lowest price ( $x_{min}$  = EUR 0.00, as there are free standards in certain sets). Based on these data and the total number of standards ( $N=122$ ), using the equation (1), the following number of ranges is obtained  $K=7.88 \approx 8$ . The width of these eight ranges is calculated using the equation (2), and it is

$21.45 \approx 22$ . The data obtained in such a manner are given in Table 7.

**Table 7. Grouping all standards**

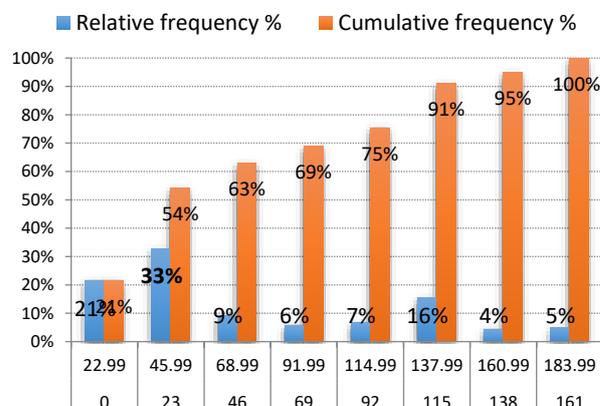
	Interval	Arithmetic mean of the interval	Frequency	Cumulative frequency	Decreasing cumulant	Relative frequency %	Cumulative frequency %
0	22.99	11.50	26	26	122	21	21
23	45.99	34.50	40	66	96	33	54
46	68.99	57.50	11	77	56	9	63
69	91.99	80.50	7	84	45	6	69
92	114.99	103.50	8	92	38	7	75
115	137.99	126.50	19	111	30	16	91
138	160.99	149.50	5	116	11	4	95
161	183.99	172.50	6	122	6	5	100
			122			100	

Based on the data presented in Table 7, a diagram illustrating the relationship between the arithmetic mean and cumulative frequency can be created, as shown in Figure 10.



**Figure 10. Graphical illustration of cumulants for all standards**

Using the same data, a diagram showing the relationship between relative and cumulative frequency can be created as well (Figure 11).



**Figure 11. Graphical illustration of the relationship between relative and cumulative frequency of all standards**

The diagram shows that, during the period from 2004 to 2017, the prices of most standards in the

analyzed sets published both at national and international levels, i.e. 33%, belong to the second price range (23-45.99), which means that most of the standards published in the abovementioned period can be bought at the prices ranging from EUR 23.00 to EUR 46.00.

## 5. CONCLUSION

According to the data presented in chapter 4.1, it can be concluded that the total number of standards belonging to ISC 3=35.240.90(99) subgroup which were published during the given time (2004-2007) in the countries included in the research was  $\Sigma l_{qp}=122$ , 80 of which were developed at national levels, and 42 by international organizations. The total worth ( $\Sigma l_v$ ) of these 122 standards is EUR 7667.17, whereas ISO standards are worth EUR 5021.43. Globally speaking, most standards, i.e. 30 of them, were published in 2014, mostly at national levels (25 national and 5 international), and they cost EUR 1376.75. This is also the year when the most expensive standards were published and therefore the highest mean price recorded (EUR 125.16).

The comparison performed between the individual sets of standards on the one hand and between each set and ISO standards on the other hand shows that the correlation between Slovenian SIST standards and ISO standards regarding the number of standards is the highest, whereas the correlation between Albanian SSH standards and ISO standards is the lowest. As to the prices, the correlation between Romanian ASRO standards and ISO standards is the highest, and again the correlation between Albanian SSH standards and ISO standards is the lowest. With regard to the correlation between the number of pages and the prices of standards, the situation is quite different. Namely, SSH standards have the highest correlation between the two, whereas Croatian HRN standards have the lowest correlation.

The description of the sets of standards using the measures of central tendency, variability and standard deviation shows that SSH standards have the smallest deviation from the mean, whereas the greatest values of standard deviation are recorded in the set of ISO standards.

Data grouping into price ranges shows that the most expensive standards in the field of e-learning are ISO standards, most of them belonging to the range of high prices (EUR 105-127.99, i.e. EUR 151-173.99). As to the national standards, SSH standards are the most expensive, and the greatest percentage of them (even 67%) cost between EUR 32.00 and EUR 37.00, whereas their mean price is EUR 36.67. SRPS standards are among the cheapest ones in the region. Out of the total number of SRPS standards, 33% belong to the price range from EUR 8.00 to EUR 18.00, and their mean price is EUR 24.89. The situation is similar

with MKS standards, whereas the cheapest standards are ASRO standards (even 55% of them belong to the price range from EUR 7.00 to EUR 13.00). The mean price of ASRO standards is EUR 12.83. Speaking about the countries bordering Serbia, MEST standards in Montenegro, and Bulgarian BDS standards have the highest mean price, which is EUR 49.11. The analysis of the price per page for each examined set of standards reveals that the price of ISO standards per page is the highest (the price per page = EUR 2.227). As to national standards, Slovenian standards have the highest price per page (the price per page = EUR 1.316), whereas this price is the lowest in Romania (the price per page = EUR 0.297).

The price ranges into which the prices of all the standards are grouped show that most of the standards published during the period from 2004 to 2017, i.e. 33% of the total number of standards, belong to the range from EUR 23.00 to EUR 46.00. According to the abovementioned, there appear to be significant inconsistencies between national and international standardization organizations, especially regarding the number of published standards in the field of e-learning. Since 2014, the year when most of the standards were published, the number of published standards has been falling instead of increasing, and the same trend will probably continue.

However, the trend should change in the future, and the number of national standards should increase due to the growing popularity of e-learning, which demands new standards to govern the field. The accreditation of a growing number of e-learning modules and entire study programs based solely on e-learning is expected in the following period. Their optimal growth and development require knowledge sources – standards and regulations to govern the whole process. Currently, the number of published standards is insufficient, both in Serbia and countries near it.

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# Comparative Analysis of E-Learning Standard

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**Abstract:** *In this paper is presented a comparative analysis of standards in the field of e-learning, published both by ISO and International Organization for Standardization standards, as well as standards by local organizations in the countries of the region. The aim of the research is to analyze the current situation at the global and local level in the field of e-learning. The results obtained by the survey indicate similarities and differences both in terms of publication trends and the price values of standards published by the international ISO organization and local organizations of the countries of the region.*

**Keywords:** *e-learning; standardization; trend analysis; comparative analysis*

## 1. INTRODUCTION

It is important to note that standardization is a set of coordinated activities for the adoption of standards and related documents, while the standard is a publicly available document, determined by consensus, and adopted by a recognized body, in which rules, requirements, characteristics, instructions, recommendations, or recommendations are laid down for general and re-use, guidelines for activities or their results, in order to achieve an optimal level of regulation in a particular area in relation to existing or potential problems [1].

Within ISO / IEC international standardization, and according to the international standard classification, standards are organized in 40 groups. The e-learning group that will be considered in this paper is an information technology group (35), e-learning (35.240.99) and a group in which standards are defined service organization, quality management and administration (03) and 03.100.30 (e-learning from the aspect of human resources management) [2].

E-learning is standardized by the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). In addition to the aforementioned organizations, there are many other e-learning standards, for example: AICC, IMS, DCMI, ADL-SCORM, ALIC, IEEE LTSC, ADRIADNE, CEN / ISSS WS-LT, CEN / ISSS CDFS, CEN / ISSS WS on Privacy, W3C etc.c [3]. The JTC 1 / SC 36 subcommittee for e-learning functions in the framework of the First Technical Committee (JTC1 ISO / IEC). This subcommittee contains seven working groups (Working group) and one advisory group [4].

The paper presents trends in the development of standards in the field of e-learning published by

both ISO and International Organization for Standardization standards, as well as standards by local organizations of the countries of the region: SRPS (Institute for Standardization of Serbia), HRN (Institute for Standardization of Croatia), BAS (Institute for Standardization of Bosnia and Herzegovina), SIST (Slovenian Institute for Standardization) and MKS (Institute for Standardization of Macedonia).

MEST standards (Institute for Standardization of Montenegro) have been derived from the countries of the region since there are no standards related to e-learning while searching at the official presentation.

## 2. RELATED WORK

In the paper [4], is presented a systematized analysis/synthesis and cross-section of the state of international and local (ISO / IEC and SRPS) standardization in the field of distance learning was presented, with the aim of presenting an analysis of the current state at the local (SRPS) and the global (ISO) level in sub-fields of e-learning. Authors working through the PDCA concept conclude that the price of access to standards and annual innovations exceeds the frameworks of individuals, that the development of national standards requires continuous teamwork, that DLS checks require adaptation of documentation for accreditation and provide a proposal for improvement in terms of the need for software development On-line access to local standards.

The authors in [5] observe the level of innovation by ISO and SRPS organization in the period from 2004 to 2012. In this paper is explained the correlation of the standards of e-learning and the standard number 12 accreditation documentation.

In the paper [3], the authors analyze the trend of publication of ISO and SRPS publication of e-

learning standards for the period from 2004 to 2015 as well as the connection of standards with the Massive open online courses as the standards have not yet been developed.

### 3. RESEARCH METHODOLOGY

The aim of the research is to analyze the current state and trends of publishing standards on global (ISO) and local (SRPS, HRN, BAS, SIST and MKS) level in the e-learning sub-area (ICS 35.240.90 / 99), and the price values between the observed standards.

Methods of research used in the paper are analysis, inductive-deductive method and comparative method. In the paper is used statistical analysis for comparing published and prediction of price values of the standards in preparation.

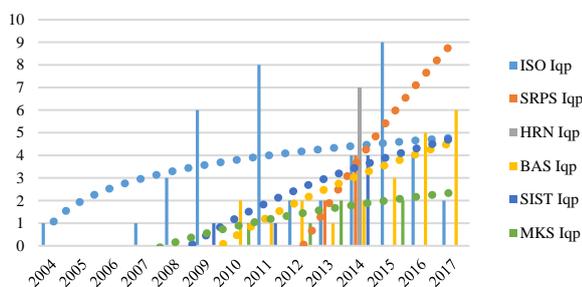
The data were collected on official web sites of the International Standards Organization (ISO), the Institute for Standardization of Serbia (SRPS), the Croatian Institute of Standards (HRN), the Institute for Standardization of Bosnia and Herzegovina (BAS), the Slovenian Institute for Standardization (SIST) for the standardization of the Republic of Macedonia (MKS).

According to [5], [6], [7], [8], [9] and [10], the number of e-learning standards in the period from 2004 to 2017 is 89. The following table gives an overview of the standards published by global and local organizations.

According to [4] standardized documents include indexes: Iqp - current published standards, Iv - value index.

**Table 1.** Overview of published ISO / SRPS / HRN / BAS / SIST / MKS standards by years

ICS 35.240.99		2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.	2012.	2013.	2014.	2015.	2016.	2017.	Σ
ISO	Iqp	1			1	3	6		8	2	2	4	9	4	2	42
	brStr	6			39	169	773		253	56	184	281	224	137	136	2258
	ΣIv	38			158	494	1048		1104	256	236	460	1072	470	356	5692
SRPS	Iqp										2	4				6
	brStr										144	142				286
	ΣIv										68	108				176
HRN	Iqp											7				7
	brStr											313				313
	ΣIv											272				272
BAS	Iqp							2	1	2	1	2	3	5	6	22
	brStr							160	59	74	38	94	71	87	350	933
	ΣIv							122	55	86	45	99	108	137	480	1132
SIST	Iqp						1		1			4				6
	brStr						/		/			/				0
	ΣIv						/		/			/				0
MKS	Iqp							1		1	2		2			6
	brStr							3		13	74		28			118
	ΣIv							8		15	50		23			96



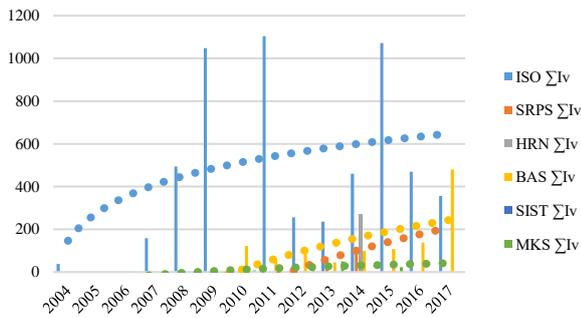
**Figure 1.** Number of published standards by years

Based on the previous table, it is possible to generate a chart of published standards (Iqp) by

years for international ISO and local standards (SRPS, HRN, BAS, SIST, MKS).

The mathematical expressions of the logarithmic functions in the function of the trend of published standards are as follows:

- $y_{ISO} = 1.4096\ln(x) + 1.0689$
- $y_{SRPS} = 20.984\ln(x) - 46.318$
- $y_{BAS} = 5.8713\ln(x) - 10.91$
- $y_{SIST} = 5.0288\ln(x) - 8.5087$
- $y_{MKS} = 2.1196\ln(x) - 3.2324$



**Figure 2.** Graphically displayed values of published standards

The mathematical expressions of logarithmic functions in the function of the values of published standards:

- $y_{ISO} = 190.26\ln(x) + 146.39$
- $y_{SRPS} = 419.68\ln(x) - 898.35$
- $y_{BAS} = 330.12\ln(x) - 626.53$
- $y_{MKS} = 42.584\ln(x) - 71.075$

For SIST standards published by the Slovenian Standards Institute according to [9], there are no price values.

Based on the table, it can be concluded that the highest number of announcements was in 2014, a total of 20 standards were published by international (ISO) and local (SRPS, HRN, BAS, SIST, MKS) organizations.

According to the previous chart, in 2014, 21 standards with a total price of 939 CHF were developed. Unlike 2014, in 2015, seven standards have been developed, 14 have been developed. Although the total price of the standard is 1203 CHF published in 2015.

The lack of published standards in 2015 in relation to 2014 can be explained by a greater number of announcements by the international (ISO) organization.

The total price of the standard published in the period from 2004 to 2017 expressed in CHF is 7368, of which only the international (ISO) standard is 5692 CHF.

#### 4. COMPARATIVE ANALYSIS OF PUBLISHED E-LEARNING STANDARDS

The prices of international and local standards are defined on the basis of price classes, the number of pages of the observed standard and the language in which the standard is published.

##### 4.1. Statistical analysis

Based on the price values of the standard, it is possible to determine the value of the median, average value, mod, standard deviation and the minimum and maximum price value of the standard.

**Table 2.** Statistical values of the standard

	Standards				
	ISO	SRPS	HRN	BAS	MKS
Median	138,00	29,52	41,33	40,54	18,78
Average value	135,52	29,33	45,81	44,68	19,08
Mod	138,00	/	41,33	40,54	/
Standard deviation	47,96	14,83	9,43	16,28	8,41
Min	16,00	9,72	34,18	22,65	8,27
Max	198,00	50,89	62,00	90,61	30,80

From the previous table, it can be concluded that the highest price values of the standard are those published by the ISO organization, while observing the price values of organizations publishing standards in the region, it can be concluded that the highest price values (average) for HRN standards. The cheapest standards are the standards published by the Institute for Standardization of Macedonia (MKS standards).

On the basis of the price level, it is possible to:

- group data in the form of an interval numeric series
- calculate the rising and decreasing cumulant
- calculate the relative frequency and the cumulative frequency in percentages

for ISO standards:

Number of standards (samples)  $N = 42$ ; Maximum value: 198.00; Minimum value: 16.00;

Number of intervals:  $K=1+3,3 \cdot \log N = 6,357 \approx 6$

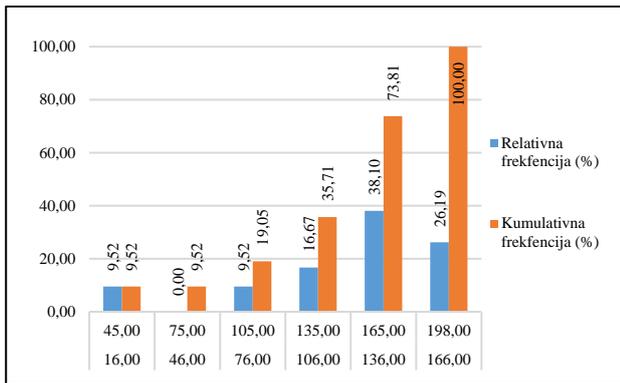
Interval width:  $i=((X_{max}-X_{min}))/K = 30,30 \approx 30$

**Table 3.** Grouping of data in the form of an interval numerical series - ISO standards

Group interval		Frequency	Arithmetic mean	Increasing cumulant	Decadent cumulant	Relative frequency (%)	Cumulative frequency (%)
16,00	45,00	4	30,50	4	42	9,52	9,52
46,00	75,00	0	60,50	4	38	0,00	9,52
76,00	105,00	4	90,50	8	38	9,52	19,05
106,00	135,00	7	120,50	15	34	16,67	35,71
136,00	165,00	16	150,50	31	27	38,10	73,81
166,00	198,00	11	182,00	42	11	26,19	100,00
		42				100	

Based on the table 3, it is possible to create a relative and cumulative frequency graph

(expressed as a percentage) of the publication of the ISO standard.



**Figure 3.** Frequency of publication of ISO standards

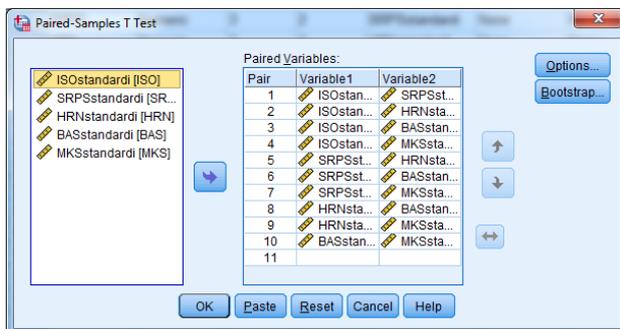
According to a figure 3, it is concluded that for most (38.10%) published standards, between 136 and 165 CHF should be allocated.

**4.2. Testing to determine the difference between price levels**

**Table 4.** Observed standards

Observed standards	Organization									
	ISO		SRPS		HRN		BAS		MKS	
	Price (CHF)	Number of pages								
19788-1	178,00	55	38,85	65	62,00	59	50,42	65	30,80	55
19788-2	118,00	19	26,42	29	41,33	23	40,54	29	18,78	19
19788-3	138,00	28	9,72	3	48,48	32	40,54	25	22,53	28
19788-5	138,00	34	32,63	45	53,25	38	45,31	34	27,22	34
19796-1	178,00	67	50,89	131	40,06	125	76,30	121	8,27	3
Σ	<b>750,00</b>	<b>203</b>	<b>158,51</b>	<b>273</b>	<b>245,12</b>	<b>277</b>	<b>253,11</b>	<b>274</b>	<b>107,60</b>	<b>139</b>

The observed standards can be paired in order to test the zero hypothesis on the equality of arithmetic meanings ( $H_0: \mu_1 = \mu_2$ ) according to the previous table based on price or page numbers. At the end of the previous table, the number of pages is quite equal. Standards are paired by price values.



**Figure 2.** Paired standards

In order to determine the differences, it is possible to do statistical tests using the distribution over the observed standards. Student's t-test is the most commonly used parameter significance test for testing the zero hypothesis. One-Sample t-test is used when we want to know if our sample comes from a particular population, but we do not have complete information about this population. He tests whether the sample comes from a population with a specific mean value. Therefore, this test is also called the t-test difference of the mean value of the basic set and sample.

In order for the test to be adequately regulated, it is possible to observe from the table of published standards the standards published by all observed organizations, based on the above, it follows the following table.

During testing, SPSS program was used, and according to [11], it is representing software package used for statistical analysis.

By default, the level of confidence that is defined is 95%. As a result of the t-test test, three tables are obtained.

Paired Samples Statistics table shows the mean values of the tested variables, while the N column represents the number of observations observed, or the number of standards. In the next column, standard deviations are shown and in the last error of standard deviations for the observed standards.

**Table 5. Paired Samples Statistics**

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	ISO standard	150,0000	5	26,83282	12,00000
	SRPS standard	31,7020	5	15,25813	6,82364
Pair 2	ISO standard	150,0000	5	26,83282	12,00000
	HRN standard	49,0240	5	9,02888	4,03784
Pair 3	ISO standard	150,0000	5	26,83282	12,00000
	BAS standard	50,6220	5	14,92407	6,67425
Pair 4	ISO standard	150,0000	5	26,83282	12,00000
	MKS standard	21,5200	5	8,69912	3,89036
Pair 5	SRPS standard	31,7020	5	15,25813	6,82364
	HRN standard	49,0240	5	9,02888	4,03784
Pair 6	SRPS standard	31,7020	5	15,25813	6,82364
	BAS standard	50,6220	5	14,92407	6,67425
Pair 7	SRPS standard	31,7020	5	15,25813	6,82364
	MKS standard	21,5200	5	8,69912	3,89036
Pair 8	HRN standard	49,0240	5	9,02888	4,03784
	BAS standard	50,6220	5	14,92407	6,67425
Pair 9	HRN standard	49,0240	5	9,02888	4,03784
	MKS standard	21,5200	5	8,69912	3,89036
Pair 10	BAS standard	50,6220	5	14,92407	6,67425
	MKS standard	21,5200	5	8,69912	3,89036

In the next table Paired Samples Correlations table, the number of observations is given, while the

second column shows the correlation. Third column Sig. the value of the correlation coefficient is given.

**Table 6. Paired Samples Correlations**

		N	Correlation	Sig.
Pair 1	ISO standard & SRPS standard	5	,708	,181
Pair 2	ISO standard & HRN standard	5	,324	,594
Pair 3	ISO standard & BAS standard	5	,762	,134
Pair 4	ISO standard & MKS standard	5	-,111	,858
Pair 5	SRPS standard & HRN standard	5	-,041	,947
Pair 6	SRPS standard & BAS standard	5	,836	,078
Pair 7	SRPS standard & MKS standard	5	-,359	,553
Pair 8	HRN standard & BAS standard	5	-,319	,600
Pair 9	HRN standard & MKS standard	5	,903	,036
Pair 10	BAS standard & MKS standard	5	-,683	,203

Paired Samples Test table, the first column presents the mean value, then the standard deviation and the standard deviation error, the confidence level of 95% (upper and lower limits). The last three columns of the table represent the realized test statistics (column t), the df column represents the number of degrees of freedom (the number of independent information units involved

in estimating the parameter representing the degrees of freedom of the parameter estimation are equal to the number of independent values that are included in the estimation minus the number of parameters used as intermediates in the evaluation of the parameter itself.) and the p-value of the test (Sig. (2-tailed)).

**Table 7.** Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	ISO – SRPS standard	118,29800	19,32021	8,64026	94,30879	142,28721	13,691	4	,000
Pair 2	ISO – HRN standard	100,97600	25,38387	11,35201	69,45777	132,49423	8,895	4	,001
Pair 3	ISO – BAS standard	99,37800	18,23151	8,15338	76,74060	122,01540	12,189	4	,000
Pair 4	ISO – MKS standard	128,48000	29,11485	13,02056	92,32914	164,63086	9,867	4	,001
Pair 5	SRPS – HRN standard	-17,32200	18,04704	8,07088	-39,73036	5,08636	-2,146	4	,098
Pair 6	SRPS – BAS standard	-18,92000	8,65636	3,87124	-29,66829	-8,17171	-4,887	4	,008
Pair 7	SRPS – MKS standard	10,18200	20,09126	8,98509	-14,76460	35,12860	1,133	4	,320
Pair 8	HRN – BAS standard	-1,59800	19,75713	8,83566	-26,12972	22,93372	-,181	4	,865
Pair 9	HRN – MKS standard	27,50400	3,91024	1,74871	22,64880	32,35920	15,728	4	,000
Pair 10	BAS – MKS standard	29,10200	21,81455	9,75577	2,01565	56,18835	2,983	4	,041

From the obtained results (the last column of Sig. (2-tailed)) we conclude that there is a significant difference in the price values based on the observed pairs (seven of them), therefore we reject the zero hypothesis since they are less than 0.05.

## 5. CONCLUSION

Based on the previous presentation, it can be concluded that the publication of standards by local organizations depends on the publication of the global ISO organization. As a problem it can be noticed that until adoption or harmonization of standards of local organizations can pass several years from the moment of adoption of the global ISO standard.

The statistical analysis of the price level of the published standards is gupped into the interval numerical series, the increasing and decreasing cumulative as well as the relative and cumulative frequency are calculated in percentages.

Based on the statistical analysis, it can be concluded that for most of the published ISO standards (38.10%), between 136 and 165 CHF should be allocated.

Differences in the prices of the representative standards published by organizations have been proven using the t-test, the concordance between the standards concludes that most published standards differ significantly. Although the volume of published standards by the number of parties is not significantly different, differences in price values can be explained as differences in purchasing power and economic situation of countries that publish standards.

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# Knowledge Sources in ICS Fields With Daily Intensity of Innovation – „TIE”-2017

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**Abstract:** *The paper presents the multicriteria research and statistical analysis of knowledge trends in the standardized Engineering fields (**technics**) and Information Technology (**informatics**). The focus is on the innovation of the sources of knowledge (in **education**), at the beginning of the second decade of the XXI century until 2017 – “TIE”-2017. The goal is to provide the resources and improve the quality of knowledge, on the platform of the international I (ISO) and local (national SRPS) standardization. The paper presents the significant details (results and analysis) by comparing the trends of knowledge sources, according to the analyzed fields / subfields classified according to the International Classification for Standards (ICS) ICS1 = 35 (Information Technology - IT), where ICS1 = 01 to 99. Moreover, the paper presents the plans for further development of an access to knowledge sources in the form of standards (as obligations), as well as comparisons of the index of innovation in IT with other standardized fields, especially the fields of engineering (e.g. ICS1 = 01, 23, 25, 35, 49, 83, 91 - daily intensity of innovation or weekly intensity - ICS1 = 29, 33, 59, 75, 77, etc.).*

**Keywords:** *standardization; knowledge sources; trends of knowledge; innovation index*

## 1. INTRODUCTION

The paper deals with a comparative analysis of local (SRPS – label for standards in Serbia, [1]) and international (ISO/IEC, [2]) knowledge sources in the fields classified according to ICS (international classification for standards). A comparative analysis of the field which has the highest (daily) intensity of innovation was presented for ICS1:

- 35 - Information technology comparable with
- 01 - Generalities; Terminology; Standardization; Documentation;
- 13 - Environment; Health protection; Safety and other Engineering fields:
- 23 - Fluid systems and components for general use
- 49 - Aircraft and space vehicle engineering,
- 83 - Rubber and plastic industries,
- 91 - Construction materials and building; or the daily intensity of innovation in engineering and technology (2016), and the weekly (flow 2017):
- 29 - Electrical engineering,
- 33 - Telecommunication; Audio and video engineering,
- 59 - Textile and leather technology,
- 75 - Petroleum and related technologies,
- 77 - Metallurgy, etc.

One of the objectives of the research in those fields is to compare innovativeness and determine the importance of local in relation to global knowledge

sources. The focus is on the fields which belong to the area of **technics and informatics (TI)** with the aim of **education – TIE** (knowledge-based innovation).

The goal of this research is: 1) to determine the innovativeness in the fields of Information technology and Engineering fields, 2) to compare the mentioned fields and determine if there are differences between local and global knowledge sources (KS), 3) to determine the trend lines of innovation of KS, 4) clustering by the fields of innovation in time (until 1.2017), through PDCA – “TIE”-2017.

The content of the paper represents the upgrade of the previous works of the authors. The methodology is indicated in the previous works, so the largest part of this paper is dedicated to the results and discussion.

### 1.1. Related Work

There are many papers dealing with the standardization of Information technology and mentioned engineering fields. Some of them use the methodology similar to the one used in [3-7]. The proposed research has similarities with related research [3-7] regarding the fields of research, but the methodology used here is completely original and gives an insight in a comparative analysis of local and global levels.

Also, there are papers by other authors which deal with standardization, but with a different approach [8].

Compared to previous studies, according to [9], the annual sample of KS (on the ICS platform) is increased every year.

## 2. METHODOLOGY AND HYPOTHESES

The criteria of clustering vary depending on the separated and real innovation of KS, which is in accordance with the set goals and hypotheses.

### 2.1. Initial hypotheses

The initial hypotheses and research objectives are realized in the ICS fields with *daily intensity of innovation* through the PDCA (Plan, Do, Check, Act) method:

**Hypothesis\_1** - P (Plan) Planning and prediction of necessary future resources and financial requirements for KS – for each mentioned field at local (SRPS) and global (ISO) levels;

**Hypothesis\_2** - D (Do) Research and evaluation of knowledge sources enable obtaining explicit mathematical relations, and also trend lines of knowledge, as well as the possibility of comparing all the fields;

**Hypothesis\_3** - C (Check) There is a possibility of defining the correlations between knowledge with the intensity of innovation (Ii), with checks of clustered ICS fields according to the annual intensity of innovation at local (SRPS) and global (ISO) levels;

**Hypothesis\_4** - A (Act) Defining the relations between continuous (according to the PDCA) and discontinuous knowledge innovation, with the goal of improving knowledge base system on the platform of SRPS and ISO standardization.

### 2.2. Methodology

The statistical methodology and deductive - inductive methods have been used for predicting the future development and innovation. Methodologically, statistical indices have been formed for the comparison of ISO – SRPS relations in the fields of Information technology (ICS1 = 35) and other Engineering fields (ICS1 = 01, 23, 25, 29, 33, 49, 59, 75, 77, 83 and 91), i.e.: Quantity indices (Iq), value index (Iv) and index of quantitative variation for ranking (Iqi). The PDCA methodology and statistical research have been applied.

Quantity indices (Iq), defined and determined for both ISO and SRPS, refer to: Samples (Iqs), Published standards (Iqp), Standards Under development (Iqu), Standards Withdrawn from use (Iqw), Deleted projects (Iqd), Innovations in various stages of development (Iqi = Iqu/Year) - for the full previous calendar year. In general, for the knowledge sources (KS) - population Iqs, the equation (1) has been derived:

$$Iqs (KS) = Iqp + Iqw + Iqd + Iqu \quad (1)$$

Two original JAVA applications [3] have been used for the analysis of the results. The methodology simplifies the proofs of the initial hypotheses (see Section 2.1, Hypothesis 3), using the relation (2), [10] to continually or periodically update the knowledge base - depending on the increase of KS ( $\Delta KSt$ ).

$$Ii/ICS = \Delta KS_{t/ICS} \approx (Iqu_{global/t} + (Iqp + Iqw + Iqd)_{/global+local/t-1})_{ICS} \quad (2)$$

The relation  $Ii = \Delta KS_{year/ICS} = Ii_{year} \approx (Iqu_{/ISO/year} + (Iqp)_{/ISO+SRPS/year-1})_{ICS}$  has been applied to the examples of research  $\Delta KS_{year/ICS}$  in this paper.

## 3. RESULTS AND DISCUSSION

This section gives the results of the research related to local and global knowledge sources in Information technology and *Engineering fields* with the greatest (daily) intensity of innovation (ICS1 = 01, 23, 25, 29, 33, 49, 59, 75, 77, 83 and 91).

According to the applied methodology, 2017.01:

- on a sample of Iqs > 100000 KS,
- some of these fields (Table 2) are not the fields with the daily intensity of innovation (ICS1 = 29, 33, 59, 75 and 77),
- some fields do not belong to the engineering sciences (ICS1 = 11 - medicine, ICS1 = 13 - naturally- mathematical sciences).

The results are given for the period of three years (analysis of standards) in this field (ICS1 = 29, 33, 35) with two references [4, 5]. These results present systematized knowledge about engineering fields and Information technology field (ICS=35) where the authors also have significant results [3, 6, 7]. Another reason for choosing this period (2016-2017) for the analysis is that there is a declining line of trends in engineering fields in the last two years.

Innovation indices (Ii) of each field are determined by the cluster (year) of innovation (daily, weekly, monthly, etc.). The frequency of innovation is determined by the cluster:

- based on the annual time series of innovation, Table 1 (KS),
- based on the defined parameters of innovation (model), as well as
- according to the index indicators, Table 2 (increase of KS in code Ii or  $\Delta KS_{year/ICS}$ ).

The fields in which the values of this index (Ii) are greater than 250 (Ii > 250) belong to the cluster of daily innovation.

After the quantitative analysis we presented the examples of necessary resources and knowledge of all SRPS and ISO standards for all analyzed fields. Also, the examples of trend lines for SRPS and ISO are presented. An in-depth analysis of KS

innovation in the subfields of one of the four areas being compared, was presented in other papers, on the example of ICS1 = 29 [4-5]).

**Table 1.** Knowledge sources (KS), Innovation indices (Iqu, Iqp/i, Iqd...), indices of value (Iv), parallel ISO - SRPS, for the example: ICS1 = 29, 33, 35 (1.2015 - '15; 1.2016 - '16 and 1.2017 - '17)

I	Field/Year		Samples (Iqs)		Published (Iqp)		Withdrawn (Iqw)		Delete (Iqd)	Developed (Iqu)			Iqp/(Year-1)		Iv - "trend" Iv/(Year-1)		ΣIvalues (CHF) ΣIv/Year.01	
	ICS1	Year	ISO	Srps	ISO	srps	ISO	srps		ISO	ISO	srps	ISO	srps	ISO	srps	ISO	srps
1)	2)	3)	4)	5)	6)	7)	8)	9)	10)	11)	12)	13)	14)	15)	16)	17)	18)	
1	29	'15	66	2844	27	2391	27	405	0	12	48	1	136	138	3736	3006	70975	
		'16	71	3077	27	2604	27	448	0	17	25	0	259	0	7028	2556	71574	
		'17	91	3228	32	2626	31	557	0	12	45	9	127	1422	3004	4044	76519	
2	33	'15	200	2282	118	2143	73	101	1	8	38	1	227	88	7436	14922	62800	
		'16	201	2493	116	2374	80	115	0	5	4	1	252	88	7454	15062	69551	
		'17	209	2726	115	2548	82	171	0	4	7	1	224	118	7057	15224	75300	
3	35	'15	6693	1721	3407	1527	2425	177	49	812	17	238	239	33376	9927	377156	53392	
		'16	7023	1919	3618	1660	2638	256	53	714	3	411	217	46402	8379	399768	57437	
		'17	7315	2110	3728	1785	2823	287	93	631	38	302	157	38384	5564	434588	61919	

**Table 2.** Analysis results for innovation indices (Iqu and Iqp for Ii > 250, 2016), according to data 2017.1

ICS1	01	11	13	23	25	29	33	35	49	59	75	77	83	91
1)	2)	3)	4)	5)	6)	7)	8)	9)	10)	11)	12)	13)	14)	15)
Iqp/SRPS/2016	51	100	161	82	111	127	224	157	207	69	77	93	35	154
Iqu/ISO/2017	354	290	407	221	259	12	4	631	211	84	128	144	261	214
Ii/2017.1	405	390	568	303	370	139	228	788	418	133	205	237	296	368

Note: Iqu/ISO/2017 = Standards under development, including: Amd, Cor and Std (amendments, corrections and standards)

**3.1. Fields with daily intensity of innovation**

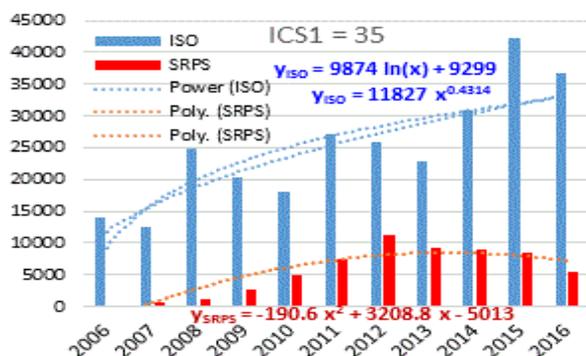
As a starting point, we have done a quantitative analysis for all *Engineering fields* with daily intensity of innovation (ICS1 = 01, 23, 25, 35, 49, 83, 91). This is shown in Table 1, which provides a possibility of comparing local and global level of knowledge sources: Iqs/35/ISO/2017.1 = 7315, Iqs/35/SRPS/2017.1 = 2110 etc.

The table presents all fields, their indices and values in CHF. The presented results are given for the local (SRPS) and global (ISO) levels.

The analysis results for ICS1 = 35, are presented graphically in Fig. 1 and Fig. 2.2: with the trend of planned future needs, according to the relations (3.1) and (3.2).

$$Y_{35/ISO/2006-2016} = \text{Logarithmic/Power/Linear} \quad (3.1)$$

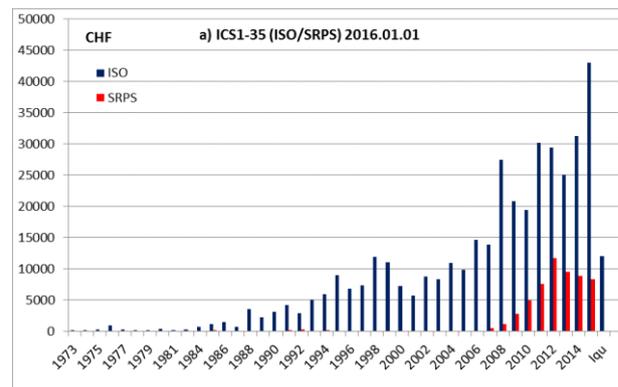
$$Y_{35/SRPS/2006-2016} = - \text{Polynomial} (2012_{max}) \quad (3.2)$$



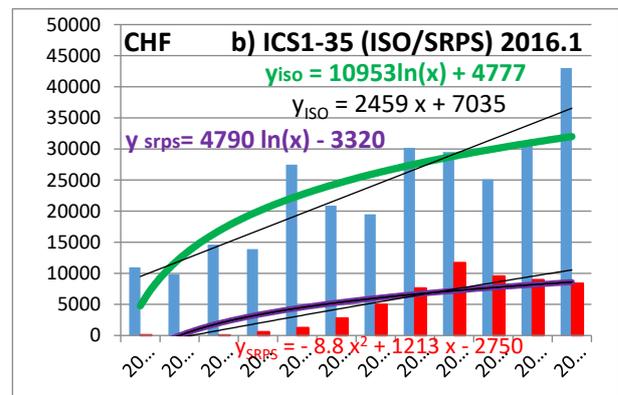
**Figure 1.** Analysis results for ICS1 = 35 (2017)

An additional analysis of the results is graphically shown in Fig. 2.1: a) with all available KS from the period from 1973 to 2015 (Iqu); Fig. 2.2: b) with

the trend of planned future needs, according to the relations (3.1) and (3.2)



**Figure 2.1.** Analysis of KS for ICS1 = 35 (2016.1)

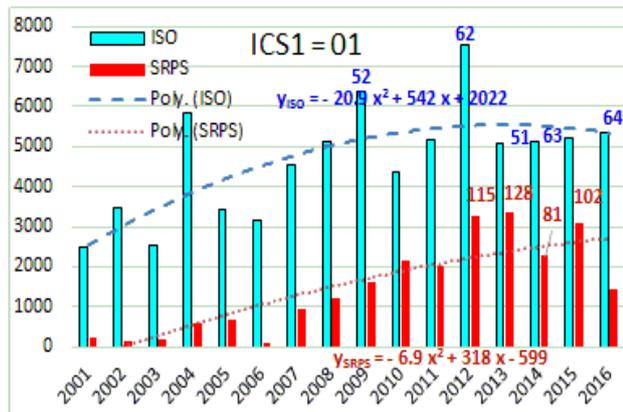


**Figure 2.2.** Results for ICS1 = 35 (2016)

The analysis results for ICS = 01 are presented graphically in Fig. 3, with all available samples from the period from 2001 to 2016, with the trend of planned future needs for KS, according to the relations (ISO - 4.1) and (SRPS - 4.2).

$$Y_{01/ISO/2001-2016} = - \text{Polynomial/ Linear} \quad (4.1)$$

$$Y_{01/SRPS/2007-2016} = \text{Polynomial (2013}_{\max}) \quad (4.2)$$

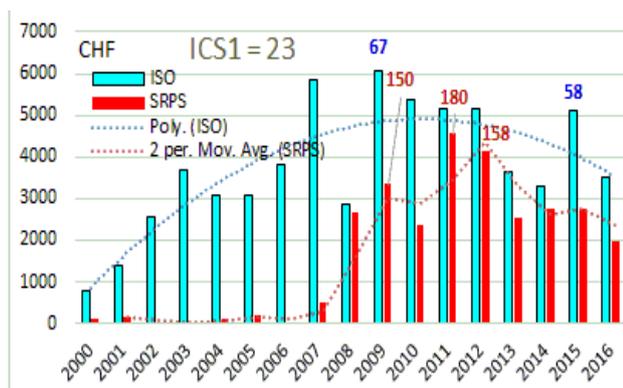


**Figure 3.** Results for ICS1 = 01 (2017)

The analysis results for ICS = 23, are presented graphically in Fig. 4, with all available samples from the period from 2000 to 2016, with the trend of planned future needs for KS, according to the relations (ISO - 5.1) and (SRPS - 5.2).

$$Y_{23/ISO/2001-2016} = \text{Polynomial (2009}_{\max}) \quad (5.1)$$

$$Y_{23/SRPS/2007-2016} = \text{Polynomial (2013}_{\max}) \quad (5.2)$$

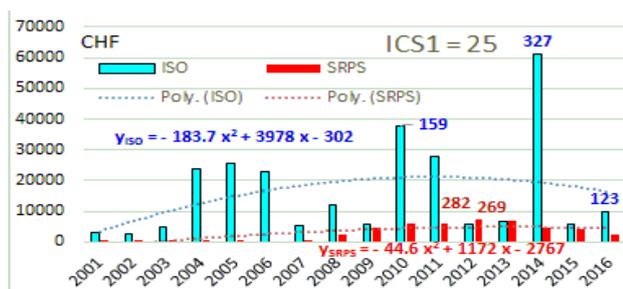


**Figure 4.** Results for ICS1 = 23 (2017)

The analysis results for ICS = 25, are presented graphically in Fig. 5, with all available samples from the period from 2001 to 2016, with the trend of planned future needs for KS, according to the relations (ISO - 6.1) and (SRPS - 6.2).

$$Y_{25/ISO/2001-2016} = \text{Polynomial/ Linear} \quad (6.1)$$

$$Y_{25/SRPS/2007-2016} = \text{Polynomial (2012}_{\max}) \quad (6.2)$$



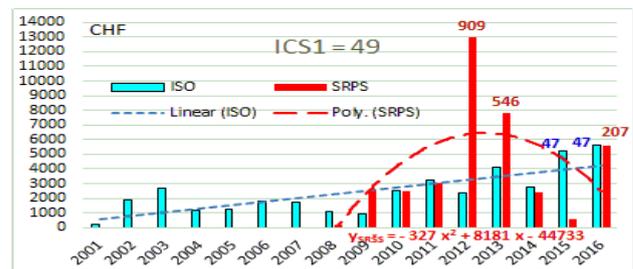
**Figure 5.** Results for ICS1 = 25 (2017)

The analysis results for ICS=49 are presented graphically in Fig. 6, with all available samples from the period from 2001 to 2016, with the trend of

planned future needs for KS, according to the relations (ISO - 7.1) and (SRPS - 7.2).

$$Y_{49/ISO/2001-2016} = \text{Linear} \quad (7.1)$$

$$Y_{49/SRPS/2007-2016} = \text{Polynomial (2012}_{\max}) \quad (7.2)$$

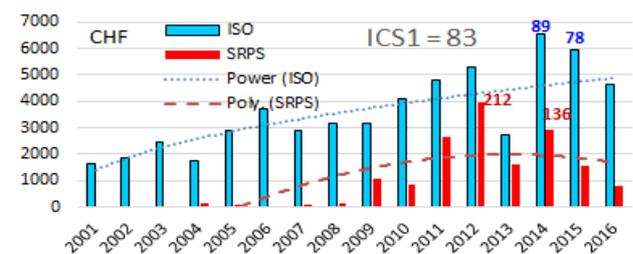


**Figure 6.** Results for ICS1 = 49 (2017)

The analysis results for ICS = 83 are presented graphically in Fig. 7, with all available samples from the period from 2001 to 2016, with the trend of planned future needs for KS, according to the relations (ISO - 8.1) and (SRPS - 8.2).

$$Y_{83/ISO/2001-2016} = \text{Power/} \approx \text{Linear} \quad (8.1)$$

$$Y_{83/SRPS/2007-2016} = \text{Polynomial (2012}_{\max}) \quad (8.2)$$

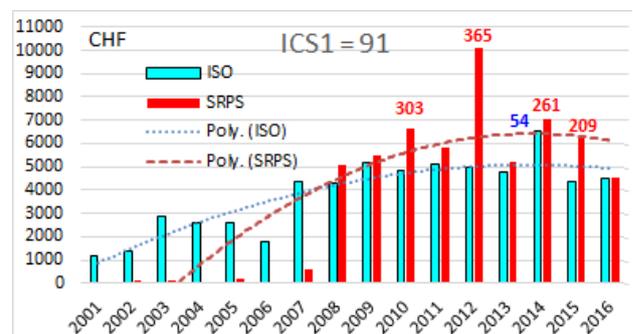


**Figure 7.** Results for ICS1 = 83 (2017)

The analysis results for ICS = 91 are presented graphically in Fig. 8, with all available samples from the period from 2001 to 2016, with the trend of planned future needs for KS, according to the relations (ISO - 9.1) and (SRPS - 9.2).

$$Y_{91/ISO/2001-2016} = \text{Polynomial (2014}_{\max}) \quad (9.1)$$

$$Y_{91/SRPS/2007-2016} = \text{Polynomial (2012}_{\max}) \quad (9.2)$$



**Figure 8.** Results for ICS1 = 91 (2017)

### 3.2. Changes in the annual innovation index

In this section, five fields are presented (ICS1 = 29, 33, 59, 75 and 77):

- Innovation index (Ii) values in previous years were greater than 250 (Ii > 250),

- belonged to the cluster of daily innovation,
- and in 2017 this index was significantly reduced ( $I_i < 250$ ).

The analysis results for  $ICS = 29$  are presented graphically in Fig. 9.1 and Fig. 9.2: with all available samples from the period from 2003 to 2016, with the trend of planned future needs, according to the relations (10.1) and (10.2).

$$Y_{29/ISO/2008-2015} = \text{Linear} \quad (10.1)$$

$$Y_{29/SRPS/2008-2016} = - \text{Polynomial} (2010_{\max}) \quad (10.2)$$

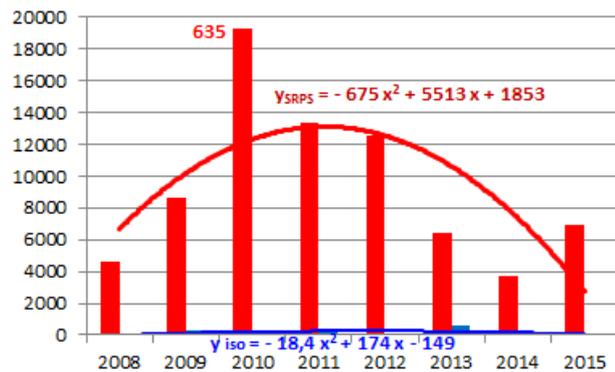


Figure 9.1. Results for  $ICS1 = 29$  (2016)

The annual KS innovations (SRPS) reached a maximum in 2012 (in Fig. 9.1,  $I_{qp/29/SRPS/2015\_for\_2010} = 635$ ; in Fig. 9.2,  $I_{qp/29/SRPS/2016\_for\_2010} = 602$  KS)

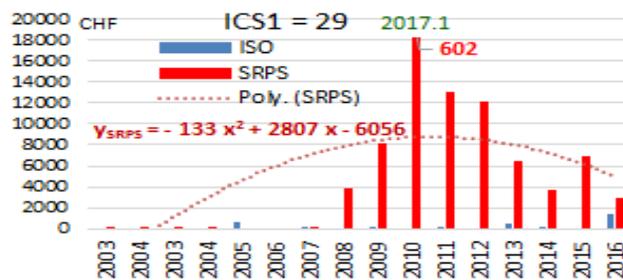


Figure 9.2. Results for  $ICS1 = 29$  (2017)

The analysis results for  $ICS = 33$  are presented graphically in Fig. 10.1 and 10.2: with all available samples from the period from 2001 to 2016; with the trend of planned future needs, according to the relations (11.1) and (11.2).

$$Y_{33/ISO/2001-2016} \approx \text{Linear} \quad (11.1)$$

$$Y_{33/SRPS/2007-2016} = - \text{Polynomial} (2012_{\max}) \quad (11.2)$$

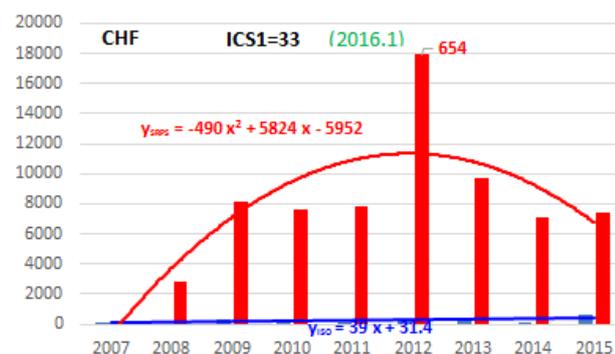


Figure 10.1. Results for  $ICS1 = 33$  (2016)

The analysis results are presented graphically in Results for  $ICS1 = 33$ : with all available samples from the period from 1980 to 2015; Fig. 10.1: with the trend of planned future needs, according to the relations (11.3) and (11.4).

$$Y_{33/ISO/2007-2015} = - 490 x^2 + 5824 x - 5952.4 \quad (11.3)$$

$$Y_{33/SRPS/2007-2015} = 39 x + 31.4 \quad (11.4)$$

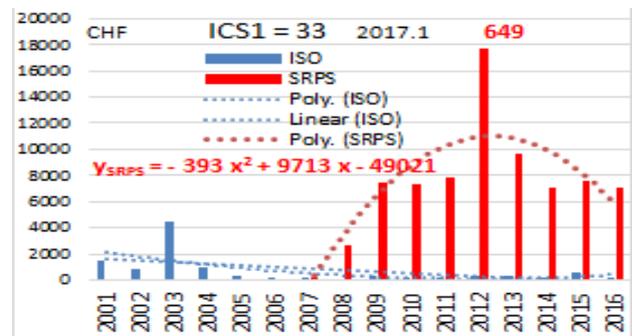


Figure 10.2. Results for  $ICS1 = 33$  (2017)

The innovation trend in this field (for  $ICS = 33$ ) is very similar to the trend in the field of Electrical engineering (for  $ICS = 29$ , see Fig. 9.1. and 9.2).

The annual KS innovations (SRPS) reached a maximum in 2012 ( $I_{qp/33/SRPS/2015\_for\_2012} = 654$  KS;  $I_{qp/33/SRPS/2016\_for\_2012} = 649$  KS).

The analysis results for  $ICS = 59$  are presented graphically in Fig. 11, with all available samples from the period from 2001 to 2016, with the trend of planned future needs for KS, according to the relations (ISO - 12.1) and (SRPS - 12.2).

$$Y_{59/ISO/2001-2016} = \text{Linear} \quad (12.1)$$

$$Y_{59/SRPS/2007-2016} = - \text{Polynomial} (2012_{\max}) \quad (12.2)$$

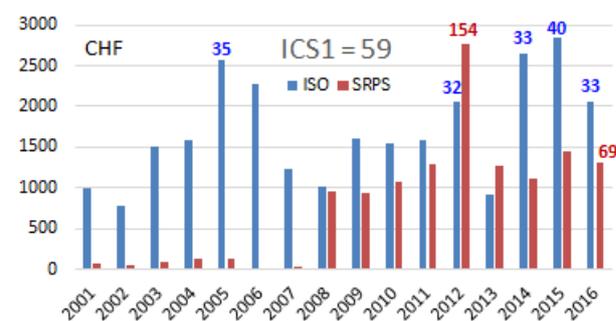


Figure 11. Results for  $ICS1 = 59$  (2017)

The analysis results for  $ICS = 75$  are presented graphically in Fig. 12, with all available samples from the period from 2001 to 2016, with the trend of planned future needs for KS, according to the relations (ISO - 13.1) and (SRPS - 13.2).

$$Y_{59/ISO/2001-2016} = \text{Linear} \quad (13.1)$$

$$Y_{59/SRPS/2007-2016} = - \text{Polynomial} (2011_{\max}) \quad (13.2)$$

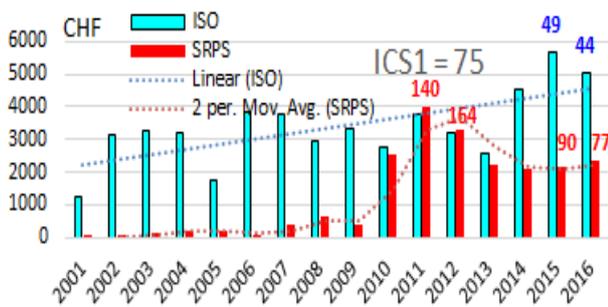


Figure 12. Results for ICS1 = 75 (2017)

The analysis results for ICS=77 are presented graphically in Fig. 13, with all available samples from the period from 2001 to 2016, with the trend of planned future needs for KS, according to the relations (ISO - 14.1) and (SRPS - 14.2).

$$Y_{77/ISO/2001-2016} = \text{Linear} \quad (14.1)$$

$$Y_{77/SRPS/2007-2016} = \text{Polynomial} (2012_{\max}) \quad (14.2)$$

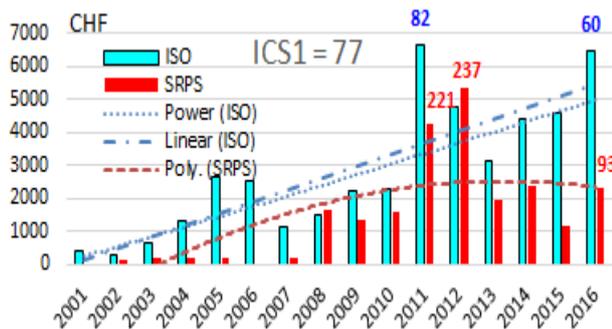


Figure 13. Analysis results for ICS1 = 77 (2017)

### 3.3. Discussion in the PDCA form

Based on these results, the discussion can be opened according to the presented initial hypotheses in PDCA: Plan – Do – Check – Act.

#### Plan: Resources

Future resources and financial requirements for each mentioned field at local (SRPS) and global (ISO) levels could be planned and predicted according to the presented results. The equations for trend lines have been established and the number of knowledge sources which are under development have been defined in this research. Table 1 (for analyzed fields) presents obvious facts and questions:

- The highest value of knowledge sources is in IT field

$$\sum IV_{/35/ISO/2016.01} = 399768 \text{ CHF (column 17),}$$

- Question: Who could plan those resources (or knowledge sources in ISO standard form)?
- The value of local knowledge sources (in SRPS standard form) has a normal statistical distribution (Gaussian curve).

### Do: Research and development

The original equations for trend lines of knowledge sources according to ICS have been established and presented in this research.

Knowledge sources are defined on the ICS platform with innovation intensity indices, value indices and other indices for comparison.

Information technologies were compared (ICS1 = 35) with all areas of ICS1, especially with engineering fields (ICS1 = 01, 23, 25, up to 91), with the highest intensity of innovation.

In the analysis of local KS (SRPS), the most common trend lines are *Polynomial*:

- in eight out of 12 analyzed fields (67%) the maximum is reached in 2012,
- intensive innovations began in 2008, as for the most of the images given in the paper,
- the illustrations obviously show a greater number of local (SRPS) innovations, but with significantly lower value indices, etc.

### Check: Innovations and clustered fields

At this stage, the correlations between the level of innovation of knowledge sources by ICS, local and global levels, are analyzed. They are specifically intended for analyzing the clusters with the daily intensity of innovation (2017), which is comparable with the analyses in [9] - 2016-2015-2014). By comparing the local and global levels, it is concluded that the four engineering fields, due to the reduction of innovations and sources of knowledge at the local level (SRPS level), have moved from the cluster of daily innovation to the cluster of weekly innovation. A comparative analysis of the annual number of innovations (Ii) of ISO–SRPS KS on the examples of global innovations ( $I_{qu/ISO/year}$ ) and local publications ( $I_{qp/SRPS/(year-1)}$ ), is shown in Fig. 14.

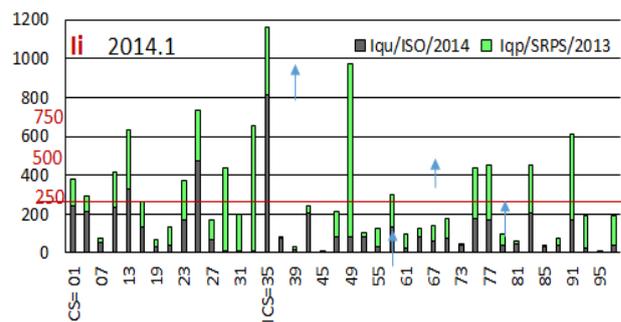


Figure 14. Comparative analysis (Ii) of innovations of KS ISO–SRPS (2014)

Tables 1 and 2, as well as Figures 1 to 13 (for analyzed fields) give obvious facts:

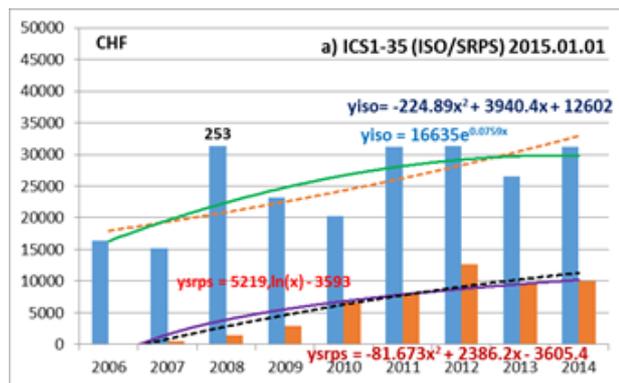
- from all international (ISO) projects under construction, most of them are in IT field ( $I_{qu/35/ISO/2017} = 621$ , column 9, Table 2),
- the number of SRPS innovations is higher than on ISO level,  $I_{qp/(29,33)/SRPS}$  (column 13 and 14),

- the most SRPS innovations are in Telecommunication; Audio and video engineering, (ICS1 = 33),  $Iq_{p/33/SRPS/2017} = 224$  (column 14).

**Act: Improvement**

Phase Act defines this methodology as applicable to any other field and gives possibilities for future research.

As an addition to the comparison of the results, in this research we have done an analysis for previous years (1.2015 and 1.2016). These results are presented in Fig. 15 and Fig.16. We chose more equations for trend lines to prove the similarities (Polynomial/ Linear/ Logarithmic/ Power...) for planning the necessary resources.



**Figure 15.** Result for IT (ICS1 = 35): 2015.01

Fig.15 and Fig. 16 show the number of KS for 2008, and according to the given data we can discuss the withdrawn standards through the years.

E.g, value for KS,  $Iq_{S/35/ISO/2008} = 217$  (2016.01, Fig. 16), reduced, relative to  $Iq_{S/35/ISO/2008} = 253$  (2015.01, Fig. 15).

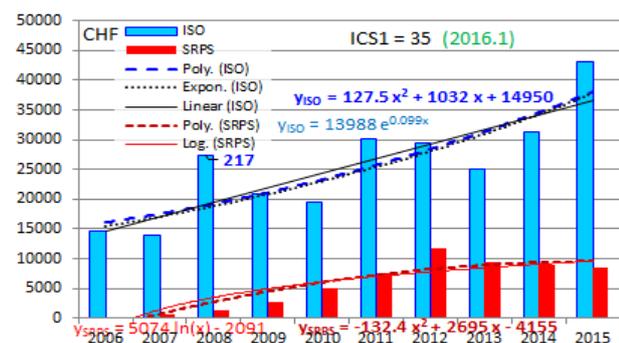
Fig. 15 and Fig. 16 show the trend of planned future needs for two periods of the analysis (January 2015 and January 2016), according to the relations (3.3), (3.4), (3.5), (3.6), (3.7), (3.8), (3.9) and (3.10).

$$Y_{35/ISO/2006-2014} = -224.89x^2 + 3940.4x + 12602 \quad (3.3)$$

$$Y_{35/ISO/2006-2014} = 16635 e^{0.0759x} \quad (3.4)$$

$$Y_{35/SRPS/2006-2014} = -81.67x^2 + 2386x - 3605.4 \quad (3.5)$$

$$Y_{35/SRPS/2006-2014} = 5219 \ln(x) - 3593 \quad (3.6)$$



**Figure 16.** Analysis results for IT (ICS1 = 35) 2016

$$Y_{35/ISO/2006-2015} = 127.5x^2 + 1032x + 14950 \quad (3.7)$$

$$Y_{35/ISO/2006-2015} = 13988 e^{0.099x} \quad (3.8)$$

$$Y_{35/SRPS/2006-2015} = -132.4x^2 + 2695x - 4155 \quad (3.9)$$

$$Y_{35/SRPS/2006-2015} = 5074 \ln(x) - 2091 \quad (3.10)$$

Although the trend lines (mathematically observed) give similar results in resource planning, this can be discussed from several aspects:

- The choice of the most favorable trend line (exponential / linear / logarithmic / polynomial / power),
- The comparison and deviations of the planned resources based on the mathematical trend line in relation to the actual realization (which is particularly relevant for the planning and realization of ISO projects),
- The comparison of innovations on local (SRPS) and global (ISO) platforms,
- The approximations included in the methodology,
- Project for the development and implementation of an information-expert system (IES),
- The necessary experience of planners (managers), etc.

Fig. 15, Fig. 16 and Fig.1 show significant quantitative quantities / quantities of innovation (numerical and value) in 2015, 2016 and 2017. At the same time, the number and value of liabilities in previous years are also reduced.

This means that a professional should know about new sources, but also about those standards that are out of use.

By comparing this research to the related research, this paper gives a proposal to analyze knowledge sources on local and global levels with PDCA approach.

**4. CONCLUSION**

Based on the presented hypotheses and results, what follows are the conclusions reached through the PDCA methodology:

**Plan: Planning resources for KS**

According to the presented results a plan for future research (and innovation of the knowledge base) is defined. Apart from a statistical analysis, future research will include data mining techniques for predicting the number of KS at local and global levels.

**Do: Products development**

D (Do); "Do"- phase: Research and evaluation of KS enable obtaining explicit mathematical relations (3-14), as well as trend lines of knowledge sources in ICS1

The given results and indices analyses enable better organization of future tasks in the

standardization of applications and products in the mentioned fields (ICS1 = 23, 25, 33, 35, 49, 83, 91).

#### **Check: The intensity of innovation (Ii) - daily**

Check phase proposes the activities for checking the initial hypotheses (according to the relation (2)) and gives an original methodology for future work which could be applied to all fields.

The following possibilities have been proven:

- The possibility of defining correlations between KS with daily (or weekly) intensity of innovation (Ii),
- With checking the clustered ICS1 fields, according to the annual intensity of innovation at local (SRPS) and global (ISO) levels.

#### **Act: Applications and system improvements**

Act-phase includes the creation of a Web based application and system (IES) for obtaining the correlations between the statistical results and knowledge improvements in order to improve the *knowledge base system* in PDCA.

#### **ACKNOWLEDGMENT**

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# Comparative Analysis of the Development and Application of Standards for Software Development in Serbia and BiH

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**Abstract:** *The paper analyzes and crosses the state of local SRPS and standardization from the neighboring state of Bosnia and Herzegovina BAS, in the field of information technologies. The accent is given on published standards; i.e. the standards currently in use in the field of Information Technology - ICS1 = 35; Substance Software - ICS2 = 35.080.*

*Presented in the paper are the current standards in the field of software development as well as the organizations dealing with them, with reference to the state of local standardization in relation to the standardization of the neighboring country.*

*The aim of the research is to look at the status quo from several different aspects in the field of software development.*

*The results of the research indicate the current state and the position of local standardization in relation to the neighboring country and serve as an indicator of the necessary financial resources for software standards; and their mutual differences in number per year.*

**Keywords:** *Software; Trend; Standardization; SRPS; BAS*

## 1. INTRODUCTION

Software Engineering is the youngest engineering discipline and, as such, still contains a high degree of arbitrariness and individuality. The process of software design itself is largely lacking in methods and techniques, as well as in appropriate tools to make it more efficient. Lack of development standards is even more pronounced. The significance of the problem is multiply emphasized by the need to ensure software quality and software-based systems.

The success of projects in each business, including in software engineering, is conditioned by the application of appropriate standardization. Software projects are becoming more and more complex, and there is a need for defining a formal project management process. Project management and the application of standardization aim at the efficient use of resources, the equal distribution of jobs and the establishment of a plan so that the project can be implemented within the deadline, as it is intended, with the envisaged way of execution and expected results. Although various standards have been developed, the percentage of unsuccessful projects is high. This tells us that further development and improvement of existing standards is needed in the future.

The presented research deals with comparative analysis of local (SRPS) and standards from the

neighboring state of Bosnia and Herzegovina (BAS) in the field of Information technology - ICS1 = 35, sub-content Software - ICS2 = 35.080. The Information Technology area is standardized by the International Organization for Standardization (ISO) and the International Electrotechnical Commission for (IEC) [1].

The aim of the paper is to analyze the situation in the stated field of standardization and forecast future financial requirements for standards in the field of software.

## 2. METHODOLOGY AND FRAMEWORK OF RESEARCH

In this paper, a dynamic analysis methodology was used, as well as statistical methods for comparing groups of standards using the t - test.

The tasks and framework can be presented in the shortest terms through the PDCA concept:

**P (Plan)** - software development planning based on neighboring country (BAS) and local (SRPS) standardization

The collection of data on standardization of the neighboring state (BAS) and local (SRPS) standardization was done with the web presentations of the Institute for Standardization of Bosnia and Herzegovina and the Republic of Serbia.

During the selection, data related to standards in the field of Information technology were separated - ICS1 = 35 subclass Software - ICS2 = 35.080 with emphasis on current standards.

**D (Do)** - Comparison of group of standards

SRPS-BAS for Software Development in Information Technology. Comparison of the SRPS - BAS standard group for software development in the field of Information Technology was done using the t - test method.

**C (Check)** - check the intensity of innovation

The original methodology that quantifies the intensity in BAS-SRPS innovation can be applied to the standards in the field of Information Technology - ICS1 = 35; Substance Software - ICS2 = 35.080.

**A (Act)** - Analysis of results and improvement of application

Improving the application of the standard in the field of Information technology - ICS1 = 35 subaltern Software - ICS2 = 35.080 in Serbia implies the improvement of the methodology of innovating standards.

**3. RESULTS AND DISCUSSION**

Differences in the arithmetic mean of the sample ( $\bar{x}_1 - \bar{x}_2$ ) will follow the t - test law if two independent independent sets of the size of  $N_1$  and  $N_2$  units whose variances are equal  $\sigma_1^2 = \sigma_2^2$  are observed. Their unique value is estimated based on the variance. [2]

The value of the parameters  $t_0$  is calculated based on the relation [3]:

$$t_0 = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{S(\bar{x}_1 - \bar{x}_2)} \tag{1}$$

The estimate of the standard error of the difference in the arithmetic mean of the sample  $S(\bar{x}_1 - \bar{x}_2)$  is calculated as follows [4]:

a) If the data in the sample is ungrouped:

$$S(\bar{x}_1 - \bar{x}_2) = \sqrt{\frac{\sum_{i=1}^{n_1} x_{i1}^2 - n_1 \bar{x}_1^2 + \sum_{i=1}^{n_2} x_{i2}^2 - n_2 \bar{x}_2^2}{n_1 + n_2 - 2}} \left( \frac{1}{n_1} + \frac{1}{n_2} \right) \tag{2}$$

b) If the data in the sample is grouped:

$$S(\bar{x}_1 - \bar{x}_2) = \sqrt{\frac{\sum_{i=1}^{n_1} x_{i1}^2 f_{i1} - n_1 \bar{x}_1^2 + \sum_{i=1}^{n_2} x_{i2}^2 f_{i2} - n_2 \bar{x}_2^2}{n_1 + n_2 - 2}} \left( \frac{1}{n_1} + \frac{1}{n_2} \right) \tag{3}$$

In this case, the hypothesis reads:

$H_0 : (\mu_1 - \mu_2) = (\mu_1 - \mu_2)_0; H_1 : (\mu_1 - \mu_2) \neq (\mu_1 - \mu_2)_0$  (4)

$H_0 : (\mu_1 - \mu_2) \geq (\mu_1 - \mu_2)_0; H_1 : (\mu_1 - \mu_2) < (\mu_1 - \mu_2)_0$  (5)

$H_0 : (\mu_1 - \mu_2) \leq (\mu_1 - \mu_2)_0; H_1 : (\mu_1 - \mu_2) > (\mu_1 - \mu_2)_0$  (6)

The table value  $t_{(\alpha, r)}$  reads the error rate  $\alpha$  and  $r$  of the number of degrees of freedom, according to the formula [5]:

$$r = n_1 + n_2 - 2 \tag{7}$$

In order to examine the average annual number of standards in the field of software development, in two different countries, in this case in Serbia and BiH, in the random way from the first and second groups, they were selected for ten years, in which they were published, with the total number .

With a probability of 95%, it was tested:

1. Can the zero hypothesis  $H_0$  be accepted that the difference in the average annual number of standards, by years, is incidental or statistically significant and depends on the country in which it is issued?
2. Can the zero  $H_0$  hypothesis be accepted that the difference in the average number of standards in the above-mentioned area is not higher than 15 standards in the listed countries?

**Table 1.** Overview of current SRPS / BAS standards on 20th March 2018, according to the number [6, 7]

Year	Number of standards	
	SRPS	BAS
1998	1	2
2002	0	18
2004	1	16
2008	1	13
2010	10	28
2011	2	9
2012	15	9
2013	0	12
2015	17	5
2017	20	30
Total	67	142

Taking into account that the number of standards is at the level of one year, the frequency value  $f = 1$  will be used.

The average annual number of standards is calculated as follows:

$$\bar{x}_{SRPS} = \frac{\sum_{i=1}^n x_i \cdot f_i}{\sum_{i=1}^n f_i} = \frac{67}{10} = 6.7 \text{ standards} \tag{8}$$

The average annual number of standards in the field of software development in Serbia on a sample of ten years is 6.7 standards.

$$\bar{x}_{BAS} = \frac{\sum_{i=1}^n x_i \cdot f_i}{\sum_{i=1}^n f_i} = \frac{142}{10} = 14.2 \text{ standards} \tag{9}$$

The average annual number of standards in the field of software development in BiH for a sample of ten years is 14.2 standards.

The estimate of the standard error of the arithmetic mean difference is calculated on the basis of formula (3):

$$S_{(\bar{x}_{SRPS} - \bar{x}_{BAS})} = \sqrt{\frac{1021 - 10 * 6.7^2 + 2768 - 10 * 14.2^2}{10 + 10 - 2} * \left(\frac{1}{10} + \frac{1}{10}\right)}$$

$$S_{(\bar{x}_{SRPS} - \bar{x}_{BAS})} = 3.83 \quad (10)$$

Hypotheses are tested:

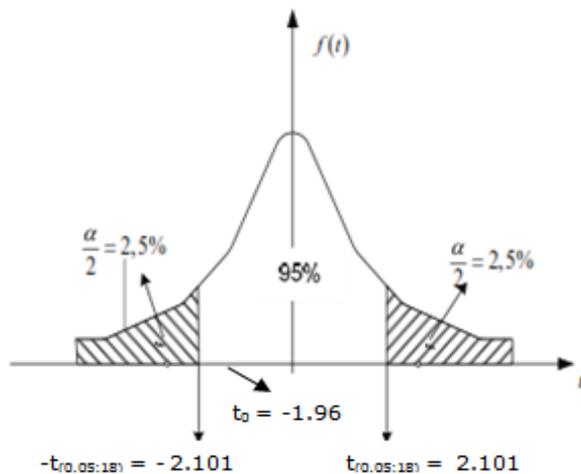
$H_0 : (\mu_1 - \mu_2) = (\mu_1 - \mu_2)_0$ ;  $H_1 : (\mu_1 - \mu_2) \neq (\mu_1 - \mu_2)_0$ , and the assumed difference  $(\mu_1 - \mu_2) = 0$ ;

The value of parameters  $t_0$  is calculated according to formula (1) and it is:

$$t_0 = \frac{6.7 - 14.2 - 0}{3.83} = -1.96 \quad (11)$$

For the risk of error  $\alpha = 0.05$  and the number of degrees of freedom  $r = 10 + 10 - 2 = 18$  value  $t_{(0.05; 18)} = \pm 2.101$ .

Since  $t_0 = -1.96 > t_{(0.05; 18)} = -2.101$ , the hypothesis  $H_0$  is accepted at the risk of error  $\alpha = 5\%$  and it can be considered that the difference in the average annual number of standards in software development in Serbia and BiH coincidental and can be attributed to random variation of data in samples. The difference  $\bar{x}_{SRPS} - \bar{x}_{BAS} = 6.7 - 14.2 = -7.5$  is random. This means that the average annual number of standards does not depend on the country in which it is published.



**Figure 1. Acceptance and rejection**  
 $H_0 : (\mu_1 - \mu_2) = 0$ ;  
 $H_1 : (\mu_1 - \mu_2) \neq 0$

2) The hypotheses in this case are:

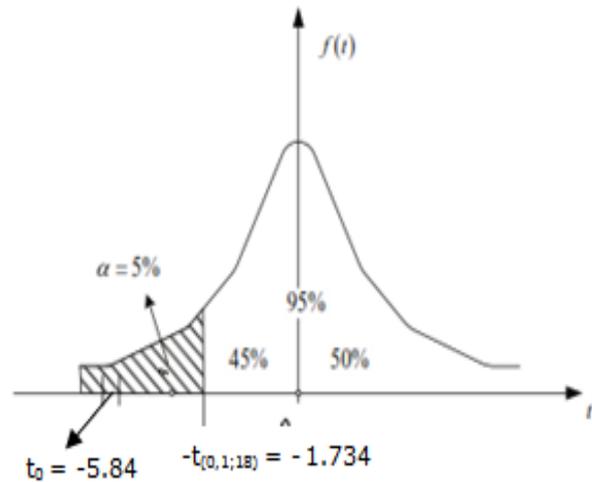
$H_0 : (\mu_1 - \mu_2) \leq 15$  standards;

$H_1 : (\mu_1 - \mu_2) > 15$  standards;

This is a one-way test, the table value  $t_{(0.10; 18)} = \pm 1.734$ ; ( $2\alpha = 10\%$ ).

The value of parameters  $t_0$  is calculated according to formula (1) and it is:

$$t_0 = \frac{6.7 - 14.2 - 15}{3.83} = -5.84 \quad (12)$$



**Figure 2. Acceptance and rejection**  
 $H_0 : (\mu_1 - \mu_2) \leq 15$ ;  
 $H_1 : (\mu_1 - \mu_2) > 15$

Since  $t_0 = -5.84 < t_{(0.10; 18)} = -1.734$ , the  $H_0$  hypothesis is not accepted, with the risk of error  $\alpha = 5\%$ , and it can not be considered that the difference in the average annual number of standards in software development in Serbia and BiH, less than 15 standards per year. The difference  $\bar{x}_{SRPS} - \bar{x}_{BAS} = 6.7 - 14.2 - 15 = -22.5$  is statistically significant and can not be attributed to the random variation of data in the samples.

In order to examine the average annual price of software development standards, in two different countries, in this case in Serbia and BiH, in the random way from the first and second groups, they were selected for ten years, in which they were published, with the total values standards.

With a probability of 95% testing:

1. Can the zero hypothesis  $H_0$  be accepted? Is the difference in the average annual value of the standard, by age, random or statistically significant, and depends on the country in which it is issued?
2. Can the zero hypothesis  $H_0$  be accepted that the difference in the average value of the standard in the above-mentioned area is not greater than 10 CHF;

**Table 2.** Overview of current SRPS / BAS standards on 20th March 2018, by number and average value <sup>1</sup>

Year	SRPS		BAS	
	Average value (CHF)	Number of standards	Average value (CHF)	Number of standards
1998	45.09	1	31.47	2
2002	0	0	35.95	18
2004	38.33	1	47.25	16
2008	42.7	1	31.41	13
2010	39.65	10	58.35	28
2011	31.82	2	66.87	9
2012	32.88	15	41.57	9
2013	0	0	48.88	12
2015	37.6	17	25.05	5
2017	36.87	20	49.08	30
Total	304.94	67	435.88	142

The average annual value of the standard is calculated using the data in Table 3, as follows:

**Table 3.** Worksheet for calculation of SRPS standardization parameters

Year	SRPS			
	Average value $x_i$	Number of standards $f_i$	$x_i * f_i$	$x_i^2 * f_i$
1998	45.09	1	45.09	2033.108
2002	0	0	0	0
2004	38.33	1	38.33	1469.189
2008	42.7	1	42.7	1823.29
2010	39.65	10	396.5	15721.23
2011	31.82	2	63.64	2025.025
2012	32.88	15	493.2	16216.42
2013	0	0	0	0
2015	37.6	17	639.2	24033.92
2017	36.87	20	737.4	27187.94
Total	304.94	67	2456.06	90510.11

$$\bar{x}_{SRPS} = \frac{\sum_{i=1}^n x_i \cdot f_i}{\sum_{i=1}^n f_i} = \frac{2456.06}{67} = 36.66 \text{ CHF} \quad (13)$$

<sup>1</sup> Average values are calculated on the middle exchange rate NBS on 20th March 2018, and the values are:

$$1 \text{ CHF} = 100.8167 \text{ RSD} = 1.67237 \text{ BAM}$$

The average annual value of software development standards in Serbia for a sample of ten years is 36.66 CHF.

**Table 4.** Worksheet for calculation of BAS standardization parameters

Year	BAS			
	Average value $x_i$	Number of standards $f_i$	$x_i * f_i$	$x_i^2 * f_i$
1998	31.47	2	62.94	1980.72
2002	35.95	18	647.1	23263.2
2004	47.25	16	756	35721
2008	31.41	13	408.33	12825.6
2010	58.35	28	1633.8	95332.2
2011	66.87	9	601.83	40244.4
2012	41.57	9	374.13	15552.6
2013	48.88	12	586.56	28671.1
2015	25.05	5	125.25	3137.51
2017	49.08	30	1472.4	72265.4
Total	435.88	142	6668.34	328994

$$\bar{x}_{BAS} = \frac{\sum_{i=1}^n x_i \cdot f_i}{\sum_{i=1}^n f_i} = \frac{6668.34}{142} = 46.96 \text{ CHF} \quad (13)$$

The average annual value of software development standards in BiH for a sample of ten years is 46.96 CHF.

The estimate of the standard error of the arithmetic mean difference is calculated on the basis of formula (3):

$$S_{(\bar{x}_{SRPS} - \bar{x}_{BAS})} = \sqrt{\frac{90511.11 - 67 \cdot 36.66^2 + 328944 - 142 \cdot 46.96^2}{142 + 67 - 2} \cdot \left(\frac{1}{142} + \frac{1}{67}\right)}$$

$$S_{(\bar{x}_{SRPS} - \bar{x}_{BAS})} = 1.31 \quad (14)$$

The average mean deviation of the difference in arithmetic mean in arithmetic mean samples in the basic set is 1.31 CHF.

Hypotheses are tested:

$$H_0 : (\mu_1 - \mu_2) = (\mu_1 - \mu_2)_0;$$

$$H_1 : (\mu_1 - \mu_2) \neq (\mu_1 - \mu_2)_0,$$

and the assumed difference  $(\mu_1 - \mu_2) = 0$ ;

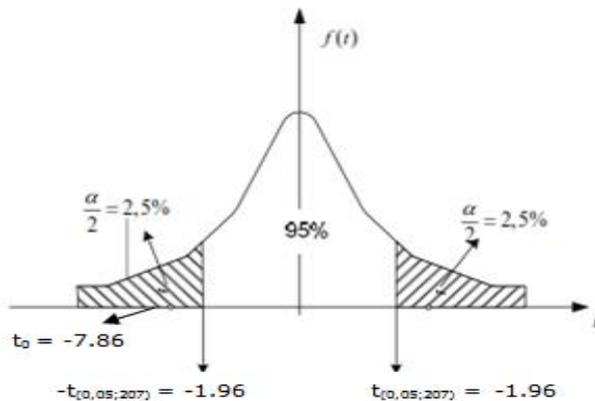
The value of parameters  $t_0$  is calculated according to formula (1) and it is:

$$t_0 = \frac{36.66 - 46.96 - 0}{1.31} = -7.86 \quad (15)$$

For the risk of error  $\alpha = 0.05$  and the number of degrees of freedom  $r = 67 + 142 - 2 = 207$  value  $t_{(0.05; 207)} = \pm 1.96$ .

How is  $t_0 = -7.86 > t_{(0.05; 207)} = \pm 1.96$ , the hypothesis  $H_0$  is not accepted at the risk of error  $\alpha = 5\%$  and it can not be considered that the difference in the average annual value of the standards in the field of software development in Serbia and BiH are random and can not be

attributed to random variation of data in samples. Difference  $\bar{x}_{SRPS} - \bar{x}_{BAS} = 36.66 - 46.96 = -10.3$  CHF is not a coincidence. This means that the average annual value of the standard is dependent on the country in which it is published in the specified area.



**Figure 3.** Acceptance and rejection

$$H_0 : (\mu_1 - \mu_2) = 0;$$

$$H_1 : (\mu_1 - \mu_2) \neq 0$$

2) The hypotheses in this case are:

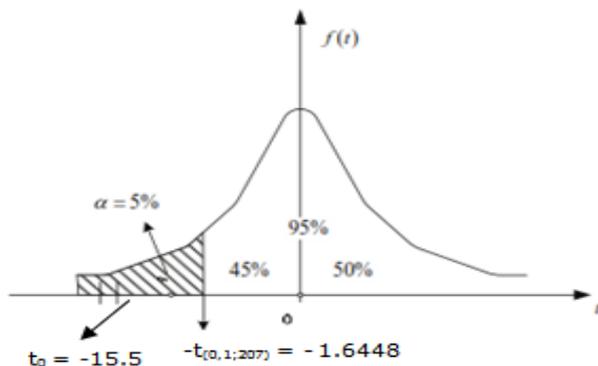
$$H_0 : (\mu_1 - \mu_2) \leq 10 \text{ CHF};$$

$$H_1 : (\mu_1 - \mu_2) > 10 \text{ CHF};$$

This is a one-way test, the table value  $t_{(0,10; 207)} = \pm 1.6448$ ; ( $2\alpha = 10\%$ ).

The value of parameters  $t_0$  is calculated according to formula (1) and it is:

$$t_0 = \frac{36.66 - 46.96 - 10}{1.31} = -15.5 \quad (16)$$



**Figure 4.** Acceptance and rejection

$$H_0 : (\mu_1 - \mu_2) \leq 10;$$

$$H_1 : (\mu_1 - \mu_2) > 10$$

How is  $t_0 = -15.5 < t_{(0,10; 18)} = -1.6448$ , the  $H_0$  hypothesis is not accepted, with the risk of error  $\alpha = 5\%$ , and the difference in the average annual number of standards in software development in Serbia and BiH, less than 15 standards per year. The difference

$$\bar{x}_{SRPS} - \bar{x}_{BAS} = 36.66 - 46.96 - 10 = -20.3$$

is statistically significant and can not be attributed to the random variation of data in the samples.

#### 4. CONCLUSION

Concluding considerations can be presented in the shortest terms through the PDCA concept:

(P) Planning the necessary resources (only for access to standards and annual innovations goes beyond individual frameworks).

(D) Development of national standards in the field of Information Technology - ICS1 = 35, Substance Software - ICS2 = 35.080 implies continuous teamwork, as well as representation of innovation in accordance with the BAS / SRPS standardization platform with current projects of the neighboring country.

(C) The trend of local SRPS standardization should be in line with the standardization of neighboring BAS.

(A) Improving (development, application and accessibility of standards in Serbia) includes the development of software for on-line access to SRPS standardization.

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# Using Web Server Log Files for Analysis and Improvements Related to Study Programs

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**Abstract:** *Almost every computer system records data about the corresponding events in the system through the so-called log data. Log data can provide meaningful information and knowledge about different aspects of system use, but placed in the appropriate context, log data also provides knowledge beyond the boundaries of the system in which they are generated. The paper shows how log data obtained from one web server can be used to analyze and improve study programs. The entire flow of log data transformation from the sources to the final results applicable for further work is shown. The paper points to a part of the potentials that log records have and how this potential can be used within the framework of higher education work. A concrete solution is presented based on the use of an appropriate infrastructure powered by Elastic Stack solution.*

**Keywords:** *Elastic Stack, higher education, log, study program, web server*

## 1. INTRODUCTION

Although the log is the term commonly used in computer and related sciences, this term dates from the time before the beginning of using computers in the form it is known to us nowadays. For example, if we look at The Illustrated Dictionary Oxford, we can find, among other definitions, that the log is "a record of events occurring during and affecting the voyage of a ship or aircraft" [1]. Basically, similar explanation ("a record of events") has been taken by computer science. But if we look deeper in computer systems, faced with their complexity, logs are more than simple records of events because each event represents individual phenomenon within an environment that usually includes an attempt to change the state [2]. Accordingly, log is described as a set of records of individual occurrences in an environment that has changed or attempted to change a previous state. Logs (log files) provide vital information about various types of behavior [3].

Using of log files in computer systems today have a wider application than one observed in some traditional sense. List of solutions based on approaches which involved some type of log files is potentially unlimited. The domain of education also is following this trend and becomes one of the areas where a large increase in the use of solutions based on the use of log files is recorded.

Zheng, He, Ma, Xue, Li and Dong in [4], analyzing one e-learning system, pointed out the complexity

of working with log files in modern educational environment and discussed potential solution and infrastructure to overcome that complexity using Big Data approach and techniques.

Takahashi, Asahi, Suzuki, Kawasumi and Kameya in [5] also used log data from one e-learning system which is realized using cloud principles. Extracted knowledge from log files is used for analysis of self-learning styles as potential improvement of system aimed to support self-learning from home. Similar approach, based on extraction of knowledge about learning styles from log data, is done by Umezawa, Aramoto, Kobayashi, Ishida, Nakazawa and Hirasawa in [6] in order to improve the implementation of the educational approach called "flipped classroom".

References [7], [8] and [9] show how log data can be used in area of higher education especially in overcoming the "language barrier" problem related to mobility of students. Provided vital information from log data, authors increased chances of getting a job in Japan for their international students that have a lack of knowledge of the Japanese language.

Log data which originally come from non-educational systems also can be used for the findings that can improve various segments of education.

Authors in [10] used log data for analysis of user influences in social networks and authors in [11] done some opposite process, construct the social network from chat between users. In both cases

some conclusions obtained from those log data can be used for generating principles for interaction between users in educational systems.

Li, Zhao, Wang, Ma and Liu in [12] used log data from one commercial business system for analyzing and finding patterns in user behavior and based on that to predict further purchases on online shopping system. Similar approach can be obtained for example in e-learning systems for prediction of next course which user will be involved in.

In this paper log data which are used are originated from classical web server of educational institution and findings from these data will be used for some analysis related to existing study programs.

## 2. OBTAINING DATASETS

As already mentioned above, log data, which are used in further explanations and analysis, are provided from single web server. This server belongs to academic institution and serve eleven web sites related to that institution: one official site of the institution, four sites of study programs, three conference sites, two journal sites and one site for presentation of R&D activities. All sites are operating under Apache HTTP Server 2.4 and all sites use common log files.

Access logs will be observed because this type of log records show all requests processed by the server. No log rotations are provided by the server. Data are recorded using format string referred as the Combined Log Format [13] represented as:

**LogFormat** "%h %l %u %t \"%r\" %>s %b \"%{Referer}i\" \"%{User-agent}i\"" combined

**CustomLog** log/access\_log combine

which means that in access log are recorded IP, identity, user, time, request, status, size, Referer and User-Agent HTTP request header. This set of data is enough for type of analysis provided in this paper.

In this paper two generated access.log files are used. Log files are shown in table 1. As we see from corresponding table we have total of over 8,5 million recorded log messages which is quite impressive number of records for not heavy-load sites of mentioned academic institutions.

Bhole, Adinarayana and Shenoy in [14] highlighted that the first phase in work with every dataset must be so called "data cleaning" which implies procedures of removing irrelevant and redundancy data in datasets. Same approach is used in this paper in aim of achieving better performances during working with datasets and obtaining more precise results from datasets. Results of datasets cleaning are shown in table 2.

As it shown in tables 1 and 2, initial state was about 8,5 million recorded log messages and after cleaning process over both datasets total amount

**Table 1.** Used access.log files

access.log	I	II
<b>Logging started</b>	22 June 2017 09:47:04	8 December 2017 08:04:37
<b>Logging ended</b>	8 December 2017 08:01:52	23 February 2018 06:46:34
<b>Number of recorded log messages</b>	6.192.378	2.349.682
<b>Size of file</b>	1,5 GB	591,1 MB

**Table 2.** Used access.log files after cleaning process

access.log	I	II
<b>Started number of log messages</b>	6.192.378	2.349.682
<b>Number of removed log messages</b>	3.348.180	982.098
<b>Percentage of removed log messages</b>	54,07 %	41,8 %
<b>Number of log messages after cleaning process</b>	2.844.198	1.367.584

of valid log messages for further processing is reduced to about 4,2 million log messages which represents overall improvement of over 50 percent. This significant reducing also made reducing in time needed for whole other sets of operations during analysis so we could say that we will use resources during data processing in some optimal and efficient way.

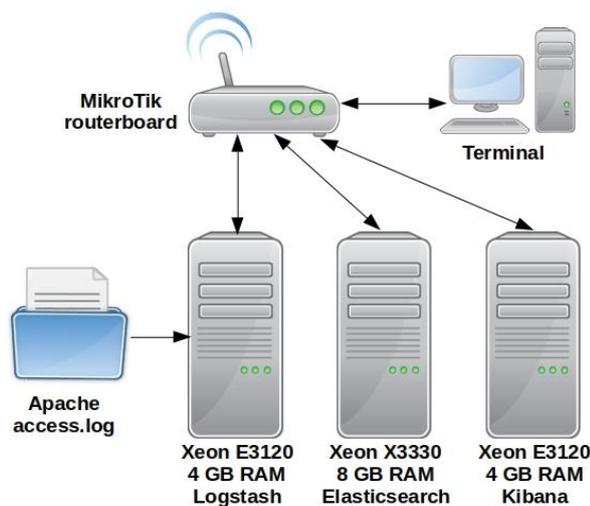
## 3. INFRASTRUCTURE FOR DATA ANALYSIS

There are many possible solutions for realization of log analytics platforms. One proposed solution is described in [15], which offers use of layered log analytics architecture. Mentioned solution is good choice for dealing with logs in Enterprise Architecture (EA) business solutions, but in case which presented in this paper authors are tried to find less complex and more narrowed solution which can handle Apache log data described above. After comparison of few solutions, which can be found on market nowadays, it was decided that

Elastic Stack product family would be used and complete analysis of log files are done using this product family consisted of Logstash, Elasticsearch and Kibana in this case [16].

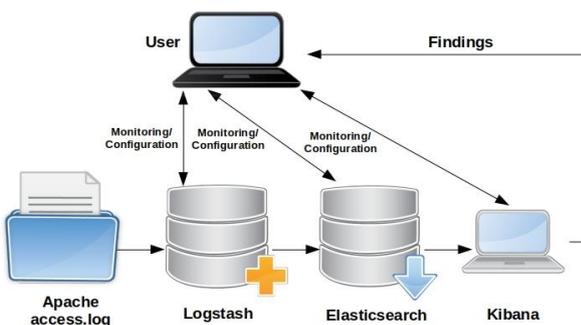
Using the recommendations of the software vendors, Elastic Stack software is used on laboratory network consisted of three HP Proliant ML310 G5p servers (one server based on quad core Intel Xeon X3330 with 8 GB RAM and two servers based on dual core Intel Xeon E3120 with 4 GB RAM, all servers equipped with standard SATA 7200 rpm hard drives) connected via MikroTik routerboard. All servers worked under Linux Fedora Server 27 operating system and MikroTik routerboard worked under RouterOS 6.42.

Deployment of hardware components is shown in the figure 1.



**Figure 1.** Deployment of hardware components

The abstraction of data flows is graphically shown in the figure 2.



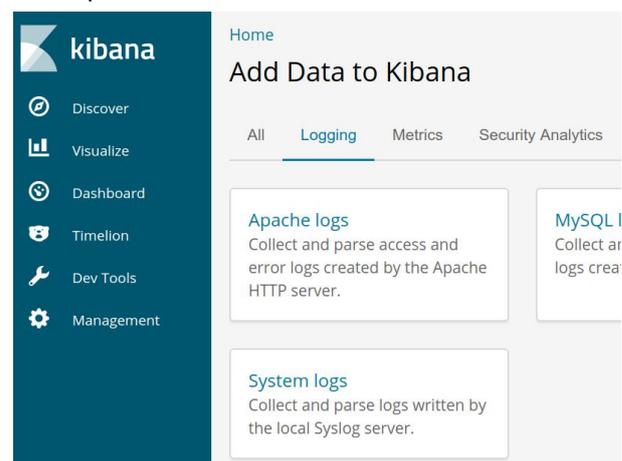
**Figure 2.** Data flows

As we see from figure 2, desired log data, which are previously cleaned as mentioned above, are first collected and processed by Logstash which represents server-side data processing pipeline. Log data are then transformed using built-in grok filter which primary function is to transform and structure non-structured data from log file. Filtered data then are sent to Elasticsearch for further processing.

Key analysis processes are happened within Elasticsearch which provided three main components for dealing with filtered data: search,

analyze and store. Using Elasticsearch capabilities we are in position to reveal some knowledge from large amount of log data which cannot be detected on some other way. Elasticsearch can be characterized as one big solver for various types of doubts, issues and events which represents priceless value in our case of answering some important questions about existing study programs.

Elasticsearch data are in raw format so it must be processed further for interpretation and presentation in some understandable way. For that reason data from Elasticsearch are sent to Kibana which has two main goals. First, Kibana is powerful visualization tool for all data which are processed by Elasticsearch. Kibana provided so called dashboards which can obtained results of data processing in one accurate, precise and appealing way. Also, Kibana provided GUI for configuring and monitoring of Elastic Stack as it shown on figure 3. With this type of data management users can improve performances of various parts of system and at the same time secure the quality of the whole process.



**Figure 3.** Configuring Elastic Stack using Kibana

Final product of all operations over log data through whole Elastic Stack components are findings which provided solutions for single or set of problems.

In this paper we used configuration based on small laboratory network described above and presented on figure 1, but we must mention that the whole process can be done also using single computer. Authors also tested this type of implementation which are realized on a computer based on Intel i5-6400 CPU with 32 GB RAM and equipped with SSD and SATA 7200 rpm HDD. All services of Elastic Stack are successful implemented and configured on this single machine and all data are processed, but if we compare performances of both solutions, better performances are achieved using small laboratory network so that solution is used further.

Also, in this research, log files that are used are final and locked without further recording of any log message. But for various purposes this whole process can be implemented in real-time

configuration. Basically, concept is the same. Only difference is that we must, before Logstash, add Filebeat component which will collect all log messages from log file in real-time and process them further to Logstash. Rest of the described process is the same.

Authors did not work with real-time data in this research, so base point in this paper will be log file attached to Logstash without presence of Filebeat.

## 4. FINDINGS

### 4.1. Search

First method which we provided using Elastic Stack over the cleaned data from log files is search. Previously, already is mentioned that in these data are provided log messages for eleven sites, so the task was to see distribution of visits among these sites. Of course we will be mainly focused on institution official site and study programs sites.

For search we will use Referer field because this field from log data provides to us the most accurate data. Of course, the addresses of all sites were well known during investigation so we could search using these parameters. Results are shown in table 3.

We will not discuss results related to sites of conferences, journals and R&D. Only we will say here that occurrence of zero hits for the site of Conference III is related to the fact that the site was not operative during creation of log file I and became operative during creation of log file II so zero result is expected occurrence for log file I.

We will discuss results related to official institution site and sites of study programs. As we see from the results, we have two observed facts. First we see good results for official site and site of study program I and very poor results for the rest of study program sites (only 2-3 percentage). And second is occurrence in log file II that site of the study program I has more hits than official site.

### 4.2. Analysis

References [17] and [18] gave some basic instructions about a way for interpreting results from log files. But analysis and interpretation of log files is some state of art and can vary significantly from case to case. In this case, our entering point was search results. In some other cases entering point can be something else.

Search method gave to us some key guidelines and knowledge about environment, but to get the real answers and to get key findings, search was only one stage of larger process. Guided with search results, further analysis are provided.

First part of analysis was related to our efforts to understand why three sites of study programs had a very poor results and to define is it anomaly or there are some key facts related to these study programs.

**Table 3.** Results of provided search over log files

access.log	I		II	
	HITS	%	HITS	%
<b>Institution official site</b>	1.546.591	54,38	589.666	43,12
<b>Study program I</b>	925.561	32,54	606.582	44,35
<b>Study program II</b>	57.412	2,02	28.426	2,08
<b>Study program III</b>	70.450	2,48	34.717	2,54
<b>Study program IV</b>	91.993	3,23	52.682	3,85
<b>Conference I</b>	75.007	2,64	12.623	0,92
<b>Conference II</b>	16.929	0,60	6.145	0,45
<b>Conference III</b>	0	0	9.505	0,70
<b>Journal I</b>	21.821	0,77	12.303	0,90
<b>Journal II</b>	33.662	1,18	4.441	0,32
<b>R&amp;D site</b>	4.772	0,17	10.494	0,77

In analysis we used almost all fields from Apache log messages, primarily time, request, status, size and Referer.

First we analyzed status codes from log messages to find are there any massive errors during visits to these sites. Most of log messages were with status code 200 (OK) so we concluded that the most requests were legitimate and without errors.

After that we made further analysis combined fields Referer and request to see distribution among visiting pages and objects per each site.

For study program sites with poor hits results major visiting pages and objects are schedules of various types (mostly classes and exams) with percentage of about 71 percent of all visiting pages. Opposite, for study program site with high hits rate, that percentage was about 34 percent of all visiting pages. Also users which visit this site mostly use site for access to some kind of teaching materials (videos, presentations, books and similar), about 52 percent of all visiting pages. From these facts we concluded that the poor results for some sites and very good result for one site on the other side

are direct consequence of presence of teaching materials on one side and major absence on the other.

Using this finding, further analysis of concrete study programs are made. Absence of teaching materials on sites with poor rates are direct consequence of very old literature which are used as teaching materials on these study programs. Some of literature are limited available and most of them not have digital interpretations or digital equivalents which could be presented to students online.

As a step for the improvement of these study programs, it is proposed to innovate literature with a special emphasis on creating digital content that will be available to students online on a 24/7 basis.

Special analysis were also made for mentioned occurrence in log file II to find what led to unusual situation that site of the study program I has more hits than official site of the institution.

Also as previously, first we analyzed status codes in pursuit for possible errors and again most of log messages were with status code 200 (OK). Among different analysis which not gave correct answer to us, the analysis which primarily involved time distribution using time field gave us precious insights.

During the comparison of obtained results for official site and obtained results for site of study program I, overlap was observed. Almost at the same time less hits were done on the official site and more hits were done on the site of study program I. After the notice of period which this were happen, further analysis are made especially for that period of time. Using adequate fields there are noticed that users more often visits teaching materials on the study program site than usually. Analyzing the timeline of events which are occurred in that period, we found that in that period were a legitimate terms for taking exams, so students study and prepare exams and using much more teaching materials on site than usually. According to that, this occurrence is treated as legitimate.

## 5. CONCLUSION

The research presented in this paper shows the possibility of transforming data contained in log files into knowledge that can contribute in improving the environment in which higher education takes place, or in this case, improvements related to study programs. Log data which were used to achieve described findings are obtained from classic web server instead common practice in similar cases when log data are obtained mostly from some specialized learning systems. As we saw, extracted knowledge from those data are efficiently made space for future actions on the improvement of the study programs.

But this presented solutions is not without some limitations.

We already mentioned that more accurate approach and results are achieved when we are dealing with those data in real-time. So the best solution for this sort of analysis of log data will be based on some sort of streaming log data and parsing them further in real time. Of course, this kind of approach requires additional investments in infrastructure which will be made exclusively for these purposes, so there is a potential issues in realization for institutions with smaller sources of income.

Also more accurate findings can be obtained when the results which are extracted from these log data are compared with other statistical indicators. For example in our case a higher degree of accuracy can be achieved if we in our observations involved exact number of students per study programs, per semester and per subject. This approach need various integrations of presented system which are dealing with log data from different aspects with various parts of information systems on faculties, universities, local administration and similar. Sometimes these integrations are very complex, demanding and expensive and require a lot of resources.

However, the prediction is that in near future we will be introduced with various systems based on use of different types of log data and we will made large amount of decisions based on insights and findings revealed from those systems.

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# Will You Bring Your Laptop? Investigating Students' Attitudes Towards BYOD

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**Abstract:** *The paper investigates students' attitudes towards introducing BYOD (Bring Your Own Device) in teaching of Information Technology (IT) related subjects. Many advantages in having BYOD are reported, but no general benefit can be taken for granted as there are specific circumstances in different technological and socio-economical environments. We examined group of senior students of IT study program, which heavily use computer labs for various subjects and part of them had already experienced usage of their own portable computers in class. Results indicated a great willingness of using own computers. A vast majority of students do have a portable computer and virtually no obstacle in introducing BYOD was indicated. These findings may encourage faculty management to start thinking in this novel way of facilitating the study process.*

**Keywords:** *students; learning; BYOD; teacher; education*

## 1. INTRODUCTION

The evolution of IT proved to be an extremely rapid one. Over three decades after PC breakout that established its place in homes, the world faced with outage of IP addresses over huge number of networked devices. Internet architects could not in their most vivid dreams anticipate what the global network would become. The economy shift followed and the need for IT experts is nowadays a hot topic worldwide.

Education system had to suffer changes. E-learning stopped to be an auxiliary method and became a mainstream. Moreover, the paradigm of e-learning itself went through a huge metamorphosis, striving towards MOOCs [1], mobile learning [2] and augmented reality [3].

Millennials were raised in IT-equipped environment and generation Z is even more involved with computers and Internet. Nowadays, kids have at least one large screen device in their pockets (cellphone, tablet). Researchers and practitioners made effort in order to utilize that fact and instrument pupils' cellphones in education [4].

Schools are trying to keep pace with technologies. With urge of "producing" fresh IT working force, there is also a pressure to equip schools and universities with up to date computers and software. Having a well-equipped computer lab is recognized as a prerequisite needed in order to use modern programming tools and new software suits. It is also considered to be a competitive advantage which will attract new students.

However, things have been changing in past few years. Number of sold laptops surpassed number of sold desktop PCs years ago and it is forecasted that in 2021 it will reach ratio of 2:1 in favor of laptops [5]. Virtually every student has a PC and many of them own portable computers as well. That brought a new possibility, that is utilized both in academic and corporate environment: bringing own computer to classes and office. A paradigm in its widest form become known as Bring Your Own device - BYOD and also may include tablets and phones. It is pretty straightforward what it means: people bringing their own portable devices and doing their work on them, decreasing or totally cutting the need for institution or company to have stationary computers or similar devices on the site and boosting users' efficiency and flexibility. Talking about education, that brings various possibilities, not limited only to computer-related subjects, but applicable to virtually any matter. Teacher can, for instance, set an online quiz, that students are supposed to attempt at the end of the lesson taught in class.

However, bringing own laptop does not mean the institution is done with its responsibilities. Many prerequisites are up to be taken care of in order for BYOD to succeed, like defining policies of usage and preparing more robust infrastructure, with special attention put on security [6].

This paper focuses to possibilities and obstacles that BYOD brings to lab exercises in IT related subjects. We investigated the students' perspective of their potential usage of own laptops over faculty's desktop PC-s in context of various subjects that require intense usage of computers.

First, we examined related literature. Then a student-survey is made, based on the work in the field, reported examples of best practice and our own experience. We conducted a survey among undergraduate IT students and discussed the results. At the end, we presented conclusions and directions for future work.

## 2. RELATED WORK

Since slogan "Bring Your Own Devices" was first associated to IT companies, many studies concentrate on opportunities and risks that it brings. The most recognized advantage of BYOD is the user satisfaction and productivity. On the other hand company's security is threatened by unauthorized parties obtaining access to sensitive private information or confidential company information [7]. Since traditional risk management is not suitable for BYOD mobile working environments, attempts are made to find new kind of HCI for risk and trust management [8]. Also, bringing BYOD policies to companies emerges as an important issue [9].

Parallel to IT organizations, increasing number of studies have attempted to investigate how mobile learning can be leveraged to increase student engagement and teacher productivity through BYOD model. Researches focus on various aspect of BYOD, such as BOYD pilot projects [10], guidelines [11], policies [12], applications in primary schools [13], higher education [14], students perceptions [15], teachers impressions [16] of its impact., etc.

Author Song conducted one-year case study on the project "Bringing Your Own Device (BYOD) for seamless science inquiry" in a primary school in Hong Kong. Findings show that young learners made important advancement of content knowledge in science inquiry, supported by their own mobile devices. She concluded that students developed a positive attitude toward using BYOD for seamless science inquiry, but emphasised that educators have to help students to further increase their capability in perceiving the affordances in seamless learning environment in order to make optimal use of BYOD [13].

Through investigation of ActiveClass system Barkhuss came to indirect findings concerning BYOD. Students were not provided with any devices by the university and had to bring their own laptop or PDA with a wireless connection. Author reported that although majority of students owned laptop or PDA, many students chose not always to bring their laptops to class because their laptops were too heavy to carry around all day. They also worried that would run out of battery at inconvenient times [17].

Research conducted by Ragan et al. revealed that even when students bring their laptops, during the

class period that is too long (2h and 50 min) they often surf the web, keep up with the latest social media, or even play online games. Through laptop-use survey and laptop-use classroom observations this research indicates that students tended to be off-task in using their laptop almost two-thirds of the time if the lecture is too long. An analysis of the various laptop frequency activities over time showed that engagement in individual activities varied significantly over the duration of the class [14].

In their research, Benham et al. concentrate on students' impression of how using mobile computing devices in the classroom would likely impact their learning. They examine several questions such as types of mobile computing devices students are using, why students wouldn't bring them to class, and what kind of expectations do students have concerning BYOD. Survey shows that most of the students use smartphones and laptops and the fear of loss or theft, the fact that the devices are either not allowed or not required, the inability to get a wireless network connection, and a lack of appropriate software applications for a business curriculum appear repeatedly. One of the main problems students noticed is instructors inability or unwillingness to actively engage mobile computer devices in the classroom [15].

On the other hand, through one-year study Song investigated the affordances and constraints of BYOD from teachers' perspectives in higher education. Study showed that some teachers considered using BYOD in class time-consuming and inappropriate for certain learning contents and thus, teacher professional development is needed in this regard to empower teachers in pedagogical practices with new technologies [16].

The latest research done by Castillo-Manzano et al. implicates several issues that has to be aware of when promote BYOD to universities, such as improvement of physical infrastructure e.g., more sockets and better wi-fi networks, but also restricting access to internet leisure content over the university wi-fi network, at least during class time. Integration of these devices into instructors' teaching activities is also one of the main issue that has to be further developed [18].

## 3. RESEARCH

The research target group consisted of third and fourth (final) year IT students at Faculty of Technical Sciences in Čačak. We chose these students for the following reasons:

- A substantial deal of their classes is held in computer lab.
- Being on senior years of study makes them more experienced, so their attitude is fully built in the matter of learning technologies.

- These students recently faced a situation where the computer lab they were supposed to use was (as consequence of shipment delay) not equipped with PC-s for three weeks, so they were advised to bring their own laptops, if possible. Therefore, they could test their attitudes in practice, which might bring more reliable questionnaire data.

Students were asked to fill the questionnaire, set on the official e-learning platform (Moodle). First of all, students were asked if they had a laptop. Answering "no", would end the survey, while "yes" would proceed with questions.

Answers were defined in form of Likert scale with five orders of response. (Grade 5 - fully agree, 4 - mostly agree, 3 - ambivalent, 2 - mostly disagree and 1 - fully disagree.)

77 students answered, 16 were females and 55 males. The gender structure represents the whole population well, as there are more male students enrolled in this study program.

The first question was eliminating, as it was pointed towards discovering if students have laptops at all. About 91% of students confirmed they have their own laptops. These are ones who proceeded with the questionnaire. We wanted to gather answers from students who can easily set themselves in situation of bringing their own laptops, so we can get more representative data, as much possible close to real case that would occur. Therefore, students not having laptops did not proceed with the questionnaire. That made total of 71 students filling the complete questionnaire.

Questions regarding usage of own computer was put into two main categories: potential benefits and potential shortcomings. Also, an optional field was set for observation to be written.

Thirteen students added optional comments. These can be sorted in three categories:

- Faculty's computers are more convenient for use and there is no need to bring own computers.
- Faculty's computer lab should have better performance and faculty requires more labs.
- One should bring his own computer.

Analyzing the results, flexibility, as expected is showed up to be important for potential acceptance of BYOD. Students know their machines and have familiar programs, can easily keep their work and take it home, where they can further work on it. This factor is very important for students. On the other hand, among potential obstacles there is lack of comfort: students are not eager to carry additional burden every day and end up with smaller screen. The most ambivalence is provided in answer regarding the issue of "who should provide computers".

Students are not sure if they have the right to claim that Faculty must provide the computers. On one hand, if students already have the laptop (which is by definition a mobile PC), they are willing to carry it and to use it for everyday work, including in class usage. On the other hand, shouldn't Faculty provide everything for the study process? This matter is obviously not clear for many students.

**Table 1. Benefits of bringing own computer**

	1	2	3	4	5
I think working on my own computer eases completing examples, because I can finish them at home.	3	6	6	20	<b>36</b>
When using my own computer, it is easier to do my tasks, because I know well my system's settings and installed programs.	1	3	14	15	<b>66</b>
It suits me to use my own computer, because I can use some of my programs.	6	4	18	24	<b>48</b>
It suits me to use my computer, because then I can utilize fast Internet and download great amounts of data.	15	18	20	23	<b>24</b>
It suits me to use my computer, because there are no restrictions: I can install whatever I want and run any application I want.	7	15	10	24	<b>44</b>
It suits me to use my computer, because then I can work on it alone.	4	6	15	28	<b>46</b>
It suits me to use my own computer, because its performance is better than Faculty PCs'	8	11	23	23	<b>35</b>

Students are somewhat intimidating by potential programs they should install in order to use it in class. That may indicate that certain programs are used exclusively in computer labs and student do not install, nor use these programs at home.

**Table 2. Shortcomings of bringing own computer**

	1	2	3	4	5
I would not like to use my own computer, because the Wi-Fi connection is unstable.	<b>28</b>	25	20	17	10
The Faculty is supposed to provide me with computer, not to require me to spend my own.	14	17	<b>39</b>	11	18
Physically carrying a laptop is a significant effort for me.	24	15	<b>28</b>	18	14

There are not enough electric outlets for charging laptops.	<b>42</b>	21	13	13	11
Desktop PCs are far more comfortable for work (larger screen and keyboard).	24	17	15	<b>25</b>	18
I am afraid I could infect my computer on Faculty network.	<b>42</b>	18	23	11	6
I would not feel comfortable bringing my computer, as someone (colleague or teacher) might jeopardize my privacy by seeing something personal on my computer.	<b>44</b>	21	20	11	4
It does not suit me to use my own computer, as I would have to install too many programs.	24	13	<b>28</b>	20	15

#### 4. CONCLUSION

Assessing users' attitudes towards acceptance of specific technology is important part of introducing changes in learning infrastructure. BYOD is often reported as a viable and efficient approach in teaching and this presumption was tested in a particular case at Faculty of Technical Sciences. Students of Information technologies showed high level of readiness for acceptance of BYOD. No potential obstacle was reported as significant one. Also, high percentage of students could participate in BYOD, as 91% of them have their own laptop.

As the number of students on this study program is increased compared to previous years (130 students starting in 2017/2018 school year), Faculty should consider introducing BYOD by forming "BYOD groups" for lab exercises, that is i.e. two groups, consisted of students having laptops, can be instructed to carry their own laptops and have lab class in non-PC classroom, relaxing the Faculty capacities. Then BYOD groups and computer-lab groups could be examined and compared in order to investigate is their success related to what computer they use.

In future work, other features and challenges of BYOD will be investigated, such as teacher perspective of BYOD and security challenges, as well as study efficiency in BYOD case.

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# Usability Testing in Human-Computer Interaction Classroom

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**Abstract:** Before launching a new product in the market, series of testing are performed, in order to satisfy required demands. One of the criteria that needs to be fulfilled is usability testing, which consists of evaluation of products and services by users. Users are expressing their opinion by accomplishing previously defined tasks regarding difficulties they meet during product or service usage. In this paper, the most important concepts of usability and usability testing are explained. Also, basics of web usability, its definition and main website usability testing elements and methods are introduced. In addition, review of few popular and free usability testing tools, as well as a practical example of website usability testing process is presented. Nowadays, usability testing is very important part of the Human-computer interaction research and study.

**Keywords:** Usability testing; Human-computer interaction; Evaluation; Web usability

## 1. INTRODUCTION

Every product and service on the market is created in order to meet the demands of a specific group of users. These products and services are rarely able to satisfy needs without continuous improvements. Also, customer requests often change over time, so usability testing on a regular basis is necessary to determine the extent to which a product or service is fulfilling the requirements. The received feedback should be used for product and service improvement.

Usability testing implies product and service evaluation by users. During the usability testing, users are performing given tasks, while test practitioners are observing examinees and recording results. Main objective of this process is determining problems and difficulties which customers encounter while using specific product or service, and collecting qualitative and quantitative data of user satisfaction with the product or service. Analysis of usability testing results is the best method for identification of customer opinions and level of product or service suitability to customer demands.

If the product is a software, usability testing should be done before it enters the market. Thus, costs of rewriting the software and the possible bad first impressions that users could gain if software is not implemented properly would be avoided. Besides that, re-implementation of testing process should be done regularly, because changes of customer needs and product functionalities are commonly occurring.

Usability testing is one of the main focuses in the area of Human-computer interaction (HCI) all over the world. Usability testing is being studied through HCI master course at some Universities or through HCI course as it is being studied at the Faculty of Technical Sciences Čačak, Serbia.

This paper will provide introduction to web usability concept, explanation of models and norms of testing and a brief analysis of usability testing in HCI classroom. As for a practical example, two differently implemented websites are compared and analyzed in order to determine whether some of them are more suited to the average user and to what extent.

## 2. USABILITY

Usability is qualitative aspect of product, which is used for measuring whether the interface is easy to use and to which degree [1, 2]. Term "usability" also refers to the process of ease of use improvement which is a part of software design. Usability consists of five components, which are related to quality of above-mentioned process [1-3]:

- Learnability – Do users easily master the basic functions during the first encounter with interface design of software product?
- Efficiency – How fast can users do the tasks when they get familiar with the interface design?
- Memorability – Do users easily return to the professional level of product use after a pause?
- Errors – Do users make a lot of errors, how serious they are, are they easy to handle?

- Satisfaction – Is design user-friendly?

There are qualitative characteristics other than usability such as utility and usefulness. Utility refers to providing the necessary functions to users, while usefulness refers to summation of usability and utility [3].

Usability of software product is of a high importance for its survival on the market. If product is complicated, unclear and inconsistent, it will not be sold. The market is big enough so every type of software will have at least two or three competitive products. Thus, buyers will not waste their time trying to understand a specific product, when they can try another one, more appealing and appropriate for their needs. About 10% of the product development budget is spent on usability testing, which leads to significant improvements in product design [1-3].

### 2.1. Usability testing

Usability testing is a technique for evaluation of software product, and it is done in real circumstances with real customers [1]. Tests are usually designed by domain experts, and they consist of series of tasks that users should complete while the examiner spectates and records his observations. Consequently, many significant data concerning the customers approach to the product, their way of handling it and existence of problems and errors which should be removed can be collected.

Usability is an important part of every product design process, so testing it only once during the product development is often insufficiently. Besides that, information about design and characteristics of competitive products should be gathered for comparison.

Nowadays, the main challenge for companies is not creating convenient conditions on the market or using modern technologies, but understanding its customer's needs. In order to learn whether product meets users demands or not, product testing should be done.

Many companies still do not apply methods for usability testing during the product design, regardless of all the benefits they can achieve through this process. Some of the reasons for that are following [5]:

- Usability testing can be expensive.
- Usability testing can delay product launching.
- Usability testing can reduce creativity.
- Usability is less important than user feedback.

Website usability testing is becoming more and more important, because the number of companies which are operating via the Internet is constantly increasing. Thus, it is significant that they have appealing and user-friendly web presentations.

Usability testing is classified into three main categories [1, 3, and 5]:

1. Explorative – which is applied in early stage of product development for efficiency and usability assessment of product prototype, as well as for the user understanding and way of thinking evaluation.
2. Assessment – which is used for user level of satisfaction, product efficiency and overall usability assessment.
3. Comparative – which is used for comparing two or more products in order to determine their differences, strengths and weaknesses.

Some of the possible methods of website usability testing are [2, 5]:

- Hallway Usability Testing – The main idea of this method is hiring random individuals for testing instead of trained personnel.
- Remote Usability Testing – This method implies using people from different countries as respondents. The testing can be performed either as a video conference or independently of evaluator. Nowadays, many remote usability testing software are being used for this method of testing. Remote usability testing is often present in HCI courses.
- Expert Review – In this method, expert in the field that is being tested is performing the tests.
- Paper Prototype Testing – This method includes creating rough drafts and hand drawings of interface which are used as design models or prototypes. This method is also of a great importance in HCI courses, especially at lower levels of design learning.
- Questionnaires and interviews – In these methods, face-to-face approach is used, so testers can directly communicate with examinees and ask them additional questions.
- Do-it-yourself (DIY) Usability Testing – As for this method, analyst is creating a testing scenario, as well as completing it in the role of average customer.
- Controlled Experiment – This method is similar to scientific experiments and it usually involves the comparison of two products, with careful statistical balancing in experimental conditions.
- Automated Usability Evaluation (AUE) – AUE is a holy grail among all of the usability testing methods. This is quick and inexpensive method which includes the use of automated tools for testing. This method easily reaches wider audience and provides results rapidly. A large number of website AUE tool prototypes has been developed, all of them with different levels of success.

### 2.2. Defining the goals

Before usability testing process starts, it is essential to make a test plan. In order to attain satisfactory test results, test subject and method must be completely comprehended. Hence, goals of usability testing should be clearly defined, which

implies objective categorization along with adequate data type selection.

There are different types of usability test objectives, and the right questions should be asked so the whole process can be fully understood and proper goals can be set. Some of these questions can arise during the product data collection, and they usually refer to main information about product, users, product successfulness, competition, product research, duration of testing etc. [5].

After the goals are set, the proper usability testing method should be chosen. Firstly, type of results to suit defined objectives should be determined. Some of the common result types are charts, rating scales, printed forms, audio or video records etc. Depending on the interest group, different results can be needed. For example, shareholders would easily understand numerical results displayed through charts and rating scales, while executive board members would rather have video presentation of test results. So, in order to choose the correct data and result types, it is crucial to properly define the goals of usability testing. In

table 1, the examples of different question types and corresponding results are shown.

Another important aspect of test planning are metrics. Metrics refer to quantitative characteristics of usability, rather than qualitative ones acquired through verbal responses to questions [2, 6, 7]. By combining the quantitative and qualitative data collected during the test, the number of usability problems, their cause and possible solutions can be identified. Qualitative methods involve direct communication with respondents and they are answering the questions how, when and what has happened, while quantitative methods involve indirect communication with respondents and they give answers to the question how much.

Usability metrics are actually statistics that measure performance of user task execution. Success rate, error rate, execution time and rates estimated by examinees are just some of the values that can be measured for quantifying usability [7].

**Table 1.** Test results depending of question and answer types [5]

Type of question/answer	Question example	Result
Oral	Describe and show what was the most irritating part of this website to you.	Verbal answers are usually directly connected to a part of website which is being tested at that moment, so this type of questions are used for gathering information about main issues of the product.
Multiple choice	Do you trust this manufacturer? – Yes – No	This type of questions/answers are primarily used for categorization. Responses can be nominal (e.g. dogs or cats), dichotomous (yes or no) or ordinal (Likert scale for measuring the level of agreement/disagreement).
Rating scale	What is the probability that you will revisit this website? 1    2    3    4    5 (Strongly Disagree (1); Disagree (2); Undecided (3); Agree (4); Strongly Agree (5))	These questions are used for presenting ordinal values with different levels (low, intermediate, high).
Written	Do you think that this website has some defects and which?	Written answers are typically used for analysis which are performed after testing.

Although defining of usability metrics is simple, gathering needed data can be time consuming and expensive. The need for this process should be justified and strongly determined so unnecessary expenses can be avoided.

Main aspects of product usability are characteristics related to product simplicity and ease of use [6]. Besides that, it is highly important that website provides accurate and accessible information and to include all functionalities that user may need. Fulfilling user demands is a must for having

satisfied and loyal customers. There are few elements which must be adjusted to users on every page of website [5, 6]:

- Design,
- Content,
- Labeling,
- Functionality and
- Navigation.

During the website evaluation, all of the above-mentioned elements must be tested. There are many tools which can be used in this process for

testing some of the following elements: page loading speed, design and navigation, interaction with users, error testing, testing of target (internal) pages, user surveys, accessibility [6-8].

### 2.3. Methods and types of usability testing

Classification of usability testing can be done on different basis. There are three main classes of usability testing depending on method used for its implementation [9]:

- In-person,
- Under the supervision and
- Remote,
  - Supervised and
  - Unsupervised.

There are many other methods which are used in combination with before-mentioned techniques, such as [4, 5, 7, and 9]:

- Card Sorting,
- Tree-testing,
- Voice of Customer Surveys,
- Heuristic Evaluations,
- Keystroke Level Modeling,
- A/B Testing,
- Click Testing.

The choice of the appropriate method and the test type depends on the well-defined objectives of the usability testing. Selection of proper test is crucial part of whole usability testing process.

Regardless of elected test type, testing should start with pilot test. Pilot test requires additional time and effort, but it provides information about test mistakes and inaccuracies. This test is a demonstration of real test and it is performed in the same way, but without analysis of results. The main goal of pilot test is not interpreting results, but identifying irregularities and errors which could occur during the real test conducting. Some of the common problems are technical problems, human errors or a set of circumstances. In order to achieve maximum precision of test and reliability of data, pilot test should be done at least once throughout the test process.

Next classification of tests is based on method of product use [4, 5, 7, and 9]:

- Scripted – These tests focus on specific aspects of testing of usability;
- Decontextualized – In these tests, products are not being used in test phase. These tests are designed for user experience and generating ideas.
- Natural – These tests are used for customer behavior patterns and product trends analysis.
- Hybrid – These creative and untraditional testes are focused on understanding of user way of thinking.

Besides previously-mentioned test classes, there are also tests which include user characteristic analysis such as: problem discovery, benchmark, eye-tracking etc.

The main purposes of eye-tracking website usability testing are determining the eye-catching parts of website and establishing user navigation through website. This type of testing must be done in-person and under supervision. Eye-tracking is very common in the field of HCI.

## 3. WEB USABILITY TESTING

Website usability testing implies using specific method and tool for testing in order to analyze every part of the website. Main goal of web usability testing is achieving the satisfaction of the website users. The web usability testing process is similar to testing of other products.

It should be kept in mind that there are currently 1 870 000 000 active websites worldwide and this number is constantly increasing [10]. This means that there is a huge number of websites with similar purpose and users have no reason to spend time trying to understand a website that is complicated when they can easily switch to the next one offered.

When performing testing, there are a few tips to follow [5]:

- Encourage users to act naturally - websites are generally made with responsive design and support different approaches to their functionalities, which users may not try if they do not feel comfortable;
- Users should complete the task the way they choose - although it might seem that the user did not understand the task or went in a wrong direction, observer should wait and watch, so information of user interaction with website could be gathered and understood;
- Competitive websites should be tested as well - by testing other, similar websites, more important information can be collected.

Whether the subject of testing is an official website of a company or a personal blog, there are six criteria that must be tested [5, 6, 9]: task performance, navigation, design, readability, accessibility and speed.

### 3.1. Tools for web usability testing

There are many tools for web usability testing depending on test type. These tools are usually commercial and their price ranges from a few hundred to several thousand dollars. However, for students needs at faculty courses, there are trial versions of many tools which are limited either by provided functions or time.

As mentioned before, there are certain segments of websites that are crucial in usability testing such as: page loading speed, design and navigation, interaction with users, error testing, testing of target (internal) pages, user surveys and accessibility. For each of these areas, one tool for testing will be presented, comparison and other analyzes [11]. Also, there are software packages

that can be used to test website usability for all the above-mentioned segments.

For the page loading speed, one of the best tools with a wide range of possibilities and analysis integrated is *GTmetrix* [11]. *GTmetrix* is a free tool that can identify all the files which are used by website, in order to identify the part of the website that takes the most time to load. It also has the ability to compare two websites and perform a large number of comparative analyzes.

In the design and navigation area, free tool called *Spur* can be used. This tool is very simple, i.e. it is only necessary to enter the page address and the system will display the page in different contrasts, zoomed in, with an unclear image, etc. [11].

As for the interaction with users, there is a paid *CrazyEgg* tool, which is used for recording the movement of the mouse and highlighting the places that users most often visit on the website. It also records mouse clicks on every position on the website [11].

In the errors and error testing field, there is a free tool called *PowerMapper*. It has very useful features when it comes to identifying errors, as well as failures that may cause errors in the future [11].

To test target (internal) pages, there are free *Google Content Experiments* that can provide information related to the first pages that users visit on the website [11].

*UserEcho* is a free tool used for creating surveys on the website that everyone can complete. As a result, direct feedback from users regarding important questions about website can be collected [11].

Accessibility of websites can be checked with *BrowserShots* tool. This is a free tool used for testing the website appearance and functionalities in different browsers and on different devices [11].

## 4. EXAMPLE OF WEB USABILITY TESTING

### 4.1 Methods of analysis

This work includes research realized through testing of several elements of websites using available tools. In test plan, two websites are chosen for testing, one that gives an impression of functional and practical website, and another that looks less efficient. In this research, remote, unsupervised methodology is used and comparative test type.

Master students from study programs Electrical and computer engineering and Information technologies did all testing and present obtained results. Students chose two websites for testing: [www.uspon.rs](http://www.uspon.rs) [12] and [www.metalacposudje.com](http://www.metalacposudje.com) [13]. They are both official web presentations of companies, but the first one also includes web shop functionality.

Comparative tests are carried out by testing each website individually, and then both results obtained are compared. Testing of each element on both websites must be performed with the same tool and the same methodology. Thereafter, results are being compared, and a website that provided better performance for tested element is being selected. When all elements are tested, on both websites, a general conclusion about the usability of websites is made. Also, all of the elements that are being tested are evaluated in sense of relevance for usability.

One of the reasons why these websites were selected for analysis is that they are web presentations of local firms, so the test results could be useful both for them and for other smaller local firms in terms of highlighting the areas they should pay attention to when it comes to usability of websites. The crucial factor that influenced the selection of these two websites is the subjective opinion of students that they differ in their usability level, so it would be easier to explain the advantages and disadvantages of one in relation to the other website.

In this example, the following website usability elements were tested using tools listed in brackets: accessibility (*BrowserShots*, *Responsinator* tools), page loading speed (*GTmetrix* tool), user interaction (*Clueapp* tool) and error checking on the website (*PowerMapper* tool).

### 4.2 Results of usability testing

For accessibility testing, tests were performed on three different browsers: Chrome, Firefox and Opera, on three different operating systems: Linux Ubuntu, Windows 7, and Mac OS. In addition, websites were tested on two browsers that are typical for Linux and Mac OS: *Dillo* and *Safari*.

Primary conclusion for the website of the Uspon Company is bad responsive rate, which is the first disadvantage of this website. Therefore, further testing on tablets and phones of different sizes would be superfluous. As for the Metalac Company, website has a responsive design and has been adapted for viewing over the phone, tablets and computers. However, the Uspon website has given a better overall result when testing on different search engines and operating systems was done.

When it comes to page loading speed, the Uspon website is in the lead. An average loading speed of 6.5 seconds measured on 77 requests was estimated for Uspon website, while on the Metalac website average time was 11 seconds for 129 requests. It should also be taken into account that the home page of Metalac is more than 5MB larger than Uspon website. The overall conclusion for loading speed is that both websites have very low ratings, so this usability element should be considered as one of the disadvantages of these websites.

In the Figure 1 detailed loading speed time consumption for both websites is presented. In Figure 1 a) it can be seen that a significant part of the loading time for Metalac website is spent on loading the images which are obviously very large. This means that the entire website takes up plenty of space and consequently it takes too much time to load. In order to improve this segment of usability, images should be optimized by changing their size and resolution or even completely removing some of them. In figure 1 b) it can be seen that loading speed divided by elements for Uspon website is much shorter and evenly distributed. In this segment of usability, observed websites vary greatly, and it can be concluded that Uspon website shows somewhat better results.

In the interaction with users testing field, initial impressions on a sample of 10 users who visited these websites for the first time or very rarely are collected. For ten users surveyed, the most memorable items on the Uspon website are the company logo, advertisements and navigation (Figure 2). Also, users noticed red color adequately integrated with the gray. It can be concluded that website designers have found the most suitable positions for the most important parts of the website, such as the logo and navigation. Based on this sample of users and their opinions, the impression is that no changes should be made in terms of design and layout of the elements on the website. However, perhaps this impression would be different if the survey was conducted over a larger number of users using different search engines and devices.

In the Figure 3 the results of survey on the impressions of the Metalac website are shown. Within five seconds (the duration of the home page display before the survey appears), the page could not be loaded, so the users gave responses accordingly to that occurrence. Although this was not the point of the test, it provided information about the opinion on the pages with slow loading

speed and the website designers should definitely deal with this problem.

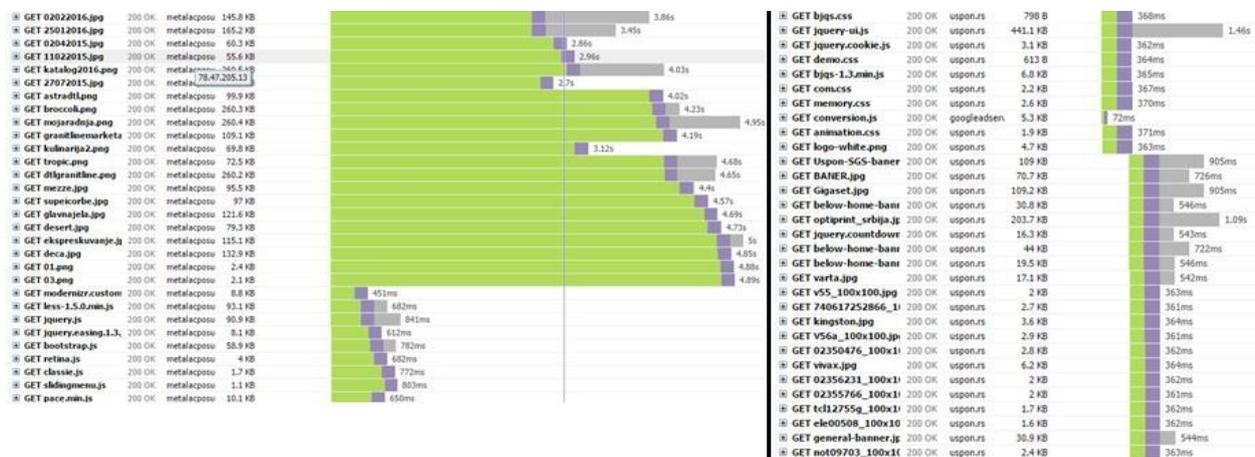


Figure 2. User opinions about website Uspon



Figure 3. User opinions about website Metalac

As an improvisation of the test, due to the lack of desired results in the previous survey, an additional test was carried out, as the authors of the work went through all the elements of the website. It was noticed that navigation is well placed, but at some pages navigation is missing and there are no Home and Back buttons. This is certainly an oversight and a deficiency of design.

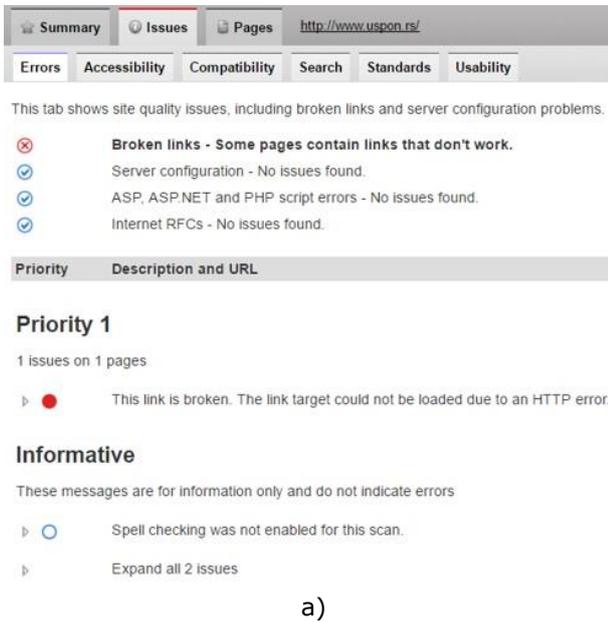


a)

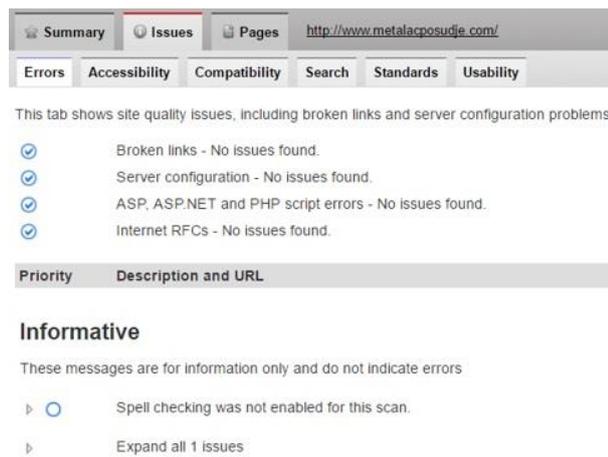
b)

Figure 1. Loading times for a) Metalac website b) Uspon website

When testing errors, it is necessary to enter the addresses of the websites that are being tested in the *PowerMapper* tool, and the system itself will recognize bugs and errors. In the Figure 4 the results of testing for both websites are shown.



a)

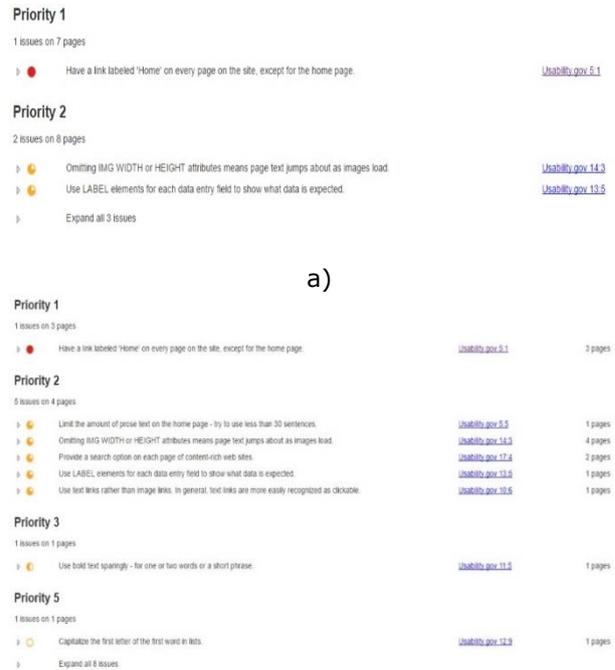


b)

**Figure 4.** Testing results for errors a) *Uspon* website b) *Metalac* website

As it can be seen in the Figure 4a, the *Uspon* website has an error in the form of a link that does not work, i.e. does not lead anywhere. The *Metalac* website did not have any errors (Figure 4b)).

What can also be noticed is that both websites have certain flaws that are not in accordance with the guidelines established by *Usability.gov* (Figure 5), an institution that defines good practices when it comes to usability of websites. In both websites minor errors are detected and grouped by priority level. Explanation and solution within the standards and guidelines of this institution for all errors are provided.



a)

b)

**Figure 5.** Oversights on the sites that are not in accordance with standards a) *Uspon* website b) *Metalac* website

At the end of the error test, it can be concluded that both websites in this segment are free of any major errors and serious failures. Practically, there are no mistakes that can affect the usability of these websites. The only thing that is noticed is that some segments are not in compliance with the guidelines and rules of good practice proposed by *Usability.gov*.

This research provided the information about usability problems in four segments of websites. Majority of the results confirmed the initial impressions of the students about the websites. In Table 2 an overview of the final results is shown. The exact level of the quality and usability of websites was not established, so results are not presented quantitatively, but as a pluses and some minuses, depending of determined level of usability for each segment. Comparative analysis showed that the *Uspon* website has a great advantage over *Metalac* website.

**Table 2.** Results of testing

Segment \ Website	Uspon	Metalac
Accessibility – responsive design	-	+
Accessibility testing	+	-
Loading speed	+	-
User interaction	+	-
Error testing	+	+

## 5. CONCLUSION

Usability is a very important feature of every product, whether it is a tangible product or a service, a software or a website. The extent to which customers' requests are met, represents the level of user satisfaction with the product, which directly affects its survival on market.

The usability test is a topic that is attracting more and more attention of many companies, and it will surely be important to everyone who wants their product to be successful and to fulfill demands of the users. Although it may require a lot of resources and time to obtain needed data for analysis, usability test can also be done with a very small budget, often with paper and pencil only. Despite that, the results will certainly be significant to the products sustainability on market, because any feedback from the user is better than no feedback at all.

This paper presents a comparative usability testing of two websites, with an attempt to show in practice that some website elements can affect its performance. It is necessary to pay attention to the as more details as possible and to try to eliminate all problems and errors. Feedback of the users is very important and their opinion should be relied on during the website design and usability improvement, since they are those who determine the success of the website, product and company.

Usability testing found an important place in HCI courses, where students from Master studies learn theoretical concepts and use some of the available software for usability testing and evaluation of user interfaces. This way they are more prepared for future job opportunities in sector of Information technologies.

## ACKNOWLEDGEMENTS

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# The concept of development of the intelligent tutoring system sensitive to emotions

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**Abstract:** *This paper represents the contribution to the development of the intelligent tutor system sensitive to emotions. The proposal of the model of emotion recognition during the learning process, having in mind the necessary sensors and the emotion classification. The use of RBF neural network is suggested because of the simple and temporally hardly changeable nonlinear object approximation provided it is possible to place the center and determine the amounts of variables RBF neurons in advance, where the studying of the network can be reduced only to the settings of crucial coefficients in output layer.*

**Keywords:** *intelligent tutor systems; neural network; RBF networks*

## 1. INTRODUCTION

The majority of theories regarding the learning process has mainly ignored the importance of the connection between the learners emotions or emotional states and learning. Nevertheless, it is claimed that cognition, motivation and emotions are three components of the learning process. The emotion is traditionally observed as the root of motivational energy, but it is often not considered as the independent learning or motivational factor. During the last two decades, more attention was paid to the correlation between the emotions and learning process [1]. Various algorithms of machine learning are used in order to detect multiple emotional states through the model of a student [2].

The JAFFE database with the face photos was used [6]. The facial expressions of those defined in [5] were used. The Facial Expression Recognition 1.0 software is used for face recognition, and it is based on the reduction of dimensionality based on neural networks and PCA methods.

## 2. SUGGESTION OF THE EMOTION RECOGNITION MODEL DURING THE LEARNING PROCESS

The aim of this model would be the development of relation between learning and emotions when the learners are interactive with the learning system (computer tutor system). The participants can take part in the training with any section studied, where tutor system asks the questions regarding the section studied. Every interaction with the tutor can be recorded. During the tutorship phase, it can be demanded that the participants express aloud their emotional states. The participants can be provided

with the list of emotional states including the following: fury, boredom, confusion, scorn, curiosity, abhorrence, cognition and frustration.

Video shooting of every participant would end with their loud statement of the emotional state they are in. The emotion expression should have the tendency to be very quick and last only around three seconds.

### 2.1 Sensors

The automatic detection system for the level of learners interest according to the body posture can also be developed. Various algorithms for machine learning can be used in order to classify the learner's static positions which occur most often in the real time (leaning backwards, sitting upright, etc.) Therefore, the interest of the learners could be recognized (high interest, low interest and taking break).

The assessment of the learner's answers regarding their emotional state could also be performed in the model proposed. Based on the interactive session with the student, the system could perform its own assessment of the student's answers. The assessment of the student's answers could include information such as: the correctness of the answer, reactions and the response time, length of the answer and many other parameters.

### 2.2. Emotion recognition

Two different approaches to the classification of emotions could be applied.

The first would integrate the data from all the three sensors in the high dimensional vector before the classification attempt.

The other way would be to classify individually each entry from the sensor, and then integrate the

classification of each sensor into super classifier, in order to obtain one emotion as a result.

Each approach is connected to corresponding advantages and weaknesses, and the only way to determine which one is better is empirical research.

As far as biological motivated classifiers are concerned, some could be used, for example, different types of neural networks. Our exclusive use of noninvasive sensors for emotion detection could have side effect of creating the data with background noise. Because of that, it would be necessary to remove the background noise before the classification using the appropriate techniques.

### 3. RBF Networks

In the field of mathematical modelling, the network of radial basis functions (Radial Basis Function-RBF networks) is artificial neural network using the radial basis as the activation functions. These neural networks are two-layered static neural networks, where the zero (input) layer forwards the inputs into the network to the entrance of the first layer conducted of neurons with activation functions with the round basis and represents its so-called receptive field.

The second layer is the network layer, which is also its output layer, and is consisted of perceptrons with linear activation function of identity activation.

RBF network has the ability of approximation of arbitrary continual nonlinear function, and its approximate ability is determined by the position of the center of RBF neuron, variation of activation functions as well as the values of coefficients of the output network layer.

The adequate values of these parameters of RBF network are calculated using the learning algorithms. RBF neural networks are especially used in the case of the approximation of simple and temporally hardly changeable nonlinear when it is possible to place the centers and determine the values of RBF neurons, and where the learning of network can be reduced to the setting of coefficients of the output layer. The behaviour of RBF neural networks, in this case, becomes lineary dependent on parameters.

The properties of RBF network are significantly determined by the position of the center of RBF neurons. RBF functions are traditionally used for the interpolation of many nonlinear variable functions, where the number of centers is equal to the number of the data, so that one center is placed in each input data. The approximation of the arbitrary nonlinear continuous function is also possible to achieve with the smaller number of the well placed centers.

Broomhead and Lowe [Broomhead i Lowe, 1988] suggested in their papers to put the centers in accidentally chosen input data. There is also the possibility of monotonous placement of centers in

the space of input entries. The variances of the activation functions influence the network behaviour less and are usually chosen as the second root product of the neuron distance from the two nearest adjacent neurons Moody and Darken, 1989. year [3]. These networks can approximate the arbitrary nonlinear continuous function with accidental equal placement of the centers of RBF neurons, but necessary number of RBF neurons can be very high. We can also achieve the reduce of the RBF neurons number by expansion of the network learning method and by adjusting the center position. The RBF network behaviour, in this case, becomes nonlinear dependent on parameters, but also with comparable approximative features [4].

### 4. RBF NETWORK TRAINING

Optimal architecture of RBF network is usually determined experimentally, but some practical directives also exist. Problem solving procedure using neural networks consists of: collecting and preparation of the data, network training, network testing, and determining the optimal parameters of the network and training experimentally (number of neurons, number of neuron layers, learning algorithm parameters and training data).

The data preparation for RBF networks includes: Filtering, normalization and dimensionality reduction. The success of the solving depends completely on the data used for network training. It is necessary to be careful of theoretical adequacy – the representativeness of the data used for certain problem. This is very specific depending on the problem which is being solved. The RBF training includes: the determining of optimal network parameters and training algorithm, determining the number of hidden layers and the number of neurons in every layer (more doesn't mean better, the goal is to have less), dynamic parameter setting, parameter validation (with trial set), determining the training and the testing of the data and solving of overtraining problem and generalization.

Output weights training is simple when the output neurons use linear activation. There are three kinds of parameters in the RBF network necessary to be determined for adjustment of the network for certain task: middle vectors  $C_i$ , output weights  $\omega_i$  and RBF width parameters  $\beta_i$ .

As far as the sequential training is concerned, the weights are updated in every temporal step. For some tasks, there is sense in defining the aim function and choosing the parameter's value which minimize its value. The most present aim function is the smallest square function, which explicitly includes the dependence on the weight.

$$K(\omega) = \sum_{t=1}^{\infty} K_t(\omega)$$

where

$$K_t(\omega) = [y(t) - \varphi(x(t), \omega)]^2$$

The minimization of the smallest square aim function assisted by optimal choice of weight choice is optimizing accuracy.

There are some situations where many aims, such as the smoothness and accuracy, has to be optimized. In that case, it is useful to optimize the regulated aim function as

$$H(\omega) = K(\omega) + \lambda S(\omega) = \sum_{t=1}^{\infty} H_t(\omega)$$

where

$$S(\omega) = \sum_{t=1}^{\omega} S_t(\omega)$$

and

$$H_t(\omega) = K_t(\omega) + \lambda S_t(\omega)$$

where optimization  $S$  maximizes the smoothness and  $\lambda$ .

### 5. EXPERIMENTAL RESEARCH

Based on the JAFFE database with face photos (available at <http://www.kasrl.org/jaffe.html>) where ten people set three or four examples of each of the six basic facial expressions (happiness, sadness, surprise, anger, abhorrence, fear) [5] and neutral face with the total of 219 photos of facial expressions. Because of the experimental research's simplicity, only the Japanese female persons were used. The photo examples are shown in picture 1.

Based on the research defined in [7] and [8] for emotion recognition, the software Facial Expression Recognition 1.0 is used, and it is based on the neural networks and PCA method. This algorithm for facial expression recognition classifies the given picture into one of the seven main facial expression categories (happiness, sadness, surprise, anger, abhorrence, fear and neutral). The PCA method is used for the output data dimension reduction. The method keeps those characteristics of the data set which contribute to its variance the most, keeping the main components of the low order and ignoring those of the higher order. That is why the components consisting of the low order contain "the most important" data aspects. The drawn function vectors in the reduced space is used for the neural network classifiers training for classification. The suggested method is quick and can be used for applications in the real time.



**Figure 1.** Sample images JAFFE database [6]

The face classifier was primarily tested by using the photos with the face expressions of the seven Japanese ladies with following initials: KA, KL, KM, KR, MK, NA i NM. Each of these persons has set three or four copies of each of the six basic facial expressions, as well as their neutral face. The set of images is divided into seven sets, each of the sets corresponds to one person. The system is trained on seven segments, and then tested on a new data set, which is not used in training. In testing, it was noticed that the system does not recognize all the facial expressions equally true.

Table 1 represents the confusion matrix showing the wrong classifications for the data set of the woman with the initial YM. The results of our simulation experiments show that neural networks are effective in recognizing emotions using facial expressions, when we tested six emotions, we achieved a recognition rate of about 50%.

**Table 1:** Rates of the wrong classification for the person with the initial YM. HAP - happiness, USA - sadness, SUR - surprise, ANG - anger, DIS - depression, FEA - fear.

ANG	DIS	FEA	HAP	SAD	SUR	I/O
3	-	-	-	-	-	ANG
-	-	-	-	-	-	DIS
-	-	-	-	-	-	FEA
-	-	-	-	-	-	HAP
-	3	2	1	3	-	SAD
-	-	-	-	-	3	SUR
-	-	1	2	-	-	NEU

It should be noted that it is not easy to compare classification performance, because facial expressions are not always pure specimens of one category of expressions. It is important to understand that expressions are never a pure expression of an emotion, but they always represent different emotions. In each of the images used in the research, only the dominant expression

in this figure is presented - the expression that the person was asked to pose.

## 6. CONCLUSION

This research could help in future papers, such as capturing non-stationary images in real time, and simultaneously analyzing these images in accordance with the techniques of affective computing. In the future, improvements in image selection methods are also possible. Algorithms and data sets will be selected according to precise criteria: classify algorithms and several data sets. Also, these conclusions and recommendations can be tested on larger sets of data using different classification algorithms in the near future. The broader impact of the proposed research could contribute to the improvement of education, intelligent learning environments and interfaces between people and computers.

The main computing effort should be focused on achieving new methods of estimation and classification of affective emotional states. Some of the existing emotional classifiers can be used, and which would possibly be updated. A common classifier for these needs are neural networks.

Neural networks are an acceptable tool when problem solving approaches are standardized in such a way that for each situation the network architecture, learning rules, the number of hidden layers, and the number of neurons in them, as well as the portable functions that need to be used in solving, are exactly defined.

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# Online Reading Strategies Use in English as a Foreign Language in Biotechnical Engineering

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**Abstract:** *The paper examines the use of reading strategies by biotechnology engineering students when reading English texts online. The study involved twenty undergraduate students learning English as a foreign language at University of Kragujevac, Serbia. The instruments used in the study were the Background Information Questionnaire and Survey of Online Reading Strategies. The participants' overall use of online reading strategies is at the medium level. The obtained results also demonstrate that the most prominent online EFL reading strategies involve trying to maintain focus when losing concentration, reading slowly and carefully in order to understand the online text better, using reference materials for better understanding when reading online, and paying closer attention to what is read when reading difficult online texts. Significant gender differences are found with four online reading strategies: overviewing the online text to see what it is about, confirming the purpose of reading, guessing the content of the online text, and self-questioning about the online text.*

**Keywords:** *biotechnology engineering; English as a foreign language; online reading; reading strategies.*

## 1. INTRODUCTION

In the new knowledge economy reading has become highly important and remains the most effective human activity for transforming information into knowledge [1] no matter if it refers to reading on paper or reading online. Reading is considered a basic academic skill vital for the development of professional competences in various occupations [2]. Reading in a foreign language academic setting is significant in terms of students' expected involvement in later academic pursuits at academic level such as reading abstract materials, understanding the key ideas from the texts and lectures, reading scientific materials, writing summaries and critical essays. On the other hand, reading online has become common in our daily lives since the amount of reading material available online has been rapidly increased [3].

Since the beginning of the 21<sup>st</sup> century there has been an increased interest in reading research and how technology affects various aspects of reading all over the world. These issues become even more important in the context of professional development in engineering as a potent field of human activities. In the contemporary world of globally interconnected engineering activities, reading skills in English as a foreign language (EFL) have become vital for biotechnology engineers in performing their professional activities [4].

Perceptive foreign language learners are aware of and use appropriate reading strategies in learning a foreign language. The purpose of reading strategy use is to improve readers' performance in reading foreign language texts.

This study seeks to explore how biotechnology engineering students behave when they read English texts online by exploring the reading strategies they use. Also, it aims to find out potential gender differences in online reading strategy usage.

## 2. THEORETICAL BACKGROUND

The main issues of the research are focused on online language learning environment, reading and reading strategies in a foreign language, and the role of gender in a foreign language reading strategy use.

### 2.1. The importance of online language learning and reading in higher education

Since the beginning of the 21<sup>st</sup> century the digital technologies have been used in higher education to develop and distribute education. The use of information and communication technologies (ICTs), particularly the Internet, is highly important in language learners' exposure to authentic language on the topics they are learning about in foreign language classrooms.

Many forms of foreign language learning/teaching practices still have been carried out in a

school/classroom setting; however, in today's networked world driven by ICTs language learning environment can also be virtual which means that students and teachers do not have physically direct communication in the same classroom – they are far away in space and time. Nowadays distance education is most frequently realized through e-learning or online learning as interactive learning in which the learning content is available online providing automatic feedback to the students' learning activities [5].

ICTs have an important role in foreign language reading around the world. Online reading serves as a source of input for innumerable foreign language readers [6]. The texts EFL readers encounter online can be nonlinear texts, multiple-media texts, and interactive texts [7]. Such texts introduce new challenges for EFL readers. One of these challenges is undoubtedly the role of new literacies which include skills, strategies, and insights necessary to successfully exploit the rapidly changing ICTs that continuously emerge in our world [8]. New literacies, being deictic, multiple, multimodal, multifaceted, require not only critical literacies and new social practices but also various forms of strategic knowledge [9], including online reading strategies.

## **2.2. Reading and online reading strategy use in foreign language learning**

Various definitions of reading come from the fields of mother tongue acquisition and foreign language learning. Reading may be defined as a psycholinguistic process as it uses language to get to the meaning [10], as extracting the information from the text [11], as decoding as the skill of transforming printed words into spoken words [12] or as the process of receiving and interpreting information in language form via the medium of print [13].

Since the mid-1970s, close attention has been given to the importance of language learning strategies [14, 15]. Language learning strategies are defined as specific actions, behaviors, steps, or techniques — such as seeking out conversation partners, or giving oneself encouragement to tackle a difficult language task — used by students to enhance their own learning [16]. Later, in the 1980s, various taxonomies of language learning strategies were proposed [17, 18], classified according to their psychological functions into memory, cognitive, compensation, metacognitive, affective and social strategies. They also can be classified according to skill area - reading, writing, listening, and speaking [19].

Foreign language reading strategies refer to those for building reading habits in a foreign language (e.g. making a real effort to find reading material that is at one's level or within the zone of proximal

development), for developing basic reading skills (e.g. planning how to read a text, monitoring to see how the reading is going, checking to see how much of it is understood, and making summaries in one's mind or in the margins of the text), and for determining what to do when encountering unknown words and structures (e.g. guessing the approximate meaning by using clues from the surrounding context, using a dictionary so as to get a detailed information of individual words meaning) [19].

Most foreign language reading empirical research is focused on the identification of metacognitive reading strategies of foreign language learners, the differences in using reading strategies between native and non-native English readers, gender differences in using reading strategies, relationship between reading strategy use and self-rated reading ability [20, 21]. Skilled readers are more able to reflect on and monitor their cognitive processes while reading, and tend to be better at regulating the use of these strategies while reading [20]. This research base on strategies is lacking in examining what foreign language learners do when they read online.

Relatively few studies discussed online reading strategies. When readers are engaged in online reading, they interpret the writer's viewpoints and integrate abundant materials by utilizing online reading strategies [22]. Readers also may transfer their print-based strategies to online reading but they will also need to use additional strategies in online reading [23].

The current study is a step in exploring what reading strategies EFL readers use while reading online.

## **2.3. The role of gender in foreign language reading**

Several studies have been focused on the role of gender in foreign language reading [24-26]. It has been found that females show more positive attitude to reading while males report significantly more goal-oriented strategies with more memorizing, elaboration, and instrumental motivation [25]. Moreover, gender is an important factor in students' perceptions of the use of foreign language reading strategies in higher education: it has been revealed that male learners think about whether the content of the text fits their reading purpose more than female learners [27]. Nevertheless, there is a paucity of research dealing with the role of gender in online language reading practices [28].

## **3. RESEARCH QUESTIONS**

This research was carried out to examine the undergraduate biotechnology engineering students' perceived use of online EFL reading

strategies. The following research questions are explored in the paper:

1. What foreign language online reading strategies are used by the participants?
2. How frequently these online reading strategies are used?
3. Are there any differences between females and males in their perceived use of online reading strategies in EFL?

## 4. METHODS

### 4.1. Participants

The participants in this study are 20 undergraduate students in the field of biotechnology engineering at the University of Kragujevac, Serbia. They are learners of English as a foreign language (EFL). Seventy percent of the participants are females and thirty percent are males. The learners ranged in EFL proficiency from high beginning to advanced.

### 4.2. Variables

The following variables are used in this study:

- 1) the perceived use of online EFL reading strategies; and
- 2) the participants' gender – 14 female and 6 male undergraduate biotechnology engineering students.

### 4.3. Instruments

Two instruments were used in the research: the Background Information Questionnaire (BIQ) and the Survey of Online Reading Strategies (SOORS).

The BIQ was used to gather information about the participants' demographic characteristics and experiences in learning EFL.

The SOORS was used to measure the perceived use of online reading strategies by non-native English readers. This self-report scale consists of 34 Likert-scale items with choices ranging from "never or almost never true of me" (1) to "always or almost always true of me" (5). The SOORS instrument [6], was adapted from the original Survey of Reading Strategy instrument (SORS) [21] so that each item was modified to include the word "online" each time a reading task was referred to. A pilot study was conducted among 20 undergraduate biotechnology engineering students.

### 4.4. Procedures and analyses

The research instruments were distributed to the participants by their EFL teacher during their regular EFL classes. The EFL classes were focused on developing students EFL reading skills both in online and face-to-face learning environments.

The measures of internal consistency, descriptive statistics, and analysis of variance (ANOVA) were analyzed by using SPSS 20.0 Package for

Windows. For the Likert-scale strategy-use items of the SOORS, the following key was used to help to interpret the means: mean values from 3.5 to 5.0 indicate high use, from 2.5 to 3.49 indicate medium use, and from 1.0 to 2.49 indicate low use [17].

## 5. RESULTS

The instrument overall internal consistency and reliability was established - Cronbach's alpha was  $\alpha = 0.79$ . This result shows that the SOORS instrument is internally consistent and reliable [29, 30]. It is not uncommon for contemporary researchers to characterize reliabilities in the 0.60s and 0.70s as good or adequate. This result is within the scope of the coefficient values found in the literature for the SORS, as the basis for SOORS, ranging from 0.74 to 0.93 [20, 31, 32]; however, it is lower than the result found for the referent instrument OSORS in [6], reporting Cronbach's alpha  $\alpha = 0.92$ .

### 5.1. The use of online EFL reading strategies in biotechnology engineering

Descriptive statistics, including a frequency analysis of overall reading strategy use, mean value, and standard deviation of the overall and each strategy use, were employed to describe the strategies the undergraduate biotechnology students use when they read English texts online. The means of self-reported scores for online reading strategy use are shown in Table 1 and Table 2.

The frequency analysis revealed that almost one third of the participants in the study (30%) reported that they used online reading strategies frequently; almost two thirds of the respondents (65%) showed medium use of online reading strategies, while only 1 student (5%) used online reading strategies rarely.

**Table 1.** Overall and top four online EFL reading strategies

Online EFL reading strategies	M (SD)
Trying to maintain focus when losing concentration	4.50 (0.69)
Reading slowly & carefully to understand online text better	4.20 (0.70)
Using reference material (online dictionary) for better understanding when reading online	4.15 (0.88)
Paying closer attention to what is read when reading difficult texts	4.05 (0.89)
Overall online EFL reading strategies	3.28 (0.36)
N=20	

The mean value of the overall perceived use of the online EFL reading strategies is  $M = 3.28$  (Table 1), which indicates the students' moderate use of online reading strategies. The four most

frequently used online reading strategies are illustrated in Table 1 ( $M > 4.00$ ).

The other online reading strategies at the high level of usage involve re-reading online for better understanding ("When online text becomes difficult, I re-read it to increase my understanding") ( $M = 3.95$ ), checking understanding when coming across new information ("I check my understanding when I come across new information") ( $M = 3.90$ ), guessing the content of the online text ("I try to guess what the content of the online text is about when I read") ( $M = 3.90$ ), using background knowledge for better understanding when reading online ("I think about what I know to help me understand what I read online") ( $M = 3.85$ ), visualizing information when reading online ("I try to picture or visualize information to help remember what I read online") ( $M = 3.85$ ), reviewing the text characteristics ("I review the online text first by noting its characteristics like length and organization") ( $M = 3.75$ ), setting purpose for reading online ("I have a purpose in mind when I read online") ( $M=3.60$ ), confirming the purpose of reading ("I think about whether the content of the online text fits my reading purpose") ( $M = 3.60$ ), and adjusting reading speed ("I adjust my reading speed according to what I am reading online") ( $M = 3.55$ ).

The three least frequently used online reading strategies are taking part in live chat with other learners of English and with native speakers of English, and underline/circle information in the printed online text for better understanding; the mean values were  $M = 1.65$ ,  $M = 1.25$ , and  $M = 2.25$ , respectively, all mean values being  $M < 2.50$  indicating low strategy use.

The rest of online reading strategies were reported as medium usage strategies ( $2.49 < M < 3.49$ ), as shown in Table 2.

**Table 2.** Online EFL reading strategies used at the medium level

Online EFL reading strategies	M (SD)
Taking notes while reading the text online	2.85 (1.04)
Taking overview of the online text for the content	3.35 (1.18)
Reading online text aloud for better understanding	2.65 (0.93)
Selecting what to read & what to ignore	3.30 (0.92)
Reading online for academic purpose	3.20 (1.32)
Using text features (tables, graphs, pictures)	2.55 (1.15)
Contemplating the online text read	3.30 (0.80)
Using context clues	3.30 (1.08)
Paraphrasing when reading online	3.25 (0.97)
Using typographical features for key information	2.85 (1.31)

Analyzing & evaluating information in the online text	2.95 (1.19)
Finding relationships among the ideas in the online text	3.35 (1.14)
Self-questioning about the online text	2.90 (1.25)
Confirming predictions	3.45 (0.99)
Guessing the meaning of the unknown online words/phrases	3.40 (1.05)
Scanning the online text for the purpose of reading	3.15 (1.18)
Reading online texts for fun	3.00 (1.26)
Evaluating the online text before using the text information	2.75 (1.07)
N=20	

## 5.2. Gender differences in online EFL reading strategy use

As previously mentioned 14 female and 6 male participated in the research. According to ANOVA, the female and male students generally use overall online EFL reading strategies at the similar levels of frequency since the significant differences were not recorded ( $p > 0.05$ ). The only significant gender differences were found with the students' perceived use of four individual online EFL reading strategies (Table 3).

**Table 3.** Gender differences in online EFL reading strategy use

Online reading strategies	Females/Males (M)	p
Overviewing the online text for the content	3.00 / 4.17	0.039*
Confirming the purpose of reading	3.20 / 4.50	0.041*
Guessing the content of the online text	3.64 / 4.50	0.01*
Self-questioning about the online text	3.29 / 2.00	0.031*
N=20 * $p < 0.05$		

The male students take an overall view of the online text to see what it is about before reading significantly more frequently ( $M = 4.17$ , indicating high strategy use) than their female colleagues ( $M = 3.00$ , indicating medium strategy use); the mean difference is significant at the 0.05 level ( $F = 4.939$ ,  $p = 0.039$ ,  $p < 0.05$ ). Also, the male participants think whether the online text content fits their reading purpose and guess the online text content significantly more frequently ( $M = 4.50$  for both strategies, indicating highly frequent strategy use) than the female students ( $M = 3.20$  and  $M = 3.64$ , respectively). On the other hand, the female students ask themselves questions about the online texts significantly more frequently ( $M = 3.29$ , indicating medium strategy use) than their male colleagues ( $M = 2.00$ , indicating low strategy use). All these results are presented in Table 3.

## 6. DISCUSSION

The results of this study continue to add to our understanding how strategies are used by EFL readers, particularly within the context of reading online.

The obtained results revealed that biotechnology engineering students reported to use online EFL reading strategies at the medium level, which is consistent with the findings obtained in the literature [33-35].

The findings from the SOORS also reveal that the most prominent online EFL reading strategies used in biotechnology engineering involve efforts to maintain the focus when losing concentration while reading online, reading slowly and carefully to understand online text better, and paying closer attention to what is read when the online text becomes difficult. It was not surprising that EFL readers most frequently look up an online dictionary when they read online reading material as vocabulary is perceived to be highly difficult task among EFL learners [34]. The least frequently used online reading strategies besides highlighting information in the printed version of an online text in order to understand the text better are participating in live chat with other learners of English and with native English speakers. The reason why learners seldom live chatted with other learners may be because they tended to focus on the understanding of the online English materials instead of social interaction with other readers [34] or because of the students' limited opportunities to interact with native speakers of English [33].

There is no significant difference between female and male students with regard to the overall online EFL reading strategy use. These findings are in line with the findings reported in [20, 35]. It is possible that with foreign language reading strategy use, gender differences are more related to task demands than biology. However, the participants differed significantly on four individual online EFL reading strategies. The results found in this study in the context of online reading are relatively consistent with [20], which indicates that male and female college ESL students only differed in one individual strategy. Several research findings have shown significant variations in terms of the frequency and adaptability of reading strategies between the genders [26, 36].

## 7. CONCLUSION

The study reported in this article is one step toward better understanding of the use of online EFL reading strategies in engineering domain. It reveals that biotechnology engineering students use online reading strategies moderately. There were no statistically significant differences in

overall online strategy use between female and male students. However, there were significant differences between females and males with regard to the use of certain individual online reading strategies.

These results have important pedagogical implications. Online reading is a new form of representation which requires high levels of multi-modal competence [37]. Readers should understand the complex ways these modes operate as well as their limitations and potentials [38]. They also need to understand how links function – where a particular link will take them and what to do when they get there [39]. EFL teachers need to be aware that success in online reading depends on being highly strategic [40], which requires explicit regular instruction. EFL learners tend to use a fixed set of reading strategies that they have long been accustomed to regardless of the text type; they should also be aware of different types of online reading strategies; and more importantly they should be aware of online reading strategies characteristic of skilled readers.

This study has several limitations that could be addressed in further research. The results of this study were based on the limited number of students; this, they cannot be generalized to the whole student population in biotechnology engineering and particularly not to engineering profession in general. Moreover, the SOORS instrument is a self-reporting tool - it means that the participants' responses depend on their sincerity and willingness to cooperate in the research as well as on their awareness of the online reading strategies they use. The present study is a pilot study and hence an initial step in validating the usage of characteristic online EFL reading strategies in biotechnology engineering by the students.

Further studies could investigate how the examined strategies correlate with the students' levels of EFL proficiency or the level of reading comprehension particularly when reading a printed text and when reading online. Future studies could also examine gender variations in using online reading strategies across populations and disciplines. This last issue is important because the gender differences are found, they may lead EFL teachers and researchers to look for ways to minimize them and afford both genders maximum opportunities to achieve high levels of online EFL reading strategies.

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# Mechanism for Migrating Data in Relational Databases

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**Abstract:** *In this paper, we will describe mechanisms for data migration to relation databases, which can be found on the market today. Database practical use in teaching at the Faculty of Education in Bijeljina is on courses Informatics (for the first year of study) and Internet programming (in third year of studies). On these two courses, the students meet with relational databases and based on the communication of lecturers to students determining that there is about 80% of them first-time encounters with this subject matter. Relation Database Management System-RDBMS that will be used on concrete examples is Microsoft Access and MySQL. The aim of this research paper is to provide a software mechanism to students for migration data in MySQL Database with usage on previous knowledge about Access-a database. We will describe methods for migration of data from Access-a into MySQL databases. For practical example we will use, MS Access 2010 in combination with graphical interface, MySQL Workbench 6.3 CE.*

**Key words:** Access; MySQL; RDBMS; Workbench; Export

## 1. INTRODUCTION

**Database,** is a collection of related data organized in such manner way to allow easily access, manage, and maintenance by side of authorized users. Throughout the history of mankind, the data were stored through images and sculptures, while with the appearance of letters the data began to be stored in books. With the use of computers, data began to be stored initially in files that were stored on floppy disks, tapes, hard disk computers, etc.

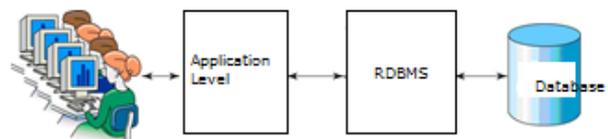
With the growing need for organization business and the amount of data to be processed as well as the reduction of time parameters related to easier and faster retrieval of big sets of data, the inevitable technological advancement was the transition from files to an organized collection of related data-Database.

Edgar F. Codd set up basic rules for Relational databases that are available on market today, [1]. Those are 12 rules that the Code proposed for that purpose and he had defined what it minimum takes to have one RDBMS. According to Stonebraker et al. in [2], "Relational databases were created for business data processing needs during the time when interfaces and hardware were different. Despite some changes, no RDBMS has been completely redesigned since that time."

In accordance with that claim, we come to the conclusion that the application solutions that work on relational databases are stable. Especially if we look from the points of view of possible changes in the technologies approach and the usage databases that are not relational. The general DBMS functions are:

1. Recovery databases from lost of data
2. Managing parallel execution of transactions
3. Protection of data

Main functionality of RDBMS as connection between users on one side and database on the other we can see in "Figure 1". A graphical interface known as the Application Programming Interface -API, which is used to develop applications, is in most cases integrated in the functionality of the RDBMS.



**Figure 1.** Main components of RDBMS-a

Some of the most famous RDBMS are: MySQL, Oracle, Microsoft SQL Server, Microsoft Access, SQLite, Sybase Adaptive Server Enterprise, and so on.

This work will address the two RDBMS which are studied in subjects Informatics and Internet programming in the Faculty of education in

Bijeljina, and they are Microsoft Access and MySQL, respectively.

Some of the similarities and differences of the two systems are listed in Table 1.

**Table 1.** Microsoft Access and MySQL comparison

	Microsoft Access	MySQL
Description	Combines the back-end RDBMS with a GUI frontend for the manipulation of data and queries	A widely used open source RDBMS
Manufacturer	Microsoft	Oracle
ACID transactions	No	Yes
Operating systems	Windows	FreeBSD, Linux, OS X, Solaris, Windows
Supported programming languages	C, C#, C++, Delphi, Java, VBA, Visual Basic.NET	Ada, C, C#, C++, D, Delphi, Haskell, Java, Perl, PHP, Python, Ruby
The license	Commercial	Open Source
Ranking (Points)	131.95	1228.87

The final ranking of these two databases, which is shown in Table 1. based on [3], indicates that the MySQL database is for cca. nine times more grade on scale than Microsoft Access. This result is expected when we take into account the fact that most users like to use open source solutions that are free.

## 2. METHODOLOGY

The main goal of this paper is to provide mechanisms for data migration to relation databases in our case from Access to MySQL. Simulation of data migration in two scenarios will also be performed without the use of software and with the use of third party software. This two scenario were carried out from the reason that is practical part of the course in the field of Internet programming at the Pedagogical Faculty in Bijeljina. From the practice and introductory interviews with the generations of students before the school year 2018, it was noted by the lecturers that 80% of students who attend lectures in the course of Internet programming only at the faculty meet for the first time with some complex RDBMS. Within the Informatics course, students also encounter MS Access with other programs that are part of the MS Office package. The access objects that are being studied by students are: Tables, Forms, Queries and Reports. Objects of the macro type and modules are not studied in this course.

Later, this knowledge from Access is upgraded by learning MySQL within the Internet Programming course topic.

## 3. EXPORT OF ACCESS DATA IN MYSQL

Microsoft Access can be used to exchange data with database on MySQL. This option provides functionality how to start filling up and update the database. If we have existing data in the Access database or table in Excel, it can be read in Microsoft Access and exported to a database on the MySQL server. The most used methods to migration data from Access to MySQL is direct (which do not require the use of additional software) and indirect (when additional software is required). In this paper, two direct and one indirect method will be described. For both methods, the main precondition is the previous installation of the Open Database Connectivity-ODBC interface.

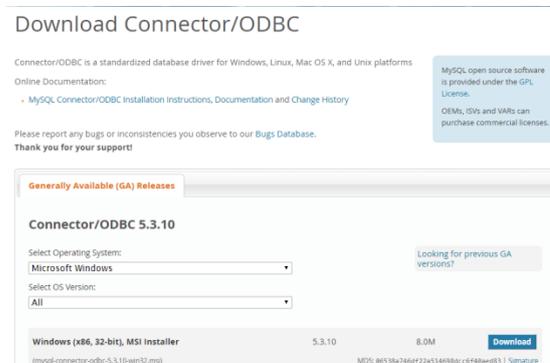
### 3.1 ODBC standard

ODBC is a widely-used Application Programming Interface API, for access to the database interface, [4]. This standard allows the use of databases in distributed system environments such as MS Access, Oracle, MySQL etc. ODBC provides the specificity of access to a particular database and allows developers to develop module without the need to enter into the basics of database operation.

The next step is to show how to connect the MySQL database and the MS Access software package. For both methods (direct and indirect), the ODBC driver must be installed on the computer. To connect MySQL databases and MS Access, we must configure ODBC through system setup within the control panel [5].

The procedure consists of the following steps:

1) First, we need to configure the source data for the MySQL database, [6]. To do this, ODBC connector must be installed, as shown in "Fig. 2".



**Figure 2.** ODBC connector

2) Once the connector is installed, MySQL connection is created by step as show in "Fig. 3". The Data Sources (ODBC) option is selected first in the menu: "Control Panel \ All Control Panel

Items \ Administrative Tools". After that, a new driver is added to the administrator ODBC window (in "Fig. 3" is the MySQL ODBC 5.3 unicode driver).

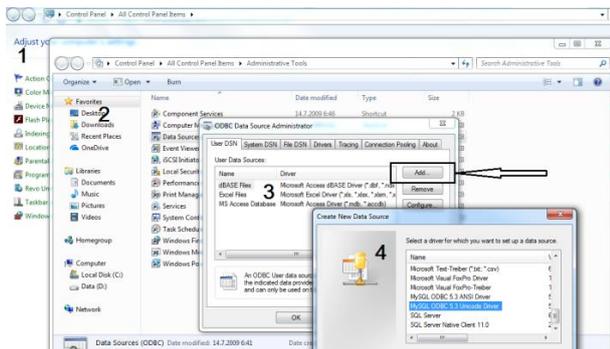


Figure 3. Adding a MySQL ODBC driver

### 3.2 Export data from Access to MySQL without using third-party software

There are two methods for this kind of export data: these are without and with active connection between databases. First, we will describe the method without creating an active connection. This method in MySQL only characterizes the export of data from one database to another, after which the active link between them is lost. More precisely data change in Access after export will not reflect on the database in MySQL. After the driver is successfully added, the setting of the connection as show in "Fig. 4" is performed. An arbitrary connection name is selected in our case. The user, password and database are entered with data that must match with data in MySQL Workbench, and for our case we have chosen the database to which should be exported from the Access table.

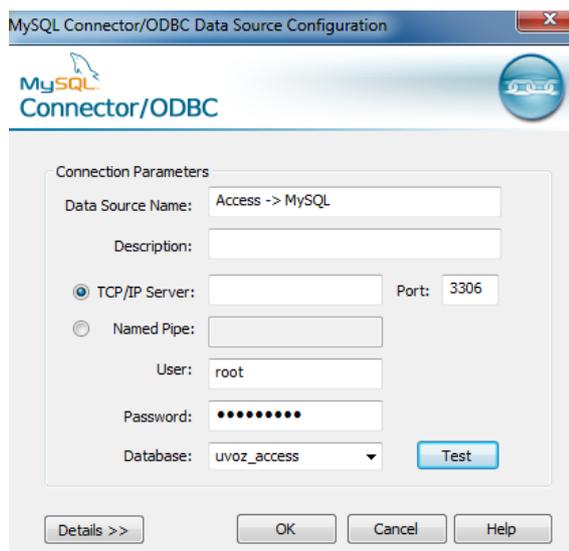


Figure 4. Creating a connection

When the connection is successfully created, we start to export data from the Access database. In Access it must be selected all the tables that we want to export to MySQL and then choose the menu as show in "Fig. 5".

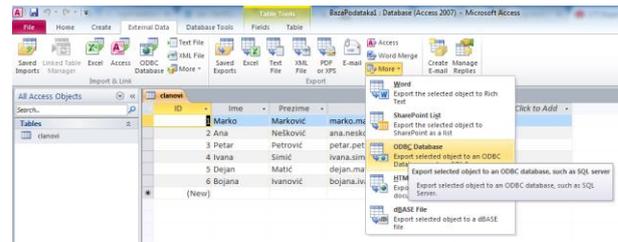


Figure 5. Export table from Access

After this step, a new window appears on desktop, where we enter the name of the table on the MySQL server. The last step is select of connection from which a table should be imported. This step for our example is shown in "Fig. 6".

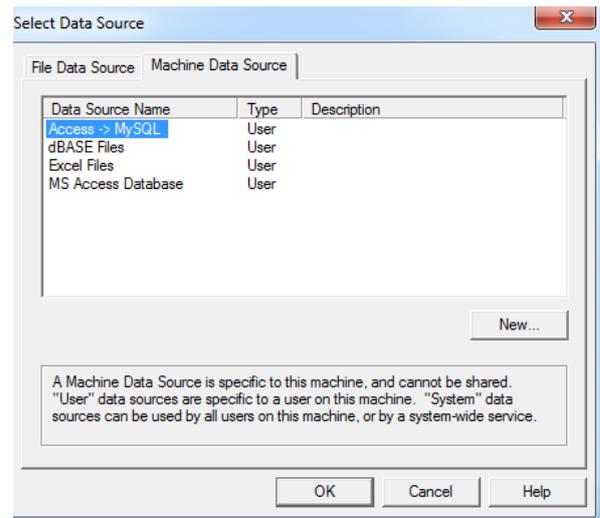


Figure 6. Select connection for import

The Access table has now been successfully imported to the MySQL server as seen in "Fig. 7".

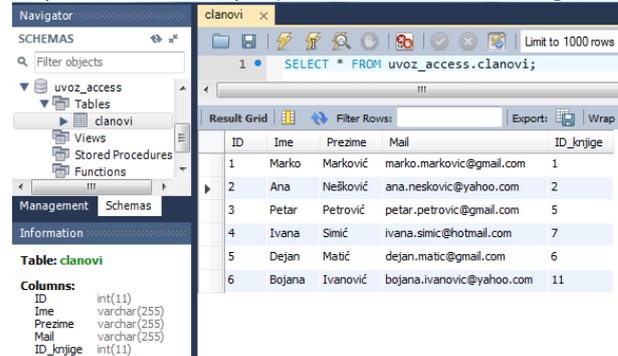


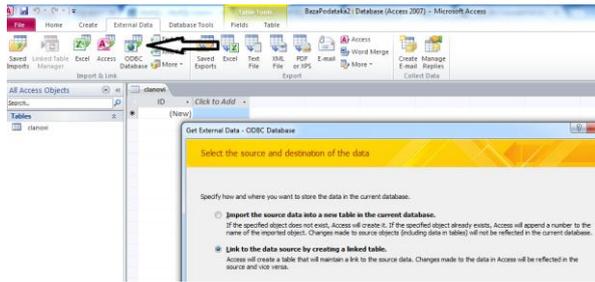
Figure 7. Table exported in MySQL Server

With another method, the active link between the database after export is retained i.e. Any changes in the MS Access database will reflect the same change in MySQL.

MS Access can also be used as a front-end to MySQL in connecting tables in MS Access database with tables that already exist on the MYSQL base. When we run query on the table in Access, ODBC is used to query the MySQL database.

The first step in process of connecting is to open the Access database that we want to link to MySQL. In the "External data" menu you need to select the "ODBC Database". The option "Link to

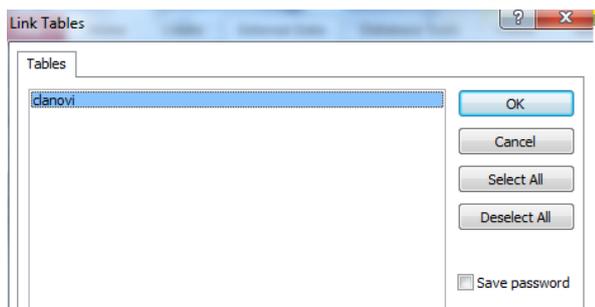
the data source by creating a linked table" is selected as in "Fig. 8".



**Figure 8.** Connecting the ODBC databases

After first step, a list of all data sources for the installed ODBC driver in our computer is displayed, as shown in "Fig. 6". We should select "Machine data source".

If the database for connection to MS Access requires a password and user name in this second step user will be prompted to enter the appropriate data. MS Access is connected to the MySQL server and shows a list of tables that can be linked. In our case, we connect the database with the table "members" as show in "Fig. 9".



**Figure 9.** List of tables for connecting

If no tables are shown in this step, this may be because of incorrect ODBC driver setup. If the database in Access already has a table with the same name as the one it is connected to, Access will add a number to the name of the new associated table. Also, if Access was unable to determine the primary key for the table automatically, it will ask to select the column that will be set up for primary key. The tables in Access and MySQL are now successfully linked.

Since the Access database already contained table members, the name of the new table has been changed, or added to the already existing table as show in "Fig. 10".

ID	Ime	Prezime	Mail	ID_knjige
1	Marko	Marković	marko.markovic@gmail.com	1
2	Ana	Nešković	ana.neskovic@yahoo.com	2
3	Petar	Petrović	petar.petrovic@gmail.com	5
4	Ivana	Simić	ivana.simic@hotmail.com	7
5	Dejan	Matić	dejan.matic@gmail.com	6
6	Bojana	Ivanović	bojana.ivanovic@yahoo.com	11

**Figure 10.** Connecting tables

The advantage of this method in relation to the above-described way is to create a link that is always active. Any update of the data in Access will also reflect on the corresponding tables in MySQL.

If we required active connection, this method will be used. However, for the teaching process that applies to practical teaching in course Internet Programming, it is not necessary to use an active link between the databases. The main purpose of all methods described in this paper is to allow the students to usage workload of MySQL tables with a lot of records in it.

Other instructions, such as Select, Update, Insert, Drop, Delete etc. will be build up directly from MySQL.

### 3.3 Export data from MS Access to MySQL using third software

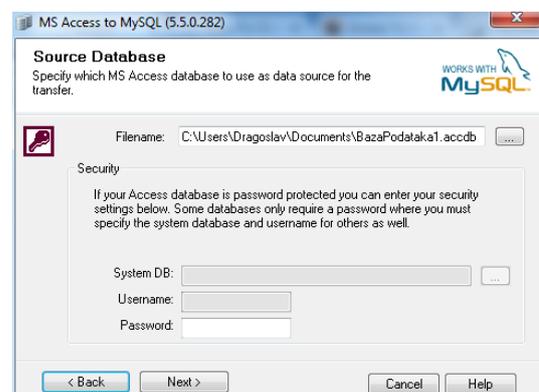
Another scenario for the migration of the MS Access database described in this paper implies the use of a free "**Bullzip MS Access to MySQL**" program, [7]. When a program starts, a wizard is launched to make it easier the process of transferring data from MS Access to MySQL.

As with the previous method of transferring the database (described in 3.1.), it is understood that ODBC driver on the computer is installed. Since the ODBC driver only supports Windows, it automatically means that, this way of migration MS Access database to MySQL can be used on the Windows operating system. This method is similar to the previously described method when no active link between the databases is created.

Below are the steps that need to be taken to successfully migration the database from MS Access to MySQL.

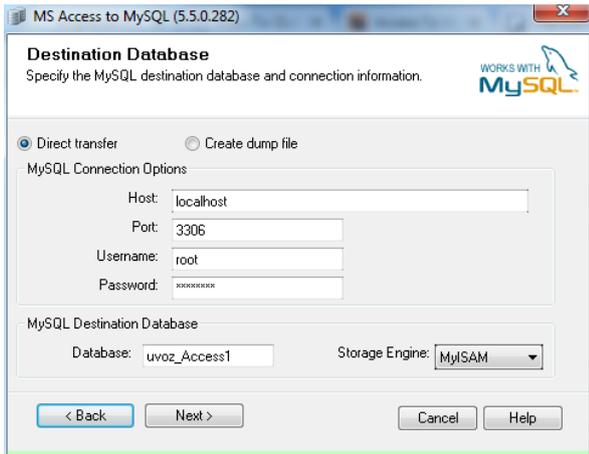
1) The first step is to prepare data for export. The name of the database that is exported to the MySQL server is selected. If access code is used for database access, the user name should also be specified in this step. This step is described in "Fig. 11". We need to set up a username and password to access to the MySQL server. In this step, the name of the database destination is also entered.

It is precondition that a database has already been created under the same name on the MySQL server. Through a few simple steps, tables from the export base are selected.



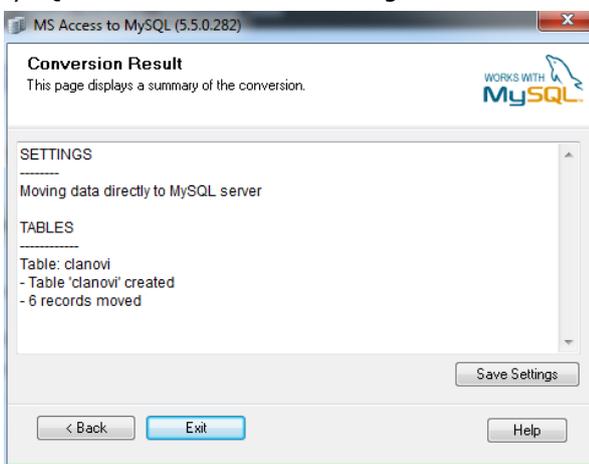
**Figure 11.** Export Database Selection

2) The next step is to set up the destination base. This step is shown in "Fig. 12".



**Figure 12.** Adjusting the destination database

The database migration results from Access to the MySQL server can be seen in "Figure 13".



**Figure 13.** Migration result

As a result, we have successfully completed the Mechanism for Migrating Data in MySQL database.

#### 4. CONCLUSION

In this paper, we have presented mechanisms for data migration of relation databases and how we can be use software tools to connect MS Access and MySQL databases. We came to the conclusion that for students previous knowledge gained in previous years of study about relational databases can applies in the final years of the study process.

We show direct and indirect methods for connection two databases. In direct method we show that it is not require for users to use of third party software for that process. Opposite of that when we use indirect method it implies the installation of the software "Access to MySQL". We also detail the two types of direct method depending on whether or not we need on-line link between two databases. However, for the teaching process applied in the practical lessons for Internet Programming course we have shown that students do not have to use the active link between the databases. A good understanding of the basics of data migration in relational databases can attract students to improve their knowledge about database administration through future development of graduate papers and works through projects.

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# Information system for obtaining reports on students of the High Technical School of Vocational Studies from Urosevac in Leposavic

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**Abstract:** *The paper presents the information system of the student service of the High Technical School of Vocational Studies from Urosevac in Leposavic, realized with the MS Office Access software package. Thus, created database provides the ability to obtain the necessary reports to monitor the progress of students in their studies and reports that can be used with statistical analyzed higher education institutions, which can be later used in the self-evaluation report and other various reports.*

**Keywords:** *MS Office Access; information system; the report; database*

## 1. INTRODUCTION

MS Office Access is a database management system (DBMS), which is used to store and load data, display, statistical analysis, and also to automate frequently repeated jobs [1,2]. It represents an excellent combination of productivity of database management software and ease of use of Windows. As a rounded application, MS Office Access provides complete management of the relational database and integrity on the level of the computer itself on the database (which prevents incomplete updating and deletion). It is possible to join tables with rules that check validity and validity and prevent input of incorrect data, and each table field can have its own format and default value which significantly increases productivity. It is possible to import and export data from many applications: dBase, FoxPro, Excel, SQL Server, Oracle, Btrieve, textual ASCII codes (fixed width and boundary fields), data in HTML format, and the use of their applications for working on the Internet. By selecting a particular option, you can switch tables, queries, reports, and views in a tabular format in HTML format [3]. Data Access Pages can use complex forms on the Internet that are linked to data in a particular network. Another advantage of MS Office Access is the ability to share a database in a local (LAN) network allowing multiple users to access and work with data stored in the database [3,4].

## 2. INFORMATION SYSTEM OF THE STUDENT SERVICE

Before beginning the design of the Student Information System (SIS), it is necessary to analyze the requirements of the user. The Student Service has a legal obligation to keep all documentation about the student until the completion of the studies and, upon completion of study, archive the documentation and keep it in its archive.

Students need to complete the exam in a quick and easy way, that the exam application is effective and that the student be sure that they will be in the exam paper. The student requires certain beliefs during studying: a certificate of study, a certificate of passed exams, a diploma certificate, etc.

Teaching staff requires a list of students enrolled in a particular study program and semester, whether in paper or electronic format, depending on the affinity of the teacher itself. The demand for teachers is to follow the student during the pre-crisis period.

The information needed by management is often not precisely defined and reduced to making a solid software base that allows for a further simple and reliable upgrade and to extract as much useful information from existing data as possible. In many cases, the necessary information comes through re-scanning student records, which takes time and there is always the fear that some sort of cautiousness has been done.



### 3. SELECTION AND FILTRATION OF DATA BY APPLICATION (QUERY)

Queries in MS Office Access can be created using the Wizards, directly in the Design mode, which provides greater flexibility and transparency in query creation or more advanced writing SQL (Structured Query Language) code [5].

Queries are database objects that allow the extraction of data from the database to be used for other purposes: as a data source used for a printed report or obtaining a list of items to be used to control search on the data entry form. An inquiry can be based on one or more linked tables.

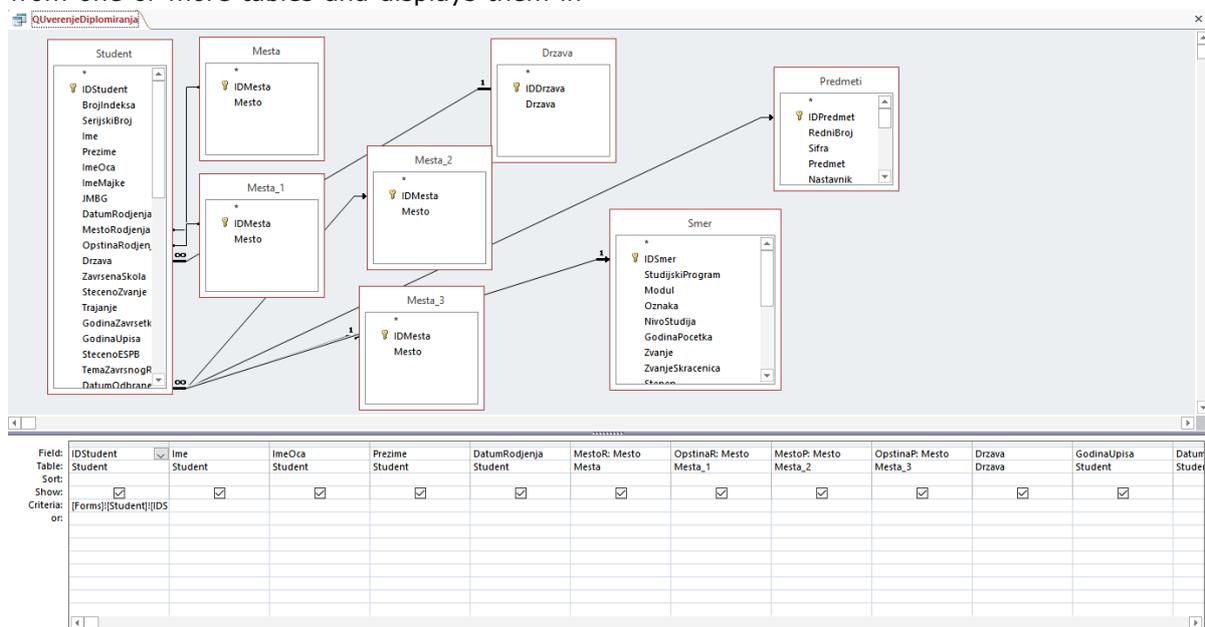
In addition to the field that is drawn directly from the table, the query can also contain the calculation fields that transform the data. MS Office Access supports multiple query types:

1. Select query – The simplest and most commonly used query type. It returns data from one or more tables and displays them in

the Datasheet View where we can change these data as needed.

2. Crosstab query – Displays summed values (sums, averages, and counts) and displays them as a spread sheet table.
3. Action query – There are several types of them, and it's common for everyone to make changes to multiple records in just one operation.
  - Update query – For a global change to a row group in one or more tables.
  - Append query – takes a group of records from one or more tables and puts them at the end of one or more tables.
  - Make-table query – Creates a new table from a part or all data from one or more tables.
  - Delete query – Deletes the group of records from one or more tables.
  - Union query – Connects data from two or more tables [4,5].

Fig. 3 shows an example of a query that is used to collect students' data for graduation certificates.



**Figure 3.** Request for gathering data to produce a certificate of graduation (Design View) (Source: authors)

The query used in this database for creating SQL code is UNION QUERY. A section of the code used

to create queries about passed and recognized exams is shown, Fig. 4.

```

QStudentPredmetPolozenPriznat
SELECT
QStudentPredmetPolozen.IDStudent, QStudentPredmetPolozen.IDPredmet,
QStudentPredmetPolozen.Sifra, QStudentPredmetPolozen.Predmet,
QStudentPredmetPolozen.ESPB, QStudentPredmetPolozen.IDOcena,
QStudentPredmetPolozen.Godina, "Polozen" AS PP,
QStudentPredmetPolozen.SemestarBroj, QStudentPredmetPolozen.RedniBroj
FROM QStudentPredmetPolozen
WHERE (((QStudentPredmetPolozen.IDStudent)=[Forms]![Student]![IDStudent]))

UNION SELECT
QStudentPredmetPriznat.IDStudent, QStudentPredmetPriznat.IDPredmet,
QStudentPredmetPriznat.Sifra, QStudentPredmetPriznat.Predmet,
QStudentPredmetPriznat.ESPB, QStudentPredmetPriznat.IDOcena,
QStudentPredmetPriznat.Godina, "Priznat" AS PP,
QStudentPredmetPriznat.SemestarBroj, QStudentPredmetPriznat.RedniBroj
FROM QStudentPredmetPriznat
WHERE (((QStudentPredmetPriznat.IDStudent)=[Forms]![Student]![IDStudent]))
ORDER BY SemestarBroj, RedniBroj;

```

**Figure 4.** SQL code for displaying passed and recognized exams – UNION QUERY (Source: authors)

#### 4. CREATING THE REPORT

In addition to the various certificates that students need, they include records of pre-educational activities of students, forming records with the number of exams, transitional statistics in the examination deadlines, all for the purpose of

Број индекса	ДС-119/11	Датум рођења	07.07.1961.	Година уписа	2010/2011
Име		Држава	Р. Србија	Датум дипломирања	24.02.2016.
Име оца		Општина рођења	Пријеполје		
Презиме		Место рођења	Рагajsка		
Студијски програм	Друмски саобраћај				
Модул					
Тема	Значај и улога шпедиције у комбинованим технологијама				

Р. Бр.	Шифра	Предмет	Оцена	ЕСПБ
1	23111	Високи језик 1	6 (пет)	6
2	23123	Телекомуникације	7 (седам)	8
3	23124	Рачунари и програмирање	6 (пет)	8
4	23211	Високи језик 2	6 (пет)	6
5	23213	Компјутерска графика	6 (пет)	6
6	23224	Статика	6 (пет)	6
7	23321	Кинематика и Динамика	6 (пет)	8
8	23322	Отпорност материјала	6 (пет)	8
9	23333	Теорија и регулације саобраћајних токова	6 (пет)	8
10	23344	Визуелни изаз	6 (пет)	6
11	23431	Безбедност саобраћаја	7 (седам)	8
12	23432	Транспортне мере	7 (седам)	7
13	23433	Стручна пракса	8 (осам)	3
14	23434	Машински цртежи	6 (пет)	6
15	23446	Поштоматска роба у транспорту	7 (седам)	6
16	23531	Аутомобил и аутомобили	6 (пет)	7
17	23532	Шпедиција са логистиком транспорта	6 (пет)	8
18	23533	Телекомуникације друмског саобраћаја	6 (пет)	8
19	23534	Моторна возила	6 (пет)	7
20	23631	Лавни градски превоз	6 (пет)	6
21	23632	Мотори СУС	7 (седам)	7
22	23634	Интерградни транспорт	6 (пет)	4
23	23635	Варпаносни превоз на друмски саобраћај	6 (пет)	4
24	23636	Завршни рад	10 (десет)	9

Р. Бр.	Шифра	Предмет	Оцена	ЕСПБ
1	23112	Привремена матемика 1	6 (пет)	8
2	23212	Привремена матемика 2	6 (пет)	7
3	23235	Увод у саобраћај и транспорт	6 (пет)	5

Освојено ЕСПБ: 160      Стручна пракса       Просечна оцена: 6,35  
 Признато ЕСПБ: 20      Завршни рад   
 Укупно ЕСПБ: 180

Figure 5. The appearance of reports passed and recognized exams (Source: Authors)

#### 5. CONCLUSION

Over time, people have tried several techniques for organizing data. Paper cards, cardboard boxes, documentation cabinets, sticky papers, indexes with ten thousand items and large pile of paper sheets stacked at the writing tables were used. After severe suffering, people have discovered that computers are incomparably better for data processing, especially when the amount of data is large, data is complex or often changes.

To make progress in the work of a higher education organization, in one part of it, requires extraordinary work and a lot of energy. The developed SIS enables further undisturbed development in many directions. Application of Internet technologies represents the future of information technologies and further research should be directed towards internet technologies. This certainly includes the development of an integrated SIS High Technical School of Vocational Studies from Urosevac in Leposavic, using LAN and WAN technologies with a web portal and distance learning systems.

improving the educational process and consequently the speed and quality of the work of the high school.

Reports created in this way can be printed or sent directly to the e-mail address from the base itself, Fig. 5 and 6.

	ВИСОКА ТЕХНИЧКА ШКОЛА СТРУКОВНИХ СТУДИЈА ИЗ УРОШЕВЦА са привременим седиштем у Лепосавцу, 24. новембра 66 18218 Лепосавић, Република СРБИЈА, Тел. факс: (381-26) 84-106, Дир. 028 84-103 Мат. бр. 0902/173, Рег. бр. 1403013310, Шифра мат. 81930, ПИБ: 101253295, ж. р. 840-124790-97 www.vtsosnec.com, E_mail: va.uros@vtsosnec.rs
	Број: _____ Датум: 12.10.2015. године

На основу члана 161. Закона о општем управном поступку ("Сл. лист СРЈ бр. 33/97"), члана 99 Закона о високом образовању Р. Србије ("Сл. гл. бр. 76/2005, 44/2010, 93/2012, 89/2013, 99/2014 и 45/2015") и члана 93. Статута Високе техничке школе струковних студија из Урошевца, са привременим седиштем у Лепосавцу и затега:

**Звечан, СО Звечан**

Увидом у службену евиденцију Високе техничке школе струковних студија из Урошевца, издаје:

**У В Е Р Е Ж Е**

(према име једног родитеља и имену)

рођен-а 22.07.1985. године, ДМБГ \_\_\_\_\_

**Косовска Митровица, СО Косовска Митровица, Р. Србија**  
(место рођења, општина, држава)

уписан-а школске 2012/2013. године, студент Високе техничке школе струковних студија из Урошевца, положио-ла све испите предвиђене Статутом ВТШСС из Урошевца, на студијском програму: **Машинство, модул: Заштита на раду**

Именован-а је одбранио-ла завршни рад из предмета: **Заштита од опасних дејстава електричне струје**

са темом: **Улога и значај електричне струје и електричних апарата у физикалној машини**  
 дана: 12.10.2015. године са оценом 10 (десет)  
 и општим успехом 7,96 (седамдесетдесетст/100) у току студија.

Именован-а је у току студија остварио-ла 180 ЕСПБ.

На основу тога и издаје му-јој се уверење о стеченом високом образовању и стручном називу: **Струковни инжењер машинства**

Скраћеница стручног назива је \_\_\_\_\_ **Струк. инж. маш.**

Ослобођено од таксе на основу ЗОАТ-а Службеног гласника Републике Србије, бр. 49/92.

Висока техничка школа  
струковних студија из Урошевца  
Директор \_\_\_\_\_

Figure 6. The appearance of the graduation certificate report (Source: Authors)

One of the disadvantages of SIS can be that the database capacity is systematically limited to 2GB along with all objects. However, this is practically negligible because the database itself is divided into two parts by Backend and Frontend, so each of these two parts is specifically limited to 2GB.

Some of the advantages of SIS are reflected in reducing the input of duplicated or incomplete data, which contributes to more efficient performance of the student service of this higher education institution.

SIS could also be accessed from another MS Access database if a need arises, for example, from the information system of the library of the High Technical School of Vocational Studies from Urosevac in Leposavic, which can represent some of the next stage of the development of this designed information system.

The SIS presented in the paper can, if necessary, be adapted to suit the needs of students and other services of other higher education institutions.

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# Knowledge Bases in the Field of Expert Systems and Artificial Intelligence

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**Abstract:** *This paper presents analysis of existing knowledge bases in the field of expert systems and artificial intelligence, i.e. published standards, web site eXpertise2Go, as well as standardized and non-standardized glossaries. Analysis was performed by searching the available knowledge bases in order to find a complete knowledge bases for the area. According to the results obtained ISO has published the highest number of standards, eXpertise2Go is the most consistent website with information about using and building expert systems, and there are glossaries which are accessible and free to readers related with expert systems and artificial intelligence.*

**Keywords:** *knowledge base, expert systems, artificial intelligence, standards, glossaries.*

## INTRODUCTION

There are enormous Internet content search possibilities due to the increase in the amount of available information. Nowadays more quickly and easily obtaining information, as well as the sharing of this information is very important.

By searching the available content, we find the knowledge bases or create our own by extracting the relevant information and combining them, into one entity in a given area. Depending on where knowledge is stored either in the computer or in the human brain, certain factors may influence the further course of the research, [1]. Knowledge identification is the first step towards defining relevant knowledge in order to achieve the goals. Within this phase, it is necessary to identify the available knowledge, [2].

The aim of research is to analyze the existing knowledge bases in the field of expert systems and artificial intelligence. Data that are shown in this paper were collected from the official websites of international and national organizations, the eXpertise2Go website, and the websites containing non-standardized glossaries. Published standards, description/structure of website eXpertise2Go and glossaries that is relevant for the given area has been investigated and shown in this paper.

## 1. INTERNATIONAL AND NATIONAL STANDARDS IN THE FIELD OF THE ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS

Standardization differs between common standards and specifications as follows:

Formal standards ("de-jure standards"): As a result of the consensus reached by the official standardization organizations The International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) were established.

Community specifications: They are open specifications, available to the public which are developed by communities or forums, i.e. The Institute of Electrical and Electronics Engineers, Inc. (IEEE) and the World Wide Web Consortium (W3C).

Industrial specifications: They are developed by closed or open specifications and available to branches of industrial consortia, [3].

Table 1 shows the standards published by the International Organization for Standardization during the period from 2004 to 2017. During this period, 13 standards, the total value of which is 1,236.00 Swiss francs (1,072.00 euros), were published. The published standards were developed in the field of health informatics.

**Table 1.** *An overview of published international standards in the field of expert systems and artificial intelligence*

No.	Standard number and title	Price
1.	ISO/IEC 2382:2015 Information technology -- Vocabulary	1,072.00
2.	ISO/TR 13054:2012 Knowledge management of health information standards	1,040.00
3.	ISO 21667:2010 Health informatics -- Health indicators conceptual framework	188.00

4.	ISO/IEC 24779-9:2015 Information technology -- Cross-jurisdictional and societal aspects of implementation of biometric technologies -- Pictograms, icons and symbols for use with biometric systems -- Part 9: Vascular applications	315.00
5.	ISO 16278:2016 Health informatics -- Categorical structure for terminological systems of human anatomy	89.00
6.	ISO/TR 13054:2012 Knowledge management of health information standards	184.00
7.	ISO/TS 18062:2016 Health informatics -- Categorical structure for representation of herbal medicaments in terminological systems	243.00
8.	ISO 15924:2004 Information and documentation - - Codes for the representation of names of scripts	388.00
9.	ISO/TS 17938:2014 Health informatics -- Semantic network framework of traditional Chinese medicine language system	88.00
10.	ISO/IEC 30122-2:2017 Information technology -- User interfaces -- Voice commands -- Part 2: Constructing and testing	38.00
11.	ISO/IEEE 11073-10101:2004 Health informatics -- Point-of-care medical device communication -- Part 10101: Nomenclature	198.00
12.	ISO 13119:2012 Health informatics -- Clinical knowledge resources -- Metadata	118.00
13.	ISO 19152:2012 Geographic information -- Land Administration Domain Model (LADM)	198.00
Total:		1,236.00
Note: The prices of the standards are expressed in Swiss francs.		

In the period from 2010 to 2017, IEEE published 7 de facto standards in field of artificial intelligence and expert systems. Among the published standards, both international and national, the most precisely defined standards in the field of artificial intelligence are those published by IEEE. The total value of these standards is 1,040.00 euros.

Slovenia published 4 standards in the field of expert systems and artificial intelligence in the period from 2005 to 2015.

**Table 2.** An overview of published de facto IEEE standards in the field of artificial intelligence and expert systems

No.	Standard number and title	Price
1.	IEEE Std 1855-2016 - IEEE Standard for Fuzzy Markup Language	1,072.00
2.	IEEE Std 1232-2010 (Revision of IEEE Std 1232-2002) - IEEE Standard for Artificial Intelligence Exchange and Service Tie to All Test Environments (AI-ESTATE)	1,040.00
3.	IEEE Std 1232.3-2014 - IEEE Guide for the Use of Artificial Intelligence Exchange and Service Tie to All Test Environments (AI-ESTATE)	188.00
4.	IEC 62243 Second edition 2012-06 IEEE Std 1232 - IEC 62243:2012(E) (IEEE Std 1232-2010): Artificial Intelligence Exchange and Service Tie to All Test Environments (AI-ESTATE)	315.00
5.	IEEE Std 2755-2017 - IEEE Guide for Terms and Concepts in Intelligent Process Automation	89.00
6.	IEEE Std 1872-2015 - IEEE Standard Ontologies for Robotics and Automation	184.00
7.	IEEE 11073-10207-2017 - IEEE Approved Draft Standard for Domain Information & Service Model for Service-Oriented Point-of-Care Medical Device Communication	243.00
Total:		1,236.00
Note: The prices of the standards are expressed in US dollars.		

Table 3 shows the standards published in Slovenia, the total value of which is 184 euros. Bulgaria, Macedonia and Montenegro have published the same number of standards (4).

**Table 3.** An overview of published standards in the field of artificial intelligence and expert systems in Slovenia

No.	Standard number and title	Price
1.	SIST EN ISO 11073-10201:2005 Health informatics - Point-of-care medical device communication - Part 10201: Domain information model (ISO/IEEE 11073-10201:2004)	132.00
2.	SIST EN ISO 13119:2013 Health informatics - Clinical knowledge resources - Metadata (ISO 13119:2012)	60.00
3.	SIST EN 62559-2:2015 Use case methodology - Part 2: Definition of use case template, actor list and requirement list	80.00

4.	SIST EN ISO 19152:2013 Geographic information - Land Administration Domain Model (LADM) (ISO 19152:2012)	116.00
Total:		388.00
Note: The prices of the standards are expressed in euros.		

The Croatian Standards Institute has published 5 standards in the field of expert systems and artificial intelligence. The total value of these standards is 1,810.00 kunas. Serbia and Bosnia and Herzegovina (5) have published the same number of standards.

**Table 4.** An overview of published standards in the field of artificial intelligence and expert systems in Croatia

No.	Standard number and title	Price
1.	HRN ISO/IEC 2382:2016 Information technology -- Vocabulary (ISO/IEC 2382:2015)	-
2.	HRN EN 62559-2:2015 Use case methodology -- Part 2: Definition of the template for use cases, actor list and requirements list (IEC 62559-2:2015; EN 62559-2:2015)	390.00
3.	HRN EN ISO 11073- 10201:2008 Health informatics -- Point-of-care medical device communications -- Part 10201: Domain information model (ISO/IEEE 11073-10201:2004; EN ISO 11073-10201:2005)	590.00
4.	HRN EN ISO 19152:2013 Geographic information -- Land Administration Domain Model (LADM) (ISO 19152:2012; EN ISO 19152:2012)	525.00
5.	HRN EN ISO 13119:2014 Health informatics -- Clinical knowledge resources -- Metadata (ISO 13119:2012; EN ISO 13119:2012)	305.00
Total:		1,810.00
Note: The prices of the standards are expressed in Croatian kunas.		

Table 5 shows the published international standards (ISO [4]), de facto standards (IEEE [5]) and national Serbian [6], Bulgarian [7], Macedonian [8], Montenegrin [9], Croatian [10], Slovenian [11], as well as the standards published in Bosnia and Herzegovina [12] in the field of artificial intelligence and expert systems during the period from 2001 to 2016. The standards were searched using the ISO / IEC 2382-28: 1995 Information Technology - Vocabulary, Part 28: Artificial Intelligence: Basic Concepts and Expert Systems, [13], and ISO/IEC 2382:2015 Information Technology - Vocabulary, [14].

ISO standards are the most expensive standards. Serbia, Croatia and Bosnia and Herzegovina have the same number of published standards, and the

same standards can be bought in Serbia at a lower price. Bulgaria, Macedonia, Montenegro and Slovenia have the same number of published standards (5). The price of the standards is the lowest in Macedonia, whereas the same standards cost twice as much in Montenegro, and even four times as much in Bulgaria and Slovenia.

During the period from 2001 to 2016, 20 international standards were published (including IEEE de facto standards), the total value of which is 2,112.00 euros. As to the national level, 35 standards were published in seven countries, the total value of which was 1,628.00 euros.

**Table 5.** An overview of published standards in the field of artificial intelligence and expert systems in the 2001-2016 period

No.	Organization	Number of published standards	Price
1.	ISO	13	1,072.00
2.	IEEE (de facto)	7	1,040.00
3.	SRPS	5	188.00
4.	BDS	4	315.00
5.	MKS	4	89.00
6.	MEST	4	184.00
7.	HRN	5	243.00
8.	SIST	4	388.00
9.	BAS	5	221.00
International:		20	2,112.00
National:		35	1,628.00
Note: The prices of the standards are expressed in euros.			

In 2017, ISO / IEC JTC 1 established the subcommittee SC 42 for the development of artificial intelligence. In May 2018, ITU is organizing the second AI for Good Global Summit in Geneva, aimed at identifying practical applications of AI, as well as the strategies to ensure the development of AI technologies and equitable access to their benefits. America, the United Kingdom, Japan, China and France make enormous investments in the strategy for the development of artificial intelligence, so significant results are expected in the future.

### eXpertise2Go WEBSITE

The website eXpertise2Go's Rule-Based Expert System Web Content provides sources of information about using and building expert systems. Demonstrations are provided along with free expert system building and delivery tools that

implement expert systems such as Java applets, Java applications and Android apps. Decision Table and Rule Induction knowledge base building/data mining tools are also provided, [15].

**Figure 1.** Content/structure of eXpertise2Go website

The mini-course comprises nine modules and notes:

1. Is this the right technology for your problem?
2. Acquiring and installing the software (providing files to download and install, and instructions);
3. Introduction to expert systems;
4. Creating first knowledge base (with instructions and the code for creating a database);
5. Inference methods and uncertainty (a simulation of reasoning mechanism: forward chaining);
6. Introduction to knowledge engineering that is presented theoretically, through guidelines and suggested readings;
7. Designing and implementing knowledge bases that deliver knowledge (where some ideas about designing, building and debugging a data base are illustrated);
8. Building internationalized expert systems which delivers knowledge bases in Chinese and Cyrillic;
9. Advanced applications:

Using the e2gRuleEngine/JavaScript interface to dynamically control inferencing;

Modules 3, 5 and 6 are generic eXpertise2Go.com tutorials that introduce basic concepts needed to understand to build one's own expert systems.

When starting the Introduction to expert systems module, a glossary appears on the right, where we can find the explanation of unfamiliar terms at any time, [15].

## eXpertise2Go Expert System Glossary

The index below provides alphabetical access to topics.

[A](#) [B](#) [C](#) [D](#) [E](#) [F](#) [G](#) [H](#) [I](#) [J](#) [K](#) [L](#) [M](#) [N](#)  
[O](#) [P](#) [Q](#) [R](#) [S](#) [T](#) [U](#) [V](#) [W](#) [X](#) [Y](#) [Z](#)  
[Home: Demos, Tutorials and Software]

The [Top] link after each glossary definition returns to the index. The [Tutorial] link (when included) accesses relevant tutorial material.

**Buy A Book!**  
amazon.com.

[Amazon.com's expert system books](#)

**Antecedent.** See [premise](#). [Top]

**Attribute.** A variable that takes on values that might be numeric, text, or logical (true/false). Attributes store the factual knowledge in a [knowledge base](#). [Top]

**Backward chaining.** The process of determining the value of a [goal](#) by looking for rules that can conclude the value of the [premise](#) of such rules may be made [subgoals](#) for further search if necessary. [Top][Tutorial]

**Breadth first search.** A search strategy that examines all rules that could determine the value of the current [goal](#) or [subgoal](#) before backtracking through other rules to determine the value of an unknown [attribute](#) in the current rule. [Top]

**Certainty processing.** Allowing confidence levels obtained from user input and [rule](#) conclusions to be combined to increase the overall confidence in the value assigned to an attribute. [Top][Tutorial]

**Figure 2.** Glossary – expert system



**Figure 3.** Inference engine for Android platform

The PCAI website (<http://www.pcai.com/>) contains links to expert systems information on the Internet, companies dealing with expert systems, and a review of literature published until 2000.

## GLOSSARIES

Research in a certain field leads to the creation of a large number of new concepts. The development of standard technology is conditioned by terminological principles and methods by combining the findings of scientific terminology and practical use. Terminologists, describe the desired terminology in a certain field, after which the concepts are defined systematically with the respective terms.

The principles of standardization can be applied in all areas of human activity (areas of specialized

communication), although not necessary. [16, pp. 8, 9].

By searching the Internet content, we can find glossaries of expert systems and artificial intelligence. Standardized glossaries have been published by the International Organization for Standardization, or some other organization. Non-standardized glossaries are in the form of online dictionaries that can be searched or sorted alphabetically.

The non-standardized of expert systems and artificial intelligence available on the Internet are as follows:

- website: thenextweb containing of basics artificial intelligence terms and concepts.  
(<https://thenextweb.com/artificial-intelligence/2017/09/10/glossary-basic-artificial-intelligence-terms-concepts/>)
- website: phrasee, glossary of Artificial Intelligence terms represents key terms, including graphics for each term and links to more detailed information.  
(<https://phrasee.co/ultimate-glossary-artificial-intelligence-terms/>)
- website: businessdictionary where there is contained text about expert systems and links to another relevant terms.  
(<http://www.businessdictionary.com/definition/expert-system.html>)
- website: quizlet contains terms which are audio supported.  
(<https://quizlet.com/77946069/vocabulary-for-expert-systems-and-artificial-intelligence-flash-cards/>)

ISO / IEC 2382-28: 1995 Information Technology - Vocabulary, Part 28: Artificial Intelligence: Basic Concepts and Expert Systems is a standardized glossary [13]. Some of the terms defined by this standard are as follows: artificial intelligence, cognitive modeling, computer-based learning, deduction, domain, expert systems, expert system shell, fuzzy logic, knowledge, knowledge acquisition, knowledge-based system, machine learning, machine vision, neural network...

One of the term relating to artificial intelligence and expert systems that is defined by the standard is given below:

2123774

expert system

knowledge-based system that provides for solving problems in a particular domain or application area in a professional manner by drawing inferences from a knowledge base developed from human expertise

Note 1 to entry: The term "expert system " is sometimes used synonymously with "knowledge-based system ", but should be taken to emphasize expert knowledge.

Note 2 to entry: Some expert systems are able to improve their knowledge base and develop new inference rules based on their experience with previous problems.

Note 3 to entry: This is an improved version of the definition in ISO/IEC 2382-1:1993.

Note 4 to entry: expert system; ES: term, abbreviation and definition standardized by ISO/IEC [ISO/IEC 2382-28:1995].

Note 5 to entry: 28.01.06 (2382)

[SOURCE: ISO-IEC-2382-28 \* 1995 \* \* \*]

## CONCLUSION

Due to the increasing amount of the available information, their selection becomes more difficult, and so does the selection of the appropriate information relating to expert systems and artificial intelligence.

The knowledge base searched for the purpose of writing this paper comprises published standards, standards setting organisations, eXpertise2Go website and glossaries.

According to the results presented above, ISO has published the highest number of standards in the field of expert systems and artificial intelligence (13), and it is followed by the IEEE, which has published 7 de facto standards. SRPS, HRN and BAS have published an equal number of standards (5). Fewer standards (4) have been published by BDS, MKS, MEST and SIST. The same standards are the cheapest in Macedonia, whereas in Slovenia, they are four times as expensive.

Standardized and non-standardized glossaries are available on the Internet, and they can serve as a basis for searching standards. There is also eXpertise2Go website, which can serve as a complete knowledge base in the field of expert systems, providing the instructions for expert systems development, as well as relevant literature in the field.

The need for standardization results from the growing number of products and services that use artificial intelligence. The standards will enable interoperability and functionality in order to ensure maximum capacity in the field of artificial intelligence and market competitiveness. The countries in the region should take part in the development of standards in the field of expert systems and artificial intelligence.

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# An Analysis of User's Information Security Awareness

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**Abstract:** *In modern systems information security is having an increased importance for organizations. With the advance of technology and implementation of guidelines for protecting systems, it is a lot harder for malicious entities to gain access to the system. However one of the main attack vectors is the user, as such it is important for users to be knowledgeable and behave in a way that will have a positive influence in protecting information. Its important for organizations to understand the awareness of users in order to be able to take appropriate actions to increase the safety of the system. This paper is going to do an analysis of user awareness specifically focusing on user's knowledge and behavior. Results of this analysis show us that the current level of user awareness of the Municipal Administration is satisfactory and that age is not important factor for awareness. Information security training is advised, but not necessary.*

**Keywords:** *Information security, User awareness, information management*

## 1. INTRODUCTION

The term "information security awareness" is used when it refers to the state in which users in the organization are introduced (ideally dedicated) to their security mission [1]. Information systems are only useful if they are used by people. Similarly, information security awareness is crucial, as information security techniques or procedures can be misused, misinterpreted or not used at all by the user, with that they lose their utility. Increased awareness should minimize user-related errors, in theory it should completely annul them and increase the efficiency of security techniques and procedures from the point of view of users.

Security risks related to information technology are a topic that is getting more and more significant. As corporations are increasingly relying on technology in their business, system security becomes their big concern. In their security report for the last quarter of 2017 Microsoft has reported they observed a 300% increase in the number of attacks on user accounts compared to 2016. Most of these attacks are caused by bad codes or poor password management and are followed by targeted phishing attacks [2].

While information security is mainly focused on the protection of confidentiality, integrity and information accessibility, information security awareness is concerned with the use of programs for security awareness to create and maintain positive behaviors as a critical element in an

effective security positive environment. The goal of the information security awareness program is to increase the significance of information systems' protection and reduce possible negative effects of security failures [3]. User security awareness is the degree or level at which each staff member understands the importance of information security, the degree of information security that suits the organization, their individual responsibility of system security and procedures accordingly [4].

Efficient management of information security requires a combination of technical and procedural controls that manage information risk. The value of controls depends on the people implementing and using them and in information security that is no different. Controls can be circumvented or misused from employees who ignore safety rules and procedures. Implementation of effective security control depends on the creation of a security friendly environment, where everyone understands and engages in behaviors that are expected of them. Von Solms R. and Von Solms B. [5] offered guidelines on how to move from information security policy to positive information security culture. The transition to positive information security culture is not always easy and simple, the ISF information security status questionnaire [6] shows that most members think that the effectiveness of their user awareness rising initiative to protect the system is not very effective and four out of five members think they do not invest enough resources and time in this initiative of increasing user awareness.

There seems to be a large number of material to help organizations to form an appropriate program for raising user awareness for information security and how to positively influence the employees. With the following material, organizations can form a good training to raise users information security awareness [7][8][9][10][11].

Consciousness and behavior among all types of users are an important part of the performance of the information security of the organization. Adequate training on information security is essential in the goal of creating and improving user awareness and behavior. Several individual or several combined measures to improve the performance of user information security, they can be distribution of messages via e.g. pamphlets, email, websites, posters, formal presentations, lunch and training sessions. Common to most of these measures is that they are one-way communication directed to a large number of individuals or authorities using expert knowledge. On the other hand, several organizational researchers claim that it is local knowledge through processes that involve employees not only necessary but also efficient in achieving the goal changes in organizational activities [12].

In the past decade research of users' information security awareness was dominantly focused on cognitive behavior. Researchers use multidisciplinary theory, such as theory in psychology, sociology and criminology introduced into models of information security. The most commonly used research theories are Theory of Reasoned Action (TRA) / Theory of Planned behavior (TPB), General Deterrence Theory (GDT), Protection Motivation Theory (PMT), Technology Acceptance Model (TAM) [13].

One of the limitations of applying these theories is that their perspective is of a single level. One theory focuses on individual behavioral factors, despite evidence from different empirical studies that indicate that external factors such as organizational or work factors have influence. Ignoring these factors and their interdependence, theories that explain and predict employee behavior risk being ineffective. The result is that, some researchers have added theoretical extensions of additional factors that affect the individual's behavior, to bridge the gap between individual and external factors in the result of behavior [13].

## 2. METHODOLOGY

Psychologists suggest that people with learned predispositions respond in a favorable or inconclusive way to a particular object, they have three components: impact, behavior and cognition [14][15]. The impact component involves positive or negative emotions towards something, the components of behavior is the intent of acting in a

certain way, while the component of cognition refers to belief and thoughts about an object [14][15].

The methodology for constructing the questionnaire uses the KAB model (knowledge-attitude-behavior) as its basis. This model is based on the theory that if system users have adequate knowledge (information) about the security of the system, they as a result would have a more positive attitude towards the security of the system, the result of which will lead to better behavior [16][17].

Because the aim of this research is to analyze the knowledge and behavior of users in the local government, the compiled survey is exclusively focused on these two aspects.

In the continuation of this paper, a survey of the user awareness of information protection will be done using the survey in the local government of Municipality Čičevac. During this questionnaire, the main focus will be the next two things:

1. Knowledge of users about the rules of using the computer (system) and basic knowledge of ways of attacking the system through the user.
2. Behavior of users, what procedures users use to facilitate system protection and whether do they have a positive behavior towards information protection.

The survey is mainly based on literature and best practice and consists of 28 questions divided into 2 categories: knowledge and behavior [18][19][20][21]. Users are not aware of these categories and the questions have been distributed so it is not noticeable. All questions carry a certain amount of points, it is possible to achieve a maximum of 100 points, the points are redistributed in such a way that knowledge-related questions carry 50 points and behavior-related questions also carry 50 points.

The first two question are related to: age and years of work experience in the municipality.

Criteria for scoring is focused on the following:

- Knowledge of basic rules of information security
- Understanding the policy put in place for information protection and following it

We have two primary criteria, each of them will yield 2 points. The scoring of the survey itself is done as follows, as there are multiple-answer questions of same importance, the answers were divided in 3 categories: Positive, neutral and negative. A positive answer carries 4 points, neutral 2 points and negative 0 points. Positive answers show that the employee not only has basic knowledge of information security they also understand policies put in place and try to follow them, this is a positive influence on information security as such those answers yield 4 points.

Neutral answer shows that the employee knows basic rules of information security but they don't fully understand the policies put in place and because of that aren't necessarily able to follow them. Those employees don't provide a positive influence but don't necessarily harm information security that is why a neutral answer yields 2 points. Negative answer means that the employee doesn't know the basic rules of information security as such they don't have a positive influence, such answers yield 0 points.

Example of a knowledge-related question with 3 answers:

1. Is the firewall on your computer turned on?
  - a. Yes, it is turned on.
  - b. No, it is not turned on.
  - c. I don't know what a firewall is.

Answer under A is considered a positive response, because the user knows how to check if the firewall is turned on and knows to turn it on. Answer under B is considered a neutral answer because the user knows how to check the firewall but hasn't turned it on. Answer under C is considered a negative one because the user doesn't know what a firewall is.

Example of a behavior-related question with 3 answers:

2. How careful are you during opening attachments that were sent through e-mail?
  - a. I always make sure I know the person and that I expect the e-mail.
  - b. While I know the company or the person that sent me the e-mail I open the files.
  - c. There's nothing wrong with opening files sent via e-mail.

Answer under A is a positive answer because user uses maximum attention during opening of files by making sure he knows who the e-mail is coming from and that he is expecting the e-mail. Answer under B is a neutral one because the user pays some attention during opening of e-mails because he knows he shouldn't open any file that was sent to him especially from someone he doesn't know. Answer under C is a negative answer because the user thinks that there are no negative consequences if he opens files from people he doesn't know so he will not take any precautions.

In table 1 we can see the percentile split of users that participated in this survey.

The largest sample group by age is that of 35-44 years, while the smallest one is the age group of 18-24 years. According to the years of employment the most numerous group is the 6-15 years of employment and the least numerous is 3-5 years. Because of the huge difference in the

**Table 1.** Sample

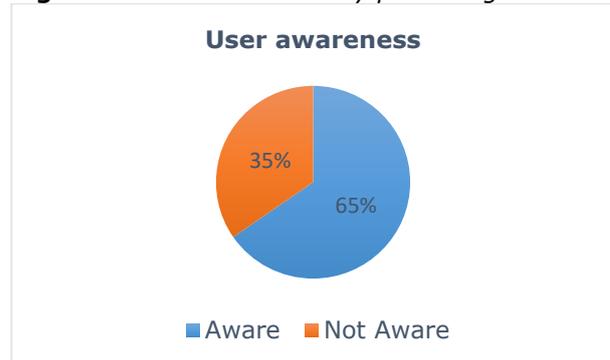
Age	%	Years of employment	%
18-24	6.67	0-2	13.33
25-34	20.00	3-5	6.67
35-44	33.33	6-15	60
45-54	26.67	16-30	6.67
55-64	13.33	31-40	13.33

number of employees by their years of employment, special attention should be paid to the group with 6-15 years of employment because they represent 60% of the participants in this poll.

**3. RESULTS**

After scoring the survey, users' awareness of information security can be further analyzed. The maximum number of points achievable in the poll is 100, users have on average achieved 65.37 points. With this information the average user awareness of information security can be concluded. As shown in Chart 1. The average user is aware (knowledge and behavior) of 65.37% procedures that are meant to relieve system security and is not aware about 34.63% of them.

**Figure 1.** User awareness by percentage



**Table 2.** User awareness by age

Age	Points	Know ledge	Beha vior	Knowle dge %	Behavi or %
18-24	92.00	44.00	48.00	47.83	52.17
25-34	72.67	32.67	40.00	44.95	55.05
35-44	63.67	25.33	38.33	39.79	60.21
45-54	64.50	26.50	38.00	41.09	58.91
55-65	48.00	17.00	31.00	35.42	64.58
Average	68.17	29.10	39.07	41.81	58.19

Age categories are 18-24, 25-34, 35-44, 45-54 and 55-64 for each category an average amount of points the employees achieved in the survey is calculated. This is further divided into the amount of points the employees achieved in knowledge and behavior as well as their average. In addition, the percentage of points the users achieved in

knowledge and behavior is calculated for each age group as well as their average.

As it can be seen in table 2, 3 age categories (35 to 65) are below the average awareness of users, the most aware are employees in the age group 18-34 years old and highly aware are employees in the age group 18-24 with average of 92 points. According to the results from table 2 it can be clearly seen that the age group of 18-24 years old with the average points of 44 in knowledge has the highest average, compared with the age group of 55-65 has only 17 points on average.

In order to find out if there is significant difference among workers in terms of age, two groups are formed: one's age is below 45, and the other is 45 and above. The ANOVA analysis is applied for the behavior test-results and for the knowledge-test result. Idea is to find out if the null hypothesis can be proved, that is to find out if the age is important for security awareness.

ANOVA analysis results are presented in Tables 3 and 4.

**Table 3.** ANOVA analysis on behavior

<b>SUMMARY</b>						
<b>Groups</b>	<b>Count</b>	<b>Sum</b>	<b>Average</b>	<b>Variance</b>		
Junior	10	398	39.8	51.06667		
Senior	6	214	35.66667	47.06667		
ANOVA						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	64.06667	1	64.06667	1.290675	0.274998	4.60011
Within Groups	694.9333	14	49.6381			
Total	759	15				

**Table 4.** ANOVA analysis on knowledge

<b>SUMMARY</b>						
<b>Groups</b>	<b>Count</b>	<b>Sum</b>	<b>Average</b>	<b>Variance</b>		
Junior	10	294	29.4	97.82222		
Senior	6	130	21.66667	77.46667		
ANOVA						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	224.2667	1	224.2667	2.476651	0.137869	4.60011
Within Groups	1267.733	14	90.55238			
Total	1492	15				

Since  $F_{crit}$  in both cases is greater than  $F$ , it can be concluded that there is no significant difference between groups and therefore the null hypothesis cannot be rejected. That means that age category cannot be taken as important for security awareness.

#### 4. CONCLUSION

Serbian government is comprehensively digitizing its services because of the sensitivity of data a government body handles; it is becoming more important for the employees to be aware of possible threats to information security. As such

there needs to be a level of awareness required to be obtained and maintained by every employee. The boundary of an aware employee and a non-aware one would be considered achieving enough points on this survey to get a passing grade in a University as such we will consider those employees who have achieved over 50% to be aware and a positive influence on information security. An aware employee knows, understands and takes necessary steps to uphold a positive information security environment. According to the results of the analysis we see that users average 65.37 points in the survey, this level of

information security awareness is satisfactory. The sample is very small to draw solid conclusions. Although youngest employees and those who are recently employed got more points than other age subcategories, no statistical evidence was found that there is a strong connection between age and awareness. Still, forming and holding an adequate training on raising users information security awareness would help not only users to gain knowledge about ways they can protect the system, but would further improve the already existing positive behavior of users towards information security. Because of the intensive modernization of local governments in Serbia, if this modernization is not accompanied by detailed and appropriate training, there will be situations where the lack of knowledge of users will have a negative effect on information security behavior.

### ACKNOWLEDGEMENTS

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# Benchmark of Web Browsers with Automated Testing Tool

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**Abstract:** *The paper investigates method of benchmark of four web browsers against open source Automation Testing tool Selenium web driver. We will present two test scenarios and in both of them it is necessary to generate an automated test using the C # programming language, in combination with the Selenium web driver. The aim of this research paper is to evaluate and compare execution time for automated test setup against four web browsers to determine their usability and effectiveness. Based on the presented scenarios and described procedures, we will show that Microsoft has seriously approached resolving the deficiencies that existed on Internet Explorer, and that Edge has become a competitive browser, at least when we are talking about test executing, which has not been the case with Internet Explorer so far.*

**Keywords:** *Benchmark; Selenium web driver; Automated test; C# programming language*

## 1. INTRODUCTION

According to Glenford et al. in [1], "Software testing is a process, or a serial of processes, designed to make sure computer code does what it was designated to do and, conversely, that it does not do anything unintended". From previous statement we can conclude that the main objective of testing is to find bugs in the computer code and to fix them to improve quality of software. For example Srinivas and Jagruthi in [2], give an assessment that the process of testing consumes 40-50 % of development cycle time and more effort for software requiring more reliability as well. From this statement we can see that a significant number of quality assurance team working hours have been allocated for testing software tools for purpose of web browsing. According to Li et al. in [3], "Seeking information on the Web has become an important learning activity in current learning environment". This assertion points out that it is very important for users to choose a particular type of web browser that will save their time spent on searching large datasets. Thus, based on the correct selection of the web browser, they will avoid the situation of being exposed to disorientation and cognitive overload, and thus simplify their Information Gathering task to finding an answer or a Website.

In the present work, we planned to study methods of automatic testing of the response of four types of web browsers, with which we can measure the load time of a particular web site.

There are two scenarios. In both scenarios, it is necessary to generate an automated test using the C # programming language, in combination with the Selenium web driver.

This paper is structured as follows: After introductory section where the general definitions of automated testing are given, there is Section 2. describing the methodology used to start two different test scripts for automatic testing using Selenium Web Driver that supports four types of Internet browsers (Mozilla Firefox, Google Chrome, Internet Explorer and Microsoft Edge). Methodology Section was developed, as a starting basis for the proposed evaluation study for automated testing outlined in Section 3. when the usage is concerned. Section 3. presents a good practice case and explains the main focus of this survey paper. In this section, the final result of the research is presented in the form of the time difference in the performance of tests on different web browsers (the worst, best and average time of execution) of the test scenarios for each browser. Based on these research results, we can evaluate Benchmark for web browsers using an automated test tool and provide the visual means to confirm our summary and conclusions outlined in section 4.

## 2. METHODOLOGY

According to Ieshin et al. in [4], use of automation test tool for program code testing increases the test execution speed and software become more reliable, repeatable, programmable,

comprehensive, and reusable. In the present work, we have created a test using the C # programming language, in combination with the Selenium web driver. Inderjeet and Tarika in [5], state that Selenium is one of the efficient open-source automated testing tools which provides a nice testing framework for testing wide variety of applications exporting scripts in almost every language including java, .net, c#. Selenium Web Driver supports all browsers for execution. With this automated testing tool, we can run more tests on different types of web browsers. Two tested scenarios were launched on 4 (four) different web browsers:

- Mozilla Firefox,
- Google Chrome,
- Internet Explorer,
- Microsoft Edge

Both of the tested scenarios are based on calculation of the response time required for the test to be performed using each web browser. The first test scenario was designed to measure the time required to open **google.ba**, then to search for the term **Automated test** and to check if the search results were loaded. The second scenario opens the **ibusiness.ba** page and, by clicking on each menu, checks if they are available and clickable.

The time in both scenarios is measured using the Stopwatch method in the following way, first the Stopwatch class object is created, followed by the Start method, as shown in "Fig. 1".

```
Stopwatch stopWatch = new Stopwatch();
// Start the stopwatch
stopWatch.Start();
```

**Figure 1.** Creating object of Stopwatch class

The next step is to call a method that performs the complete test, so that the desired URL opens and performs all necessary operations. Calling a method that performs all of the necessary test steps from Scenario 2 is shown in "Fig. 2".

```
//open ibusiness page and check menu
string message = LoadIBPage();
```

**Figure 2.** Calling LoadIBPage method

As you can see from the "Fig. 2", it is the string method which has some return value, and subject to its value, the results that arrive at the email, as a final report depend as well.

The last step is used to stop the stopwatch to get the final test time.

The stopwatch stops by calling the Stop method, as shown in "Fig. 3".

```
// Stop the stopwatch
stopWatch.Stop();
```

**Figure 3.** Stop the stopwatch

The LoadIBPage method is used to load the page you want and to check if the menus that exist on that page are available and whether they are functional. The basic idea is to somehow count the menus and the number of menus to be the upper limit of the *for loop*, in this way avoiding the possible "hard coding" in which you should know in advance how many menus page there are. The tendency of today's web pages is that there are always some changes, so it can change the number of menus. If the testing was made so that the number of the menus is "hard coded", any change in this number would failed the test. If this does not happen, the code is implemented by pre-counting the menus by using a simple java script function that is executed using **JJavaScriptExecutor** and which as a return value, has the number of desired elements. JavaScript is a powerful scripting language to develop cross-browser compatible software libraries. In combination with HTML5 or HTML6 in modern browsers, JavaScript is the language of choice to ensure portability and wide applicability interactive web-facing tools [6,7]. The entire process is shown in "Fig. 4".

```
string jsCode = "function rows(){return JSON.stringify($('*u155-18 a').length); return rows();}";
JJavaScriptExecutor jsExecutor2;
jsExecutor2 = Driver.Instance as JJavaScriptExecutor;
string values = (string)jsExecutor2.ExecuteScript(jsCode);
int c = int.Parse(values);
for (int i = 1; i <= c; i++)
{
```

**Figure 4.** Using the java script code to count the page's menu

As given in "Fig. 4", all the elements within the parent element labelled with u155-18 are counted, where # indicates that it is an element in which the u155-18 is id.

The Java script code is written in such a way that the return value is in the JavaScript Object Notation-JSON format, after executing the code, returned value must be converted into **string** format, and then **into** the int format because the return value is required as a numeric value within the loop. By this approach, we have resolved a problem if menus are created dynamically, because their number are no longer important to us.

### 3. EVALUATION STUDY

Today, there is a large number of Internet browsers in use on the web market. Web browsers have become a major component of the routine human-computer interaction, with some operating systems entirely based on browsers (e.g., ChromeOS by Google [8]). They all have almost the same functionality and offer almost the same services, but they are not used equally by users.

Some web browsers come in a package with an operating system that is used on a local machine,

others can be downloaded from the Internet (may be commercial or written in open source technology) and the user can decide which type of web browser they want to use. This is true for most internet users, but when we talk about the business world, some other rules may apply. Some companies, due to certain security clauses in contracts signed with various partners and other companies, decided to use only a specific type of browser to access the Internet. This approach is a challenge for teams that test web applications. If testing is performed exclusively on a single browser, that kind of testing may be considered incomplete.

Because of this two test scenarios are presented in this paper, both of them are tested on 4 (four) different browsers, (Mozilla Firefox version 59.0.1 (64-bit), Google Chrome version 64.0.3282.186 (64-bit), Internet Explorer version 11.309.16299.0 and Microsoft Edge version 41.16299.248.0.). All tests are executed on machines with installed Windows 10 operating system, test code is written in C# programming language using automated testing Selenium WebDriver version 3.11.0.

The final result will present the difference in test run times on different web browsers, with the worst, best, and average test run times for each browser individually.

For both scenarios testing comparison between these four web browsers is made on the basis of the following:

- A concrete browser starts,
- Measurement of time begins,
- Opening the appropriate website,
- Test scenario is executed,
- Closing the browser,
- measuring time stops,
- A report will be sent to the email with the time of the test and information about the used internet browser.

Tests are directly run from VS (Visual Studio) environments as shown in the "Fig. 5".

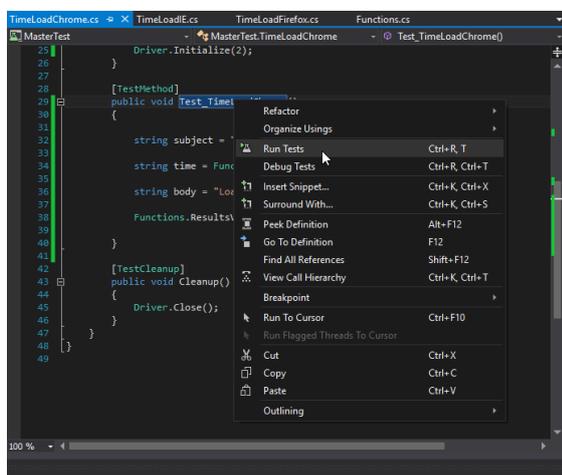


Figure 5. Run test from Visual Studio

### 3.1. Automatic test no.1

In this automated test scenario, we have a few steps to open a web site that is commonly known as "google.ba", to enter the term Automation test in the search box and click on the search after the result is displayed, it is necessary to check whether the first result is available in a row. After the completion of the test, on the test engineer's e-mail results with the time required for the execution of this scenario expressed in seconds will be sent. The test will be performed 10 times in a row on each examined browser, registering the best and worst performing times, as well as the average time for all of them. After completing all of the above test steps, the comparative results for 4 browsers are given in Chart 1. Time is expressed in seconds.

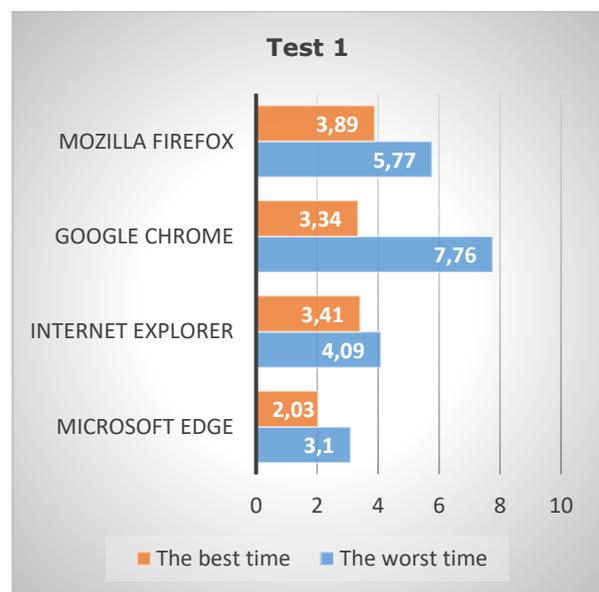


Chart 1. Showing comparative results for 4 browsers

The average time for performing the 10 reps for test 1. is given in Chart 2.

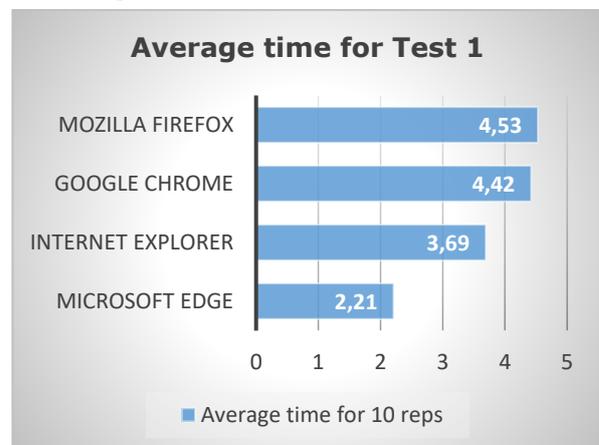
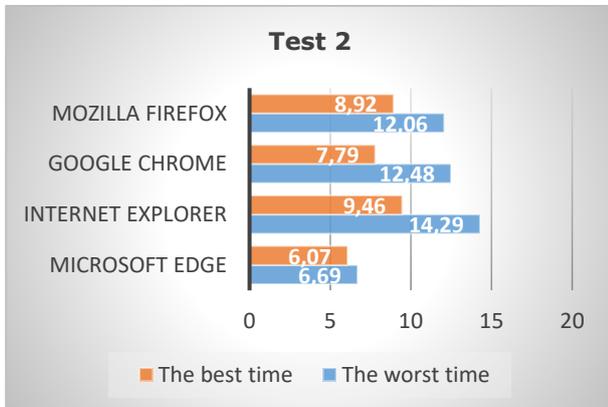


Chart 2. Display the average time for 10 reps

The results provided indicate that a Firefox browser had the slowest time, while on the other hand, the best results were achieved with Microsoft Edge browser.

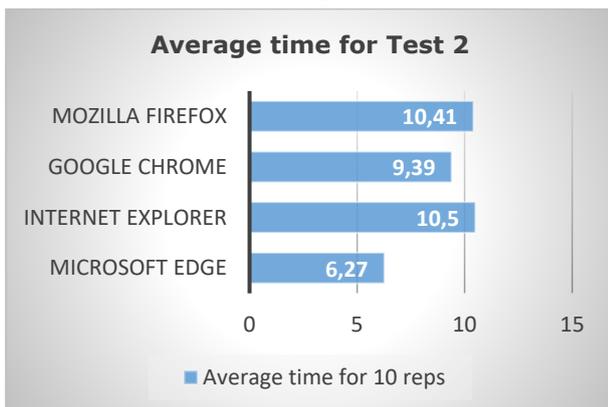
### 3.2. Automatic test no.2

In the following automated test, the **ibusiness.ba** website opens and after the displayed result, it is necessary to check that 5 menus are active and accessible. After completing all of the above test steps, the comparative results for 4 browsers are given in Chart 3.



**Chart 3.** Showing comparative results for 4 browsers

The average test run time for 10 reps for each individual web browser is given in Chart 4.



**Chart 4.** Display the average time for 10 reps

The average results for each of the individual web browsers are different from the results in test no.1. The Chart. 4, shows that the best average time as in test no.1, was achieved with Microsoft Edge, but based on the test result 2 in a more complex scenario, Internet Explorer has the worst result.

From the graphs shown, it can be seen that the test run rate differs from browser to browser, and that the difference between the worst and the best average time is reduced as the testing scenario becomes more complicated. In both scenarios, the best time has been achieved by Microsoft's next generation search engine (Microsoft Edge, which rightfully inherited an old and pretty obsolete version of Internet Explorer).

However, in the second test scenario, which is more complex than the first one, the difference between the best and the worst time is decreasing, and it can be concluded that by completing the scenario, the average execution

time is approaching each other. That situation for future testing scenarios is more than good, because testing teams are given the option (if they are not conditioned by running tests on a specific browser), to select the one which offers the easiest way for creating the tests. It should be noted that at least two browsers are included in the testing process, while at least free would be optimal, but right approach is that at least one of the browsers should be Microsoft's one.

## 4. CONCLUSION AND FUTURE WORK

Based on the presented scenarios and described procedures, it is concluded that Microsoft has seriously approached to resolving the deficiencies that existed on Internet Explorer, and that Edge has become a competitive browser, at least when test execution is concerned, which has not been the case with Internet Explorer so far.

It can be said that it is on the test designer himself to adjust to the browser as desired, and subject to his experience, to select which browser to use for testing. We should bear in mind that most of the development teams have the most problems with the older versions of Internet Explorer that are still in use, and if necessary, testing in any of the versions of this browser would be desirable. This research work can be extended to more experiments with more tools and different comparative parameters parameters as i.e. tests should be executed on computers with Open source operating system.

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# Software Testing Course in IT Undergraduate Education in Serbia

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**Abstract:** *In the last two decade, with the establishment of Information Technology (IT) departments in Serbian universities, the need for having Software Testing courses has also emerged. In this paper Software Testing is considered as an important subject but is not widely offered in many IT programs. Some faculties have one or more software testing courses in undergraduate studies, but some of them not. The Faculty of Technical Science in Čačak has IT studies, but in old curriculum doesn't have Software Testing course. Here we proposed program for this course which will be elective course on last year of studies. Also, it is present the importance of this course for student to find job position in domain of software testing.*

**Keywords:** *software testing; student; education; information technology (IT)*

## 1. INTRODUCTION

At most faculties in Serbia, students usually learn theoretical concepts of software testing as a part of Software Engineering or Programming courses. In practice, it is very difficult to learn all aspects of software testing throughout these courses. But, employers expect that graduate students have the ability to write and test computer programs [1]. In academic institutions more emphasis is given to software development than ensuring its quality.

There are many organizations which provide certificates for software testing. Some of the most recognizable in Serbia are Knowledge academy BSC courses [2] and International Software Testing Qualification Board (ISTQB) [3]. ISTQB provides courses in three levels: basic, advanced and expert. Agile Software Testing, Agile Testing Trainer, Scrum Training, etc. are some of the software testing topics included in these certified courses.

In order to obtain necessary knowledge, students should attend some of the above-mentioned specialized courses or have Software Testing course in their study program.

In recent years, Software Testing course became a part of curriculum in many Information Technology (IT), Computer Science (CS) and Software Engineering (SE) undergraduate studies. The authors of this paper propose adding Software Testing course at the final year of undergraduate IT studies at the Faculty of Technical Sciences in Čačak, accredited in 2014. During this course, main theory concepts as well as the different tools for software testing should be introduced to students.

## 2. RELATED WORK

The importance of software testing is reflected in the fact that there are many scientific papers concerning software testing in education. In [4], authors identified attitude and economics as major obstacles to software testing. Students must face these issues in order to successfully complete the testing process.

The paper [5] describes how Software Testing was gradually taken into curricula at some IT faculties. That was inevitable due to the increased complexity of software which was developed. During this course, students are required to select a tool for testing of software depending on its type and to apply it for software quality assessment.

Author of paper [6] proposes a pedagogical model in software testing teaching at the undergraduate studies. In this paper, seven course modules for teaching software testing as well as relationships between them are described.

In paper [7] authors propose postgraduate program for software testing. This is recognized as important for acquiring necessary knowledge and competencies for software testing. Although there are many software testing specialized courses available at the market, it is beneficial to include this kind of program at faculties. By attending courses offered in the above-mentioned program, students can become competent software testing professionals.

In paper [8] the performance of students in testing, given the tendencies in the industry is investigated. The authors were motivated by the lack of similar studies in software testing field.

### 3. THE IMPORTANCE OF SOFTWARE TESTING

The experience with students learning process indicated that Software testing is one of the core courses. Programming, Data Structures, Object-Oriented Programming, Software Engineering and similar courses can be helpful in development of software testing skills, but insufficiently.

At first, skills in completing stages of Software Development Life Cycle (SDLC) other than software testing were gained at IT faculties. The main focus of IT engineer education has been software development. IT students usually attend the basic programming courses firstly, and their main goal is creating applications, without worrying about testing techniques [8]. Recently, there are many new questions arising such as: Who will use that software? Is it usable? Will it work on different operating systems? Is it reliable?

Software testing is important phase of SDLC and all complex projects must be tested. There is always a need for testing, whether software companies implement new technologies, improve the existing state or maintain it.

Today, software development is a complex task. In most large software companies there is a team of IT engineers which work on one project. Each team usually has one member who is responsible for software testing or a third party company specialized in this area is engaged. In smaller software companies developed software also needs to be tested, so there is always a need for employees with software testing skill, regardless of company size.

In the area of Internet, software testing is also of a great importance. The cost of failures is very high,

especially if it includes reputational damages. Software testing is continuously adapting to the rapidly changing needs of dynamic business, so various development methodologies are created and used for testing [9].

### 4. SOFTWARE TESTING COURSE IN UNDERGRADUATE STUDIES IN SERBIA

IT, CS and SE are continuously developing, which leads to greater need of IT engineers. In order to meet the demand, number of IT students at Serbian colleges is rapidly increasing. These occurrences barely have an impact on Software Testing course, so in many faculties it remains aside. Most of courses are based on software development, while mistakes and bugs in code are not being properly handled. No matter how experienced the programmer is, mistakes can always occur. Software testing is crucial for software quality since customer wants his product to be optimized and to work without errors.

In Table 1 list of all faculties with corresponding undergraduate studies which provide Software testing course is presented. In the column Semester is shown the number of semester in which students attend Software Testing. In column No. of Students, number of students who enrolled faculties in 2017 is presented [10]. It can be concluded that about 30% of all students who are studying undergraduate IT/SE/CS studies have Software Testing course. This course is mainly in the final years of the studies.

**Table 1.** List of faculties which have Software testing course in IT/SE academic studies

No.	Faculty name and place	Undergraduate academic studies	Semester	No. of Students
1.	Faculty of Electrical Engineering in Belgrade	Software Engineering	5	180
2.	ICT in Belgrade	Internet Technology	5	40
3.	FTN in Novi Sad	Engineering of Information Systems	4	80
		Software Engineering and IT	7	80
4.	PMF in Novi Sad	Information Technology	4, 6, 8	80
5.	Technical Faculty "Mihajlo Pupin" in Zrenjanin	IT-Software Engineering	7	40
6.	Faculty of Science in Kragujevac	Informatics	8	100
7.	University of Novi Pazar	Software Engineering	7	40
8.	Department of Economics of the State University in Novi Pazar	Business Informatics	7	40
9.	Faculty of Information Technology in Belgrade, Metropolitan in Belgrade	Software Engineering	5	84
		Game Development	7	20
10.	RAF in Belgrade	Computer Science	7	25
11.	Faculty of Informatics and Computing, University Singidunum in Belgrade	Computer Science and Informatics	8	80
		Software and Information Engineering	5	50
12.	FINTECH, University Educons in Belgrade	Information Technology	5	60

During the past years, some of the colleges in Serbia noticed the importance of Software Testing course and included it into their curriculum. On the other hand, there are 18 faculties (with 27 different study programs in area of computing) which still have not integrated this course in their study programs. These faculties are displayed in Table 2. Therefore, most of the faculties cannot provide graduate students with knowledge in both software development and testing.

Larger companies usually make separate sectors for software testing, which are better known as Quality Assurance (QA) sectors. The need for QA engineers (software testers) still continues to increase since there is a lack of qualified people for that position. Consequently, including Software Testing course in as many as possible faculty programs will result in greater number of QA engineers, which is beneficial for both companies and graduate students.

**Table 2.** List of faculties which do not have Software testing course in IT/SE academic studies

No.	Name and Place	Undergraduate academic studies	No. of Students
1.	Faculty of Electrical Engineering in Belgrade	Computer Engineering and Information Theory	250
2.	FON in Belgrade	Information Systems and Technology	330
		Information Systems and Technology-Distance Learning	100
3.	Faculty of Mathematics in Belgrade	Informatics	160
4.	Faculty of Electronic Engineering in Nis	Computers and Information Technology	250
5.	Faculty of Science and Mathematics in Nis	Computer Science	55
6.	FTN in Novi Sad	Computing and Automatic	240
		Information Engineering	60
		Applied Software Engineering	160
		Animation in Engineering	60
		Information Technology	35
7.	Technical Faculty "Mihajlo Pupin" in Zrenjanin	Information Technology	80
		Information Technology Management	25
8.	Faculty of Science in Kragujevac	Computer and Software Engineering	60
9.	University of Novi Pazar	Computer Engineering	109
10.	Faculty of Science in Kosovska Mitrovica	Informatics	40
11.	Faculty of Technical Science in Kosovska Mitrovica	Electrical and Computer Engineering	80
12.	<b>Faculty of Technical Science in Cacak</b>	<b>Information Technology (from 2014 accreditation)</b>	<b>80</b>
		Electrical and Computer Engineering	80
13.	Faculty of Information Technology in Belgrade, Metropolitan	Information Technology	84
		Information Systems	66
		Computer Engineering	25
		Computer Design	20
14.	Faculty of Informatics and Computing, University Singidunum in Belgrade	Information Technology	50
15.	Faculty of Economics and Engineering Management in Novi Sad	Informatics	50
16.	Faculty of Information technology –ALFA, University in Belgrade	Information Technology	25
17.	Faculty of Mathematics and Computer Science –ALFA, University in Belgrade	Informatics	25
18.	Faculty of Computer Science, Megatrend	Informatics	75

#### 4.1 Disadvantages of old curriculum in IT studies at the Faculty of Technical Sciences in Čačak

In 2006, IT undergraduate studies were founded at Faculty of Technical Sciences in Čačak. At first, Software Testing course had not been included in these studies, so software testing was learnt as a part of Software Engineering course. Therefore, graduate students will have to learn the principles of testing as well as the tools used to test the software independently, in order to get a job at software testing position.

In the old accreditation from 2014, it was suggested that Software Testing course could be one of the elective subjects, which can be attended at the VIII semester. At that point, students will already have all of the needed pre-knowledge to learn this subject. There will be more than 100 students who will choose this course. That will be students who are now students of 2nd and 3rd year of IT.

With establishment of new, improved program in 2017, Software Testing course was finally included in curriculum as an elective subject in VII semester.

#### 4.2 Proposed structure of Software testing course program in IT studies

Software testing requires specific skills, including critical thinking, analytical abilities, and investigative skills. Good programming knowledge has a positive effect on testing, especially in structural testing, where testers need to understand the code to create test cases. Automated testing also requires a good background of programming. On the other hand, in functional testing, test cases are created using requirement specification. Even though programming is not necessary, there is a need to mentally visualize how the program satisfying given specifications will function in order to derive the test cases consisting of inputs and expected outputs. So it can be assumed that programming knowledge is a beneficial factor for successful software testing. The questions which arise are: Are better programmers, better testers as well? Do higher programming skills result in higher rates of success in testing? More specifically, do higher programming skills help in conducting testing in general, or is this more related to success in a specific testing technique, e.g. functional, structural, or automated testing [11].

Structure of Software testing course will be accomplished through Lectures and Laboratory sessions. The ST course lectures are composed of fifteen 2-hour lectures with midterm and final exam. Course should ensure that students understand the importance of ST activities and how much the good product relies on software testing phase.

In table 3, the sequence of lectures for ST course is presented.

**Table 3:** List of Software testing lecture topics

Lecture	Course title
1.	<ul style="list-style-type: none"> <li>The concept of testing</li> <li>Software testing in software development process</li> </ul>
2.	<ul style="list-style-type: none"> <li>Test Driven development</li> <li>Software analysis</li> <li>Software bugs</li> </ul>
3.	<ul style="list-style-type: none"> <li>Methods and levels of testing</li> <li>System testing</li> </ul>
4.	<ul style="list-style-type: none"> <li>Agile software development</li> </ul>
5.	<ul style="list-style-type: none"> <li>Fundamental agile testing principles, practices and processes</li> </ul>
6.	<ul style="list-style-type: none"> <li>Agile testing methods, techniques and tools</li> </ul>
7.	<ul style="list-style-type: none"> <li>Software components testing</li> <li>Bottom-up and top-down testing</li> </ul>
8.	<ul style="list-style-type: none"> <li>Midterm exam</li> </ul>
9.	<ul style="list-style-type: none"> <li>Testing goals</li> <li>Testing process management</li> </ul>
10.	<ul style="list-style-type: none"> <li>Test plan and implementation</li> <li>Testing process improvement</li> </ul>
11.	<ul style="list-style-type: none"> <li>Performance testing</li> <li>Security and penetration testing</li> <li>Functionality testing</li> </ul>
12.	<ul style="list-style-type: none"> <li>Team testing</li> <li>Testing automatization</li> </ul>
13.	<ul style="list-style-type: none"> <li>Defining user requirement management</li> </ul>
14.	<ul style="list-style-type: none"> <li>Graphical user interface testing</li> <li>Web applications testing</li> </ul>
15.	<ul style="list-style-type: none"> <li>Data base testing</li> </ul>
	<ul style="list-style-type: none"> <li>Final exam</li> </ul>

The ST laboratory sessions are composed of twelve 3-hour lectures and three terms of 3-hour project defending for all students who will finish their projects (Table 4). After attending these lessons, student will be competent to successfully test software parts or whole software. Students will learn how to analyze and choose corresponding testing tool, create test cases and efficiently accomplish software testing. In order to train students to do all of the above-mentioned on their own, they will be taught different methods, techniques and tools regarding testing. Good tester must also know how to create test cases based on tester or customer requests or complains. After that, all test cases are collected and sprint is made.

Team work is also an important part of software testing. Test cases should be properly assigned to team members, in order to have whole sprint finished in agreed time. Software testing laboratory class sessions should first cover scrum methodology, creation of test cases and sprints. After that, introduction to different software testing tools can begin. Since students have good knowledge of Java, it will be desirable that they also learn how to test applications made in that programming language. Projects made on Java course could be used as a material for testing, and on that example they could recognize software testing importance. Even students with best grades

could discover that those projects work only when used strict instructions.

**Table 4:** List of laboratory sessions topics

Lecture	Course title
1.	<ul style="list-style-type: none"> <li>Software testing introduction</li> <li>Different aspects of software construction process</li> <li>Software construction planning</li> </ul>
2.	<ul style="list-style-type: none"> <li>Scrum methodology</li> <li>Creation of sprints in agile software development</li> <li>Creation of test cases</li> </ul>
3.	<ul style="list-style-type: none"> <li>Types of tools for testing</li> <li>Introduction on tools which will be used in course</li> </ul>
4.	<ul style="list-style-type: none"> <li>Testing white, gray and black box</li> </ul>
5.	<ul style="list-style-type: none"> <li>Introduction to JUnit</li> <li>Basics tests with JUnit</li> </ul>
6.	<ul style="list-style-type: none"> <li>Intermediate testing with JUnit</li> </ul>
7.	<ul style="list-style-type: none"> <li>Test automatization with Junit</li> </ul>
8.	<ul style="list-style-type: none"> <li>Introduction to SeleniumHQ</li> <li>Basic tests with SeleniumHQ</li> </ul>
9.	<ul style="list-style-type: none"> <li>Intermediate web application testing with SeleniumHQ</li> </ul>
10.	<ul style="list-style-type: none"> <li>Introduction to AutoIt testing software</li> <li>Basic tests with AutoIt</li> </ul>
11.	<ul style="list-style-type: none"> <li>Connecting AutoIt with Selenium</li> <li>Intermediate automatization testing</li> </ul>
12.	<ul style="list-style-type: none"> <li>Database testing with Data Factory</li> </ul>
13.	<ul style="list-style-type: none"> <li>Project defend</li> </ul>
14.	<ul style="list-style-type: none"> <li>Project defend</li> </ul>
15.	<ul style="list-style-type: none"> <li>Project defend</li> </ul>

Testing will be accomplished with JUnit testing software, when their Java knowledge will be of great importance, since testing in JUnit requires knowledge of Java programming language. After desktop application testing, student will learn how to test web application with SeleniumHQ. Again, to write tests scripts, Java programming language is required. Students will be able to test whole web site or application automatically with their testing script.

Sometimes web testing requires user interaction. In that case, AutoIt software can be used for user interactions automation. Connecting AutoIt with SeleniumHQ provides possibility to make intermediate automated test scripts.

Besides of all the above-mentioned, students will also learn how to test databases. In IV semester, students are attending Introduction to information systems course, in which they are learning SQL language and database creation and manipulation. Bad database can easily lead to so called "dead lock" or performance issues. Software testing tool for databases called DataFactory can help in preventing those situations.

After lectures and laboratory sessions students will have enough knowledge to do different type of testing with different tools. Those tests will be automated and efficient and they can cover from tiny parts of software to whole software testing. To

get final grade of their knowledge in software testing, they will need to make project which consists of performing automated test of whole Java application. Students will also choose one web site or web application, which should be tested with AutoIt connected with SeleniumHQ. All that should be well documented. That project will be defended verbally before examination period. That way, students will prove their practical and theoretical knowledge learned in this course.

## 5. CAREER OPTIONS IN SOFTWARE TESTING

After finishing IT studies, there are different career paths in area of software testing. Some of the common job positions in this field are QA engineer, test manager, tester, etc. Testing career usually requires skills such as domain and analytical skills, technical knowledge, communication, soft skills, etc. Devotion, flexibility and learnability are also desirable skills for software testing professionals.

Software testing practitioners can come from a variety of backgrounds. In Figure 1, eight typical job roles in the area of software testing are shown. Below each job opportunity, main responsibilities regarding specific job are listed.

Software testing can be applied in many scopes, and some of them are following:

- Automation Testing
- Performance Testing
- Security Testing
- Cloud Testing
- Infrastructure Testing
- Information Management Testing
- Test Environment Management
- SAP Testing
- Mobile Apps and Devices Testing
- Database Testing
- Oracle Testing
- Package, product Testing
- Test Process TPI, QBP
- Agile Testing
- Test Data Management
- Web Testing
- Regression Testing
- User Acceptance Testing
- Chain Testing, E2E Testing.

Practitioners in testing services can advance in their careers by doing the following:

- Improving knowledge in various areas of testing solutions, tools, methods, processes, architectures, and disciplines.
- Applying industry expertise and specific knowledge.
- Promotion of engagement in activities which increase practical knowledge and training in order to progress to the executive level.

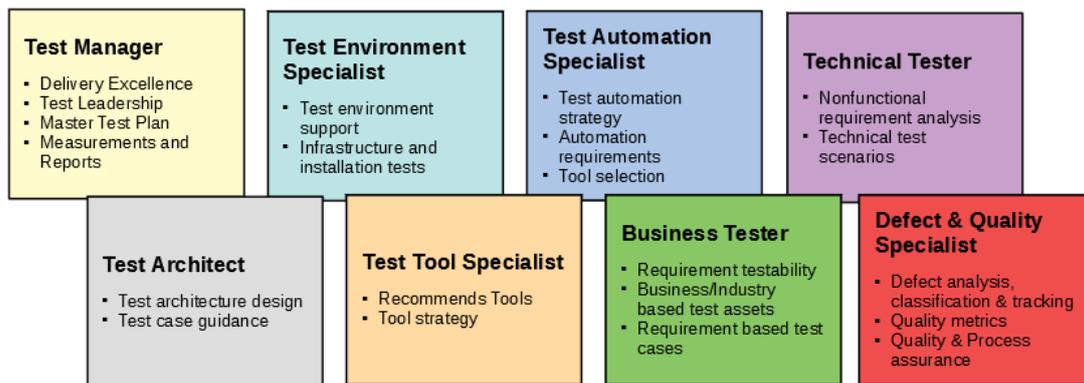


Figure 1. Different job opportunities in software testing

## 6. CONCLUSION

Due to the increasing demands of end users and complexity of applications created for them, the quality of software must be exceptional. Graduate students of IT, SE or CS studies must have abilities required for working at any stage of SDLC. Although software testing is a part of curriculum at many faculties in Serbia for more than 20 years, but there are still a lot of faculties where this area is not being studied as a separate course. This can be a big disadvantage of study program because proper knowledge of software testing cannot be achieved by learning it partly, throughout other courses. During the Software Testing course, basic theory concepts should be learnt, and some of the software testing tools should be applied.

Based on the [10] approximately 3700 students attend undergraduate IT studies in Serbia. About 50% of students are graduating within the program completion deadline. Out of the total number of IT students, about third of them have Software Testing included in their studies.

Authors of this paper propose that, due to the importance of this field, all IT study programs should have Software Testing course at least as an elective subject. Thus, graduate students would have the opportunity to apply for some of the before-mentioned job roles in area of software testing. This would be beneficial for both students and employers, because students would be able to find a job in the field of software testing without additional training, and employers could hire qualified engineers without difficulties.

## ACKNOWLEDGEMENTS

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# Teaching Adaptability and Code Reuse of Web Applications with the N-tier Architecture: Case study in VS.NET

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**Abstract:** *This paper presents results in exploring research in development of adaptable software and teaching in this field, with special concern on using n-tier web programming as an example. The model of teaching n-tier web programming is based on introducing software components organized in layers (data layer, business logic layer, service layer and presentation layer) and sub-layers within each layer. This model enables adaptability of software to changes, including changes of DBMS, business rules etc. The proposed model is compared with existing industry standard architectures, such as MVC (model-view-controller). The proposed approach is explained with a case study of n-tier ASPX/MSSQL web application.*

**Keywords:** *adaptable software; n-tier programming, web programming, teaching, MVC*

## 1. INTRODUCTION

Within higher education of software development, it is of a great importance to study issues that are common within industry environment. One of the most important groups of issues belongs to software change management. Therefore, it is very important to teach students how to create software architectures that provide easier changes of its subsystems. Such changes are frequent in business rules, as well in used data warehouse technologies (i.e. DBMS types, data formats) etc.

Aim of the research presented in this paper is to propose the n-tier architecture suitable for teaching adaptability of software. An example that illustrates the proposed approach is given with the n-tier ASP.NET web application.

This paper is structured as follows: second section explains theoretical background in software change/configuration management, third section describes related work in programming teaching, fourth section explains the proposed model with layers and sub-layers, the responding to changes and comparison to industrial standard MVC, fifth section presents an example that is used within classes of software engineering at University of Novi Sad, Technical faculty "Mihajlo Pupin" Zrenjanin, Serbia. Final section is conclusion.

## 2. ADAPTATION AND REUSE CONCEPTS

In the phase of software design and construction, there are two very important approaches (SWEBOK [1]):

- Design/Construction for reuse,
- Design/Construction with anticipation of change, i.e. suitable for adaptation.

Concepts of reuse and adaptation are very closely related.

"Construction for reuse creates software that has the potential to be reused in the future for the present project or other projects, taking a broad-based multisystem perspective. IT is desired to encapsulate reusable code fragments into well-structured libraries or components. The tasks related to software construction for reuse during coding include variability implementation with mechanisms such as parameterization, conditional compilation, design patterns etc". [1]

"Most software will change over time, and the anticipation of change drives many aspects of software construction; changes in the environments in which software operates also affect software in diverse ways. Anticipating change helps software engineers build extensible software, which means they can enhance a software product without disrupting the underlying structure." [1]

According to [1], with acceptance of eight software evolution laws, software is considered as constantly evolving, with complexity growing. Changes occur in the software during the core development or maintenance. Maintenance activities could be categorized as: corrective, adaptive, perfective and preventative.

Configuration management is "a discipline of technical and administrative direction and surveillance to: identify and document the functional and physical characteristics of a configuration item, control changes to those characteristics, record and report change processing and implementation status, and verify compliance with specified requirements". [1] [2]

"Change request (CR) may be originated by anyone at any point in the software life cycle and it may include the suggested solution and requested priority. The type of change is usually recorded on the Software change request. The formal procedure of managing changes include submitting and recording change requests, evaluating the potential cost and impact of a proposed change and accepting, modifying, deferring or rejecting the proposed change. Changes may be supported by source code version control tools." [1]

Therefore, the concepts of adaptation and reuse being followed at the design phase of the software development provide the basis for the following phases, related to the construction and deployment, as well as to the post-delivery activities. These concepts show potentials in conserving programming experiences for future related projects.

### 3. RELATED WORK

Evolution of software engineering methods and tools influences teaching in this field, particularly constant improvement in content of corresponding courses. Other important aspect of Software Engineering Teaching is methodology of the teaching process.

In [3], the importance of practical engagement of software engineering students in teamwork within real-world projects is demonstrated with the case study. Usual teaching practice is to include real-world projects in the field of information systems development [4], i.e. enterprise application development [5]. The concept of practical enterprise application development with university teaching in software engineering presented in [5] includes lab assignments in object-oriented programming of n-tier web applications with use of web services. Since dealing with the realistic projects from the real world requires complex set of knowledge and skills, as well as going through the complete software life cycle, to gain appropriate level of details in knowledge and skills requires one project to be split as set of

subprojects to be done within set of interrelated subjects. In [6], that approach of having one common project, which the student work on within many subjects (courses) is experimentally tested. Students implemented their practical work within a series of inter-related subject by following the software development life cycle: object-oriented systems analysis and design, data structures, software engineering, web programming, distributed web services and software development, software testing. This way, working at the same project from different aspects within diversity of teaching subjects/courses lead to the completing more complex and more realistic result.

Teaching software engineering within practical work on the real-world projects is closely related to software project management (SPM), where related topics are included within appropriate SPM courses/subjects. Contemporary industrial standard approach to SPM is implementation of agile principles and methods. Experiences in teaching SPM with agile paradigm are described in [7]. One of the agile methodologies is Extreme programming and empirical results in teaching with this methodology are presented in [8]. Other teaching experiences in software development are more focused on technologies in reaching the agility of development by using model-driven approach, such as [9], and even more, – using code generators based on model-driven development [10]. Teaching in software engineering is, in recent years, focused on contents that are related to modern technologies within professional environments, such as cloud computing [11]. Close collaboration of industry and higher education educators and curriculum creators is crucial for the benefit of students to be ready for the knowledge and skills requirements in the professional development environment. The need to improve college programs, in aim to prepare students for professional work, is emphasized in [12]. Particularly important contents are related with IT governance process, knowledge in business domain, ability to capture requirements by proactive asking right questions, quality of design based on experiences, peer or supervisory review of code with suggestions on quality improvements etc. Particularly important is the area of configuration management, changes of code, compliance with existing architecture and documentation [12].

### 4. THE PROPOSED N-TIER TEACHING MODEL

The proposed approach to teaching the adaptability and code reuse in application development is based on practical work in software development with n-tier object-oriented architecture and service-oriented architecture (similarly to [5], [13]), with applying component

paradigm (separate layers belong to independent components i.e. projects that are coded and build independently from other layers, but that could be integrated with referencing (References – adding link to DLL or Service References – adding alias to Web service URL). This model enables (if needed within change management) replacements of components, easy changing in particular component, teamwork development and improvement of overall software quality, as well as the code reuse.

#### 4.1. Layers and sub-layers

The proposed model of the n-tier software architecture is presented in the Table 1. The first column presents an n-tier software layer and second column is related to sub-layer. The proposed sub-layers implementation is presented in the third column with the example of VS.NET (Visual Studio .NET) web application and other executable components in the architecture.

**Table 1.** The proposed model of n-tier web application architecture in VS.NET

LAYER	SUB-LAYER	VS.NET executable component
Presentation Layer	User interface	ASPX
	Presentation logic	DLL
Services Layer	Web services	ASMX
	Mapping library	DLL
Business logic layer	Business rules class library	DLL
	Business objects class library	DLL
Data layer	Semantic-oriented class library	DLL
	Technology-dependent class library	DLL
Relational database	Stored procedures Views	<b>DBMS</b>
	Tables	
Data files	XML	

Executable components from Table 1. are:

- ASPX – ASP.NET Web form file extension
- ASMX – VS.NET web service (SOAP type) file extension
- DLL – Dynamic Link Library, file extension of executable form of class library

Presentation layer consists of:

- User interface, implemented in the example as Web forms application ASPX. Implementing web forms requires studying html + css (which are the essential part of any web page, as well as underlying structure of ASPX web form), with necessary programming part (C#) that enables access, data retrieval and basic

instantiation and using presentation logic classes, i.e. invocation of appropriate class methods.

- Presentation logic, encapsulated within a separate component, i.e. Class Library (DLL). It contains the code for data capturing and transformations, validation and preparation for presenting in the user interface. The presentation logic instantiates classes from lower layers, such as services layer, business logic layer and data layer.

Services layer consists of:

- Web services, which are consulted as remote raw data retrieval services (from other data sources, such as XML or other database) or remote business logic services, such as enforcing business rules processing or retrieving constraints (stored in the XML form) needed for local business rules processing.
- Mapping service, encapsulated within Class Library (DLL), provides integration of other layers, i.e. data exchange between classes based on different data models or coding systems.

Business logic layer consists of:

- Business objects, implemented as separate Class Library (DLL), where classes are named by the terms of the business domain actors, entities or business processes and the implementation logic is based on using methods from the data layer classes.
- Business rules are implemented enforced from separate business-rules classes or as business objects methods and their mutual interactions.

Data layer consists of:

- Semantic-oriented class library (DLL) which consists of three types of classes. For each table in relational database there are three classes: a) Single-occurrence class (contains private attributes that correspond to table fields from the relational database, as well as corresponding public properties implemented with set/get methods), b) List class, which contains typed list of "single-occurrence" classes, c) DB class, which contains methods for basic CRUD (Create, Read, Update, Delete) operations upon appropriate table from the database. These methods could be implemented with using diversity of methods (using SQL client classes and methods with SQL queries or stored procedures or using technology-dependent class library).
- Technology-dependent class library (DLL) which is semantic-independent. The technology dependence occurs because of using standard classes (from appropriate DB API) for the connection to the database and executing active SQL queries (directly or with using stored procedures). The technology dependent classes consist of the database connection, table and transaction classes,

which are implemented upon standard libraries: SQLClient (for MSSQL server DBMS), OleDb (for MS Access DBMS) or ODBC (other DBMS types). This technology-dependent class library encapsulates the API-dependent source code with general names (of classes, attributes and methods) and therefore provides ease of replacement with other DLL with the same names, but different underlying technology-dependent implementation. Example: General class name is Connection, while DB API for MSSQL DBMS (SQLClient) name for connection is SqlConnection.

In broader definition, data layer could include:

- Relational database, that consists of data tables related with foreign key constraints, as well as stored procedures and views. Stored procedures and views consist of basic CRUD (CreateReadUpdateDelete) SQL queries, which provide faster queries processing. Including stored procedures and views in Semantic-oriented class library methods improves data retrieval and processing performances.
- Data files, such as XML, which represent source of raw data or constraints queried from business rules.

#### 4.2. Responding to changes

The proposed model supports changing in:

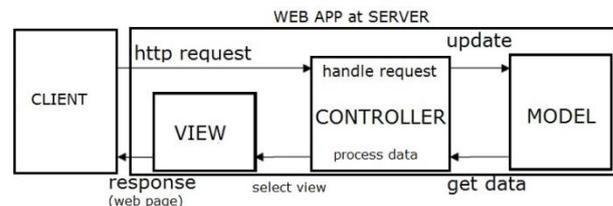
- The interface type, since presentation logic captures the logic of the application and invoking lower layers
- Coding standards between different modules and applications, with mapping service
- Data responsibilities among diversity of institutions, which is provided by using web services
- Business rules, which is enabled with allocating business rules algorithms within appropriate business objects or separate classes related to business rules enforcing,
- Business rules constraints, provided by web services or externally stored constraints in XML,
- DBMS type, which is enabled by separation of semantics and technology. By changing DBMS, it is sufficient to replace the technology-dependent DLL with other technology-dependent DLL with the same name of class library, classes, attributes and methods. This way, semantic-oriented class library will not require any changes in the source code, but only to be rebuild, because of the change in the referencing DLL.

#### 4.3. Comparison of the proposed model with standard pattern MVC

In contemporary industrial software development, some of the most important principles include:

- Agile development, i.e. quick adaptation of software to user requirements that evolve during the development process, which require an architecture suitable for frequent changes
- Teamwork development, which leads to the need of separation of the software into modules that could be assigned to diversity of teams or team members, with parallel development (which supports decrease in development time) and specialization of teams/members, which encourages quality of production
- Standard orientation, which requires all team members follow standard procedures, coding conventions, industrial models and design patterns etc. with the outcome in quality of development products and services.

One of the standard software structuring approach include MVC architectural design pattern. The concept of responding to client's request in MVC in ASP.NET (according to [13]) is presented in the Figure 1. Client's http request is received by the controller class (derived class from standard System.Web.Mvc), which queries model classes for data read, update, insert or delete. After data retrieval or change, the model gives data to the controller, which prepares the necessary output and chooses appropriate view as response (in the form of web page to be presented to client).



**Figure 1.** MVC structure and collaboration of components in responding to http request (according to [13])

Comparison of the proposed n-tier model and MVC regarding adaptability to changes and reusability of code is presented at Table 2 and explained below:

- Adaptability to changes is provided as in MVC the view is separated from application logic and data. This allows making changes in separate elements. The issue is that the controller captures all the application logic and the model integrates data model semantics and DBMS-dependent technology in CRUD support (example: Entity framework generated classes include both semantics from relational database tables and underlying technology of MS SQL Server incorporated in generated Entity framework code). The proposed n-tier model promotes separation of sub-layers and separation of semantics from the (DBMS-dependent) technological implementation. In this way, the proposed n-

tier approach is more suitable for change implementation and supports adaptability more flexible.

- Reusability of code is provided thanks to MVC approach, where the created model and controller could be used with other type of view. One issue with MVC is that the controller captures all the application logic, which makes it harder to separate, reuse and adapt particular parts. Another issue with MVC is related with very tight dependency of semantic and technology in the model component. In the proposed n-tier model, reusability is supported for all layers and sub-layer, particularly in the data layer, by separation of technology-dependent and semantically independent class libraries, which allows using the same universal technology-dependent class library for any other project. Business rules and business objects classes are reusable for similar software solution, which is particularly important for software product lines support. Even the presentation logic, captured within the class library, could be reused with any other user interface.

**Table 2.** Comparison of MVC with the proposed n-tier model

LAYER	SUB-LAYER	MVC
Presentation layer	User interface	View
	Presentation logic	Controller
Service layer	Web service	
	Mapping service	
Business logic layer	Business rules	
	Business objects	Model
Data Layer	Semantic-oriented class library	
	Technology-oriented class library	

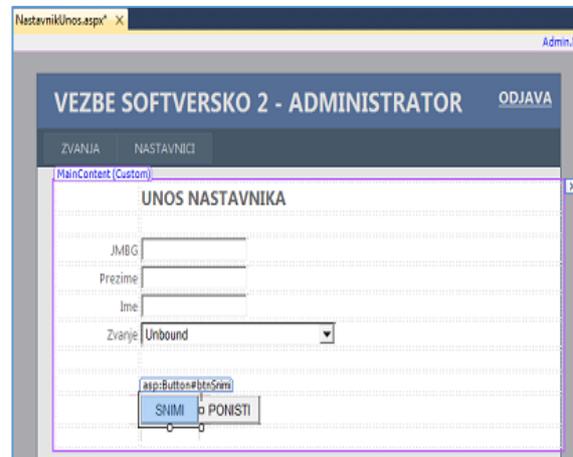
**5. EXAMPLE OF VS.NET APPLICATION**

Illustration of the proposed model is given in this section, with the example constructed within Software engineering classes at University of Novi Sad, Technical faculty „Mihajlo Pupin“ Zrenjanin.

Semantics of the example is related to records on teaching staff at the University school. The web application is developed to provide basic enterprise software functions, such as data entry, tabular presentation with filtering, updating, deleting and printing.

Within implementation of these software functions, students created user-interface project of Web forms type ASPX and parallelly created class library projects for appropriate sub-layers. One DLL file of a sub-layer class library project is attached (using References section in VS.NET IDE) in the projects of other sub-layers. Web services (ASMX) are created as separate projects and

attached to other sub-layers by using Service Reference section in VS.NET (assigning alias to URL of previously activated Web Service in localhost). Figure 2. shows the user interface of the ASPX application – the page for the entry of data related to the new teaching staff member.



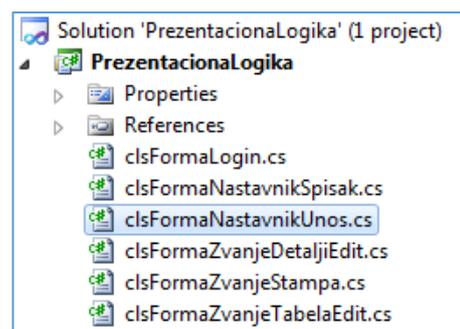
**Figure 2.** Teaching staff data entry page of an example user interface

Drop-down list (combo) gets, at the ASPX page (code presented at Figure 3.), the data from the class, which presents the presentation logic class dedicated to support this page (i.e. form in user interface).

```
private void NapuniCombo()
{
    DataSet dsZvanja = new DataSet();
    dsZvanja=objFormaNastavnikUnos.DajPodatkeZaCombo(
    );
    int ukupno = dsZvanja.Tables[0].Rows.Count;
    ddlZvanje.Items.Add("Izaberite...");
    for (int i = 0; i < ukupno; i++)
    {
        ddlZvanje.Items.Add(dsZvanja.Tables[0].Rows[i].ItemArray[1].ToString());
    }
}
```

**Figure 3.** The procedure for filling drop-down list at the page from Figure 2.

The concept of presentation logic classes organization is that each page at user interface has appropriate class in the presentation logic, that support that page. Figure 4. presents list of classes in the presentation logic that are developed, within classes in Software engineering, for the purpose of this example.



**Figure 4.** List of classes within presentation logic

For the page, presented in Figure 2, the presentation logic class is presented with the code (only attributes and methods signatures are presented) presented at Figure 5. The role of the presentation logic class is demonstrated with this example:

- Getting the data from the user interface in the exact form as they are entered,
- Transformation of data suitable for lower sub-layers,
- Preparation of data for presentation (such as data needed for drop-down list filling)
- Verification of the entered data (checking mandatory fields, uniqueness and invocation of methods from classes from lower layers, such as to check business rules or to start saving of the data).

```
namespace PrezentacionaLogika
{
    public class clsFormaNastavnikUnos
    {
        // atributi
        private string pStringKonekcije;
        private string pJMBG;
        private string pPrezime;
        private string pIme;
        private string pNazivZvanja;

        // property
        public string JMBG{...}

        public string Prezime{...}

        public string Ime{...}

        public string NazivZvanja{...}

        // konstruktor
        public clsFormaNastavnikUnos(string NoviStringKonekcije){...}

        // private metode

        // public metode
        public DataSet DajPodatkeZaCombo(){...}

        public bool DaLijeSvePopunjeno(){...}

        public bool DaLijeJedinstvenZapis(){...}

        public bool SnimiPodatke(){...}

        public bool DaLisuPodaciUskladjeniSaPoslovnimPravilima(){...}
    }
}
```

**Figure 5.** The code of the presentation logic class

Uniqueness of the data that were assigned from the user interface to presentation logic attributes is checked within the appropriate method of the presentation logic class, which invokes method from the DB class from the data layer (code presented at Figure 6).

Checking compliance of the data assigned to the presentation logic attributes with the business rules is performed within the method in presentation logic that invokes the method from the business logic layer (code presented at Figure 7).

```
public bool DaLijeJedinstvenZapis()
{
    bool JedinstvenZapis = false;
    DataSet dsPodaci = new DataSet();
    clsNastavnikDB objNastavnikDB = new clsNastavnikDB(pStringKonekcije);
    dsPodaci = objNastavnikDB.DajNastavnikaPoJMBG(int.Parse(pJMBG));

    if (dsPodaci.Tables[0].Rows.Count == 0)
    {
        JedinstvenZapis = true;
    }
    else
    {
        JedinstvenZapis = false;
    }

    return JedinstvenZapis;
}
```

**Figure 6.** Method of presentation logic for data uniqueness checking by invoking DB class method

```
public bool DaLisuPodaciUskladjeniSaPoslovnimPravilima()
{
    // POSLOVNO PRAVILO:
    // Na fakultetu ne moze biti zaposleno vise nastavnika u odredenom
    // zvanju nego sto je dozvoljeno maksimalnim brojem prema sistematizaciji
    // radnih mesta.
    bool UskladjeniPodaci = false;

    clsPoslovnaPravila objPoslovnaPravila = new clsPoslovnaPravila(pStringKonekcije);

    //izracunavanje ID zvanja
    clsZvanjeDB objZvanjeDB = new clsZvanjeDB(pStringKonekcije);
    string IDZvanja = objZvanjeDB.DajSifruZvanjaPoNazivu(pNazivZvanja);

    UskladjeniPodaci = objPoslovnaPravila.DaLiImaMestaZaZaposljavanje(IDZvanja);

    return UskladjeniPodaci;
}
```

**Figure 7.** Method of presentation logic for business rules checking by invoking class method from the business logic class library

Saving data, that were assigned from the user interface to presentation logic attributes, is performed with appropriate method from the presentation logic class, which invokes the appropriate method from the DB class from the data layer (code presented at Figure 8).

```
public bool SnimiPodatke()
{
    bool uspehSnimanja=false;

    clsNastavnikDB objNastavnikDB = new clsNastavnikDB(pStringKonekcije);

    clsNastavnik objNoviNastavnik = new clsNastavnik();
    objNoviNastavnik.JMBG = int.Parse(pJMBG);
    objNoviNastavnik.Prezime = pPrezime;
    objNoviNastavnik.Ime = pIme;

    clsZvanje objZvanje = new clsZvanje();

    clsZvanjeDB objZvanjeDB = new clsZvanjeDB(pStringKonekcije);
    objZvanje.Sifra = objZvanjeDB.DajSifruZvanjaPoNazivu(pNazivZvanja);
    objZvanje.Naziv = pNazivZvanja;

    objNoviNastavnik.Zvanje = objZvanje;

    uspehSnimanja = objNastavnikDB.SnimiNovogNastavnika(objNoviNastavnik);

    return uspehSnimanja;
}
```

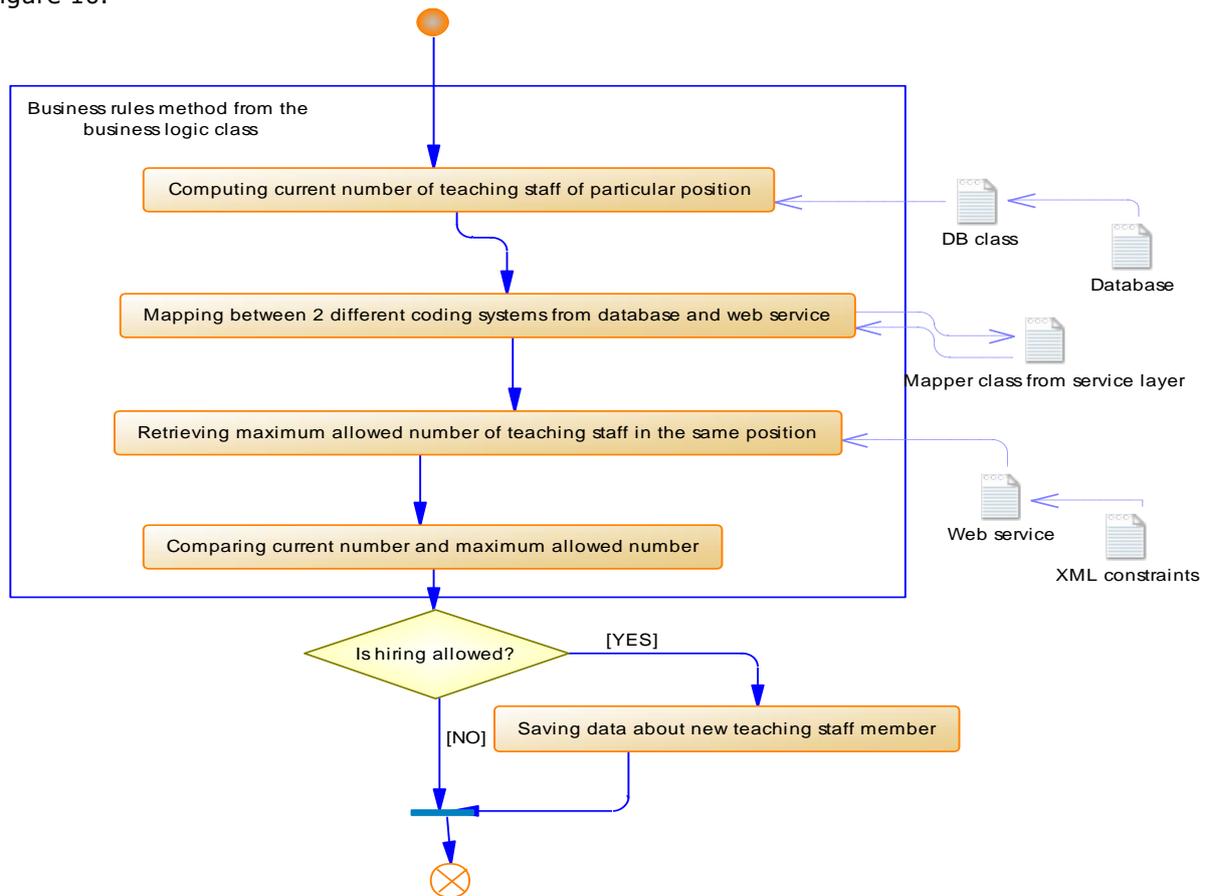
**Figure 8.** Method of presentation logic for saving data by invoking DB class method

The business rule that is checked is in this example related to the constraint on the maximal number of employees for certain teaching position, formulated in the form of

**IF (condition) THEN (action).**

IF (number of existing teaching staff is lower than maximal allowed number of teaching staff) THEN (hire a new teaching staff member).

Business rules application algorithm is presented at the Figure 9. and appropriate code is presented at Figure 10.



**Figure 9.** Activity diagram of the business rule with invocation of methods from other layers

```

public bool DaLiImaMestaZaZaposljavanje(string IdZvanjeIzBazePodataka)
{
    bool imaMesta = false;
    // *****
    // 1. IZRACUNAVANJE TRENUTNOG BROJA NASTAVNIKA U BAZI PODATAKA
    int UkupnoNastavnika = 0;
    clsNastavnikDB objNastavnikDB = new clsNastavnikDB(pStringKonekcije);
    UkupnoNastavnika = objNastavnikDB.DajUkupnoNastavnikaZaZvanje(IdZvanjeIzBazePodataka);
    // *****
    // 2. MAPIRANJE SLOJEVA - uskladjivanje ID Zvanja iz raznih delova programa
    // Web servis ima d - docenta, baza podataka ima 1 - docent
    string IdZvanjeWS = "";
    clsMapper objMapper = new clsMapper(pStringKonekcije);
    IdZvanjeWS = objMapper.DajSifruZvanjaZaWebServis(IdZvanjeIzBazePodataka);
    // *****
    // 3. IZDVAJANJE MAX BROJA NASTAVNIKA ZA ODG ZVANJE
    WSKadrovskiPodaci.Service1 objOgranicenja = new WSKadrovskiPodaci.Service1();
    int MaxBrojNastavnika = objOgranicenja.DajMaxBrojNastavnika(IdZvanjeWS);
    // *****
    // 4. UPOREDJIVANJE TRENUTNOG BROJA I MAX BROJA NASTAVNIKA
    if (UkupnoNastavnika < MaxBrojNastavnika)
    {
        imaMesta = true;
    }
    else
    {
        imaMesta = false;
    }
    return imaMesta;
}

```

**Figure 10.** Method for business rules checking within the business logic class

## 6. CONCLUSION

Constant change in the information technologies requires adaptation of the teaching contents and

improvement of teaching methodology. In the software engineering teaching, contemporary technologies and industry practices lead university teaching toward agile development, teamwork, programming of distributed software systems etc.

Aim of this paper is particularly focused on the teaching issues in development of software that is suitable for adaptation to changes. Design and construct reusable code is closely related to the suitability for code change and the teaching model that is proposed in this paper addresses both issues.

This paper proposes an n-tier model to be used in teaching code adaptation and reusability of code, while comparing the proposed model with the MVC, the industrial standard approach. As an illustration of the proposed model, an example of n-tier VS.NET web application is presented with user interface page, code segments and an example of a business rule compliance checking algorithm. The presented example is used at Software engineering classes at bachelor (undergraduate) level of study in Information Technology Engineering at University of Novi Sad, Technical faculty "Mihajlo Pupin" Zrenjanin, Serbia.

The presented n-tier model is not a complete model of enterprise-oriented professional software, but is suitable for the undergraduate study in enterprise-oriented software development. More complex teaching aspects of professional software engineering should include workflow and business rules management systems, with automated reasoning over externally stored rules written in formal language and data obtained from the database and the user interface. Such advanced (non-covered in this model) topics are included at master-level of studies at the University of Novi Sad, Technical faculty "Mihajlo Pupin" Zrenjanin, Serbia.

Comparison of the proposed model is made regarding teaching practice in India and Russia and the proposed model is recognized as similar that is taught in these countries. The proposed model is also compared with industry experiences in India and it is concluded that it enables students to understand software component paradigm and components integration, as well as techniques for developing a reusable and adaptable software in a way that prepares students for the industry practice, by making students understand basic structures and principles and empowering them to understand industrial frameworks.

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# One MCDM Approach to Learning Management Systems Evaluation

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**Abstract:** *In the paper are presented and also illustrated on a practical example possibilities of applying one MCDM approach to evaluation of the Learning Management Systems (LMSs) as an important tool in achieving more efficient educational processes. This study proposes a Fuzzy Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) approach to support evaluation of LMSs under fuzzy environment. The proposed approach enables decision makers to identify the alternative, which is closest to the ideal solution and provide more accurate and effective decision support tool, also by implementation of the fuzzy set theory within the TOPSIS process the problems of vagueness and ambiguity are solved.*

**Keywords:** *Learning Management System; MCDM approach; Fuzzy TOPSIS method*

## 1. INTRODUCTION

As technological progress is increasingly more intense, it is become vital for education institutions to take advantage of them to enhance teaching and learning processes. The LMS is one of a powerful software-based tools that will enable progress of education processes. LMS is a software-based platform for the administration, documentation, tracking, reporting and delivery of educational processes [1].

According to Coates, James & Baldwin [2] LMS provides tools for course administration and pedagogical functions of differing sophistication and potential:

- asynchronous and synchronous communication (announcement areas, e-mail, chat, list servers, instant messaging and discussion forums);
- content development and delivery (learning resources, development of learning object repositories and links to internet resources);
- formative and summative assessment (submission, multiple choice testing, collaborative work and feedback) and class and user management (registering, enrolling, displaying timetables, managing student activities and electronic office hours).

The main benefits of using LMS are: reducing learning and development costs, reducing learning time, centralizing learning resources, tracking of learner`s and teacher`s progress, increasing knowledge retention, enables flexible and collaborative learning, creating courses easily using simple editing settings, easy integration with other

systems, enables analytics and reporting features, also it increases students` engagement and brings a new dynamics in academic work and the organization of teaching, etc.

LMS is a part of an important culture shift taking place in teaching and learning in higher education [2].

The list of LMS users includes much more than just educational institutions: Traditional educational institutions such as schools, universities or colleges, businesses of all types and sizes, non-government and non-profits organizations, government agencies and local governments and online and eLearning based educational institutions. They are using LMS for: students` education in eLearning form, employee training, employee orientation and professional development, knowledge retention, etc.

The LMS handles the management and delivery of eLearning courses, also it is a powerful tool for transforming traditional educational processes into advanced forms such as eLearning or distance learning.

The quality of LMS software application is the one that obtains: diverse content options, course creation tools, learning paths, education processes assessments, interactive discussions and peer support, reporting of the education processes results.

There are numerous studies which researche the perspectives and benefits of using the LMS within educational processes [3], [4], [5], [6], [7].

There are over 700 solutions of the LMS, each offering something different than the next one.

Selecting the best LMS for some institution's unique learning needs isn't an easy task.

When evaluating the LMSs, it is not enough to consider only the technical characteristics of software applications that support the LMS concept, but it is necessary to take into account all the characteristics that determine the quality of these software applications.

The people involved in the evaluation process must assess to what extent the considered LMS meet customer requirements in terms of pricing, functionality, usability in different education systems, opportunities that they offer for evaluating of learning-teaching processes, and to assess whether that software provide appropriate support to the users which will enable them to easily install, use and maintenance the software application.

Due to the complexity, this process must be carried out exclusively by an expert team that will be made by experts from the education field, as well as IT experts, so that all aspects of assessment will be covered in an adequate manner and rational results will be secured. Also, this process requires the application of complex decision-making methods.

As we can conclude from the above, selection of the appropriate LMS is a complex process that requires a multi-aspect estimation, so a rational evaluation and ranking of LMSs requires the application of MCDM techniques.

In literature, there are several proposed approaches to LMSs evaluation, many of them are based on the use of MCDM techniques. Işık, Ince & Yigit [8] proposed Fuzzy Analytic Hierarchy Process (AHP) methodology for the selection of the most appropriate LMS. In the study [9], authors used Analytic Network Process in order to evaluate and recommend the LMS. Radwan, Senousy, Riad & El Din [10] introduced the new expert system for LMS evaluation based on neutrosophic sets. Cavus [11] evaluated the LMS alternatives using an artificial intelligence fuzzy logic algorithm.

Rational assessment of LMSs according to different criteria is possible by using Fuzzy TOPSIS method. This method will enable identification of the alternative, which is closest to the ideal solution, according the obtained closeness coefficient. Also, this approach will provide a more accurate and effective decision support tool. Also by implementation of the fuzzy set theory within the TOPSIS process the problems of vagueness and ambiguity are solved.

**2. METHODOLOGY**

The LMSs evaluation process, in this paper, will be conducted by application of the Fuzzy TOPSIS method. TOPSIS method was first introduced by Hwang & Yoon [12], it is widely used MCDM technique for ranking alternatives that are estimated in the system of different qualitative and quantitative criteria. The TOPSIS method ranks alternatives

according to their distance from ideal solution. Let  $\tilde{X} = [\tilde{x}_{ij}]_{m \times n}$  be the decision matrix of considered problem with  $n$  alternatives  $(A_1, A_2, \dots, A_n)$ , and  $m$  criteria  $(C_1, C_2, \dots, C_m)$ .

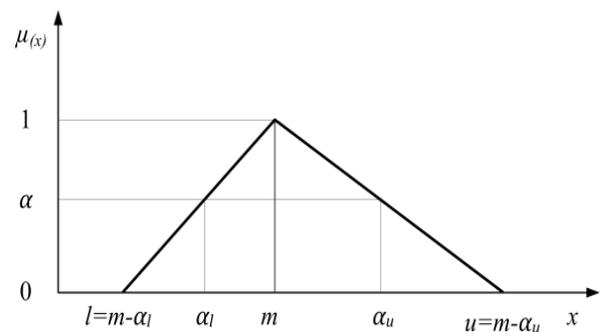
$$\tilde{X} = \begin{matrix} & C_1 & C_2 & \dots & C_m \\ A_1 & \tilde{x}_{11} & \tilde{x}_{12} & \dots & \tilde{x}_{1m} \\ A_2 & \tilde{x}_{21} & \tilde{x}_{22} & \dots & \tilde{x}_{2m} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ A_n & \tilde{x}_{n1} & \tilde{x}_{n2} & \dots & \tilde{x}_{nm} \end{matrix} \quad (1)$$

Where  $\tilde{x}_{ij}$  represents the preferences of the alternative  $A_i$  over the alternative  $A_j$ , estimated by decision makers.

Since decision makers are not capable to accurately express their subjective preferences, these are characterized by uncertainty and ambiguity. In order to handle with vagueness it is proposed the expansion of TOPSIS method by Fuzzy logic, or the application of Fuzzy TOPSIS method [13].

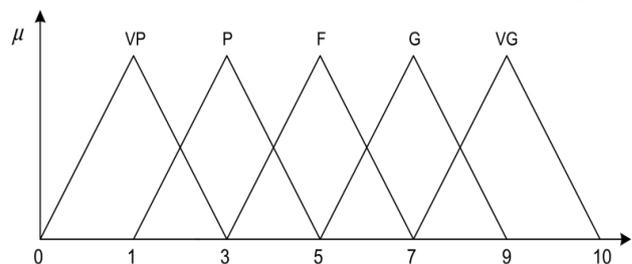
In order to deal with the vagueness of decision makers' subjective preferences, preferential relationships will be expressed by linguistic expressions (Very Poor, Poor, Fair...) that will be further represented by triangular fuzzy numbers  $(x_{ij}^l, x_{ij}^m, x_{ij}^u)$ , where are:  $x_{ij}^l$  - a pessimistic estimate,  $x_{ij}^m$  - a most probable value,  $x_{ij}^u$  - a optimistic estimate (Fig. 1).

The triangular fuzzy number belongs to closed interval  $[0,1]$ .



**Figure 1.** The triangular fuzzy number

Fuzzification of the linguistic expressions will be performed using the most frequently used scale in the literature, which is shown in Table 1 and Fig. 2.



**Figure 2.** Fuzzification of linguistic scale for alternative performance

**Table 1.** Fuzzified scales

Linguistic Scale	Triangular Fuzzy Scale
------------------	------------------------

Very poor (VP)	(0,1,3)
Poor (P)	(1,3,5)
Fair (F)	(3,5,7)
Good (G)	(5,7,9)
Very good (VG)	(7,9,10)

Normalization of the decision matrix ( $\tilde{R} = [\tilde{r}_{ij}]_{m \times n}$ ) will be executed by the transformation:

$$\tilde{r}_{ij} = \left( \frac{x_{ij}^l}{x_{ij}^{u+}}, \frac{x_{ij}^m}{x_{ij}^{u+}}, \frac{x_{ij}^u}{x_{ij}^{u+}} \right) = (r_{ij}^l, r_{ij}^m, r_{ij}^u) \quad (2)$$

Where the  $x_{ij}^{u+}$  is  $\max(x_{ij}^u)$ .

The next step is to obtain a weighted and normalized matrix ( $\tilde{V} = [\tilde{v}_{ij}]_{m \times n}$ ) by multiplying the elements of the normalized matrix ( $\tilde{r}_{ij}$ ) with the criteria weight ( $w_j$ ).

$$\tilde{v}_{ij} = \tilde{r}_{ij} \otimes w_j = (v_{ij}^l, v_{ij}^m, v_{ij}^u) \quad (3)$$

The ideal and negative ideal alternatives are determined as follows:

The positive ideal solution (PIS):

$$A^+ = (v_{ij}^{l+}, v_{ij}^{m+}, v_{ij}^{u+}) \quad (4)$$

The negative ideal solution (NIS):

$$A^- = (v_{ij}^{l-}, v_{ij}^{m-}, v_{ij}^{u-}) \quad (5)$$

The final ranking of alternatives is determined on the base of the relative closeness to the ideal solution:

$$CC_i = \frac{d_i^-}{d_i^+ + d_i^-} \quad (6)$$

Where  $d_i^+$  is distance of the alternative from FPIS.

$$d_i^+ = \sum_{j=1}^n d(\tilde{v}_{ij}, \tilde{v}_j^+), i = 1, 2, \dots, n; j = 1, 2, \dots, m \quad (7)$$

And  $d_i^-$  distance of the alternative from FNIS.

$$d_i^- = \sum_{j=1}^n d(\tilde{v}_{ij}, \tilde{v}_j^-), i = 1, 2, \dots, n; j = 1, 2, \dots, m \quad (8)$$

### 3. THE LMSs EVALUATION BY USING THE FUZZY TOPSIS METHOD

In order to illustrate the possibilities of implementing the proposed MCDM approach to evaluating LMS as an important tool in providing more effective education processes, 7 alternatives (LMS software applications) are generated (Table 2). Those LMS software applications are mostly used in higher education practice, they also correspond in their characteristics to the requirements of educational processes that are realized in our conditions.

**Table 2.** Generated alternatives

Alternative	Producer
Moodle	by Moodle
Geenio	by Geenio
TalentLMS	by Epignosis
Invanto Platform	by Invanto
LearningStone	By LearningStone
EduBrite	by EduBrite Systems
MindScroll LMS	by MindScroll

According to the available information about the alternatives, decision makers, involved in the LMS evaluation process, will assess those alternatives. Evaluation of the alternatives will be performed according to the Fuzzy TOPSIS methodology presented in the previous section.

The generated alternatives will be evaluated in a system of 5 qualitative and quantitative criteria as the key aspects of the quality of the LMS. According to the decision makers' opinions, the following criteria were selected: Functionality, Price, User Support, Usability and Evaluation Tools. By incorporating these criteria into the MCDM process, all aspects relevant to solving the LMSs evaluation problem were considered.

**Functionality:** Software functionality relates to its ability to, through its function, successfully respond to users' requirements. In the context of the LMS software application, this criterion considers whether the software provides the necessary functions and modules for supporting all teaching-learning processes such as: Student Portal, Training Companies, Skills Tracking, Mobile Learning, Asynchronous Learning, Video Conferencing, Skills Tracking, Lesson Plan Management, Test Building, Integration with other systems, Analytics and reporting features, Success Manager.

**Price:** When considering LMS price, should be included: price of license, upgrading price, implementation and training cost, price of optional functions and modules, and the cost of engaging additional hardware potentials.

**User Support:** Producers of LMSs softwares applications offers user support in the form of Community sites, blogs, training programs, consulting, guides for using...

**Usability:** Usability of the LMS software application represents the degree to which the software can be used by specified consumers to fulfill effectively the users' requirements in a quantified context of use.

**Evaluation Tools:** This criterion considers whether the LMS provides support for evaluation processes, such support for multiple types of questions and a variety of test types. Extensive reporting on test results.

In the LMSs evaluation process is involved a decision-making team. The decision-making team includes two education experts and an IT expert. Education experts have the task of assessing the effects of applying of the considered LMS on the quality of learning-teaching processes, while the IT expert is in charge of assessing the technical characteristics of these LMS software applications. This way, all the aspects of the assessment are covered, so the final results will be more rational.

The criteria involved in the decision-making process are of different importance, so first they must be assigned different relative weight. Decision makers are asked to estimate the criteria importance by using language expressions: 'Very poor', 'Poor', 'Fair', 'Good' and 'Very good'. Those

expressions are further fuzzified according to Table 1. By aggregation of the decision makers` opinions, criteria relative weight are obtained. Those results are shown in Table 3.

As we can conclude from the results obtained the most important criterion for this evaluation process is Functionality. This criterion will have the greatest impact on the LMSs softwares selection. Also the smallest feature has the criterion Evaluation Tools, however, this criterion is not insignificant and must be included in the evaluation process.

The relative criteria weight obtained in this step will be further used in the TOPSIS process for construction of the weighted normalized decision matrix.

**Table 3.** The criteria fuzzy relative weight

Criterion	Decision maker 1	Decision maker 1	Decision maker 1	Aggregate value
Functionality	VG	G	G	(5.59, 7.61, 9.32)
Price	P	G	F	(2.47, 4.72, 6.8)
User Support	F	F	G	(3.56, 5.59, 7.61)
Usability	G	F	VG	(4.72, 6.8, 8.57)
Evaluation Tools	F	P	F	(2.08, 4.22, 6,26)

In the same way, the evaluation of the alternatives, according to the considered criteria, was done. Aggregate decision-making matrix for the evaluation of the considered LMSs is given in Table 4.

Creating of the decision matrix in a fuzzy form represents the initial point of the Fuzzy TOPSIS process, which is represented and applied in this paper.

**Table 4.** Fuzzy decision matrix for the LMSs evaluation

	Functionality	Price	User Support	Usability	Evaluation Tools
Moodle	(6.26,8.28,9.65)	(4.22,6.26,8.28)	(4.22,6.26,8.28)	(6.26,8.28,9.65)	(2.92,5.28,7.4)
Geenio	(4.22,6.26,8.28)	(3.56,5.59,7.61)	(6.26,8.28,9.65)	(2.08,4.22,6.26)	(3.56,5.59,7.61)
TalentLMS	(5.59,7.61,9.32)	(5.59,7.61,9.32)	(5.59,7.61,9.32)	(5.28,7.40,8.88)	(5.28,7.40,8.88)
Invanto Platform	(0,1.44,3.56)	(7,9,10)	(2.08,4.22,6.26)	(1.44,3.56,5.59)	(2.47,4.72,6.8)
LearningStone	(2.08,4.22,6.26)	(0,1.44,3.56)	(2.08,4.22,6.26)	(1.44,3.56,5.59)	(4.22,6.26,8.28)
EduBrite	(0,2.47,4.72)	(0,2.08,4.22)	(5.59,7.61,9.32)	(3.56,5.59,7.61)	(3.56,5.59,7.61)
MindScroll LMS	(4.22,6.26,8.28)	(3.56,5.59,7.61)	(4.22,6.26,8.28)	(5.59,7.61,9.32)	(4.72,6.80,8.57)

After that the normalized decision matrix is determined with the help of transformation formula

(2). The normalized decision matrix is presented in Table 5.

**Table 5.** Normalized decision matrix

	Functionality	Price	User support	Usability	Evaluation Tools
Moodle	(0.63,0.83,0.97)	(0.42,0.63,0.83)	(0.42,0.63,0.83)	(0.63,0.83,0.97)	(0.29,0.53,0.74)
Geenio	(0.42,0.63,0.83)	(0.36,0.56,0.76)	(0.63,0.83,0.97)	(0.21,0.42,0.63)	(0.36,0.56,0.76)
TalentLMS	(0.56,0.76,0.93)	(0.56,0.76,0.93)	(0.56,0.76,0.93)	(0.53,0.74,0.89)	(0.53,0.74,0.89)
Invanto Platform	(0,0.14,0.36)	(0.7,0.9,1))	(0.21,0.42,0.63)	(0.14,0.36,0.56)	(0.25,0.47,0.68)
LearningStone	(0.21,0.42,0.63)	(0,0.14,0.36)	(0.21,0.42,0.63)	(0.14,0.36,0.56)	(0.42,0.63,0.83)
EduBrite	(0,0.25,0.47)	(0,0.21,0.42)	(0.56,0.76,0.93)	(0.36,0.56,0.76)	(0.36,0.56,0.76)
MindScrollLMS	(0.42,0.63,0.83)	(0.36,0.56,0.76)	(0.42,0.63,0.83)	(0.56,0.76,0.93)	(0.47,0.68,0.86)

According to the equation (3), the weighted matrix is obtained by multiplying the elements of the normalized matrix shown in Table 5, with the criteria relative weight given in Table 1.

The weighted normalized decision matrix is presented in Table 6.

**Table 6.** Weighted normalized decision matrix

	Functionality	Price	User support	Usability	Evaluation Tools
Moodle	(3.5,6.3,9)	(1.04,2.95,5.63)	(1.5,3.5,6.3)	(2.95,5.63,8.28)	(0.61,2.23,4.63)
Geenio	(2.36,4.76,7.72)	(0.88,2.64,5.18)	(2.23,4.63,7.35)	(0.98,2.87,5.36)	(0.74,2.36,4.76)
TalentLMS	(3.13,5.79,8.69)	(1.38,3.59,6.34)	(1.99,4.26,7.1)	(2.49,5.03,7.61)	(1.1,3.12,5.56)
Invanto Platform	(0,1.1,3.32)	(1.73,4.25,6.8)	(0.74,2.36,4.76)	(0.68,2.42,4.8)	(0.51,1.99,4.26)
LearningStone	(1.16,3.21,5.83)	(0,0.68,2.42)	(0.74,2.36,4.76)	(0.68,2.42,4.8)	(0.88,2.64,5.18)
EduBrite	(0,1.88,4.4)	(0,0.98,2.87)	(1.99,4.26,7.1)	(1.68,3.81,6.53)	(0.74,2.36,4.76)
MindScroll LMS	(2.36,4.76,7.72)	(0.88,2.64,5.18)	(1.5,3.5,6.3)	(2.64,5.18,7.99)	(0.98,2.87,5.36)

The next step implies determining the PIS and the NIS. As  $\tilde{v}_{ij}$  is characterized by triangular fuzzy number  $(v_{ij}^l, v_{ij}^m, v_{ij}^u) \in [0,1]$  the PIS and NIS are determined as:

$$A^+ = (1,1,1) \tag{9}$$

$$A^- = (0,0,0) \tag{10}$$

The distances from the PIS ( $d_i^+$ ) and NIS ( $d_i^-$ ) for each alternative are calculated using formulas (7) and (8). The fuzzy relative closeness ( $CC_i$ ) are also determined, with the help of formula (6).

Those results are presented in Table 7.

**Table 7.** The final range of the alternatives

Alternative	$d_i^+$	$d_i^-$	Relative closeness
Moodle	25.956	23.639	0.477
Geenio	28.496	20.636	0.420
TalentLMS	24.983	24.685	0.497
Invanto Platform	32.927	15.706	0.323
LearningStone	33.476	14.971	0.309
EduBrite	31.922	16.991	0.347
MindScroll LMS	27.069	22.316	0.452

According to non-fuzzy relative closeness coefficient obtained in previous process, the final rang of the considered alternatives are determined. As we can see from conducted TOPSIS process,

alternative Talent LMS is closest to the ideal solution, so that is the alternative with the best performances according to the considered criteria. The final rang is as follow:

**Table 8.** Alternative rank

Alternative	Rank
Moodle	2
Geenio	4
TalentLMS	1
Invanto Platform	6
LearningStone	7
EduBrite	5
MindScroll LMS	3

#### 4. CONCLUSION

The paper theoretical background and practical example indicate to the possibilities of using the MCDM approach, based on Fuzzy TOPSIS methodology, for the evaluation of LMS software applications.

The proposed methodology enables decision makers to identify the alternative which is closest to the ideal solution according to different criteria that are the key aspects of LMS software application quality. On the other hand, using the language expressions represented by triangular fuzzy numbers enables avoiding the problem of decision makers' vagueness in expressing subjective preferences.

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# Possibility of Deploying COSMOS Operating System on Personal Computers

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**Abstract:** *Knowing the concept and way of implementation of the operating systems is one of the most important tasks that computer experts should meet. Therefore, educational versions of operating systems are being designed and implemented. The development of such operating systems provides the opportunity for interested parties to become familiar with the possibilities of using various software tools for their realization. An example of such educational operating system is a set of program modules known as COSMOS. Modules are written in C# programming language and Visual Studio development environment is used for their translation and integration into a unique system.*

**Keywords:** *Operating systems; education; development environment; programming languages*

## 1. INTRODUCTION

The majority of computer users are familiar with only a few operating systems. For desktop computers, these are mostly MS Windows, Linux, and Mac OS [1]. On the other hand, in mobile devices, such as smart phones and tablets, Android, iOS, and Windows Mobile operating systems are primarily used [2], [3], [4]. However, this does not diminish efforts in which researchers are trying to come up with new operating system solutions. Particular emphasis should be placed on research in which operating systems are developed for educational purposes [5].

The operating system as the fundamental computer subsystem represents an important factor in the education of every computer expert. Therefore, it is necessary for students of Computer Science to learn about the functions of operating systems and the ways of their realization. A number of systems has been developed for this need. Some of them have the form of a simulator, while others can function as real operating systems. The main goal of such systems is to bring together students and everyone who wants to approach the principles of operation of the operating systems, their installation, and use in real terms. In practice, most operating systems for educational purposes are based on UNIX and its variant for microcomputers, the Linux operating system. Accordingly, there is a number of UNIX/Linux [6] distributions in practice, and the most common are MAX, MINIX/MINIX 3 [7], EdUbuntu, UberStudent Linux, SkoleLinux, EduLinux, and others.

A typical example of this system is COSMOS (C# Open Source Managed Operating System) operating system [8]. Since it is an open source program system, as well as integrated into Microsoft Visual Studio development environment, it provides great opportunities in learning about the implemented modules as well as in upgrading them. The aim of this paper is to reveal the possibilities of COSMOS operating system, as an educational tool, but also as a basis for developing a standalone operating system.

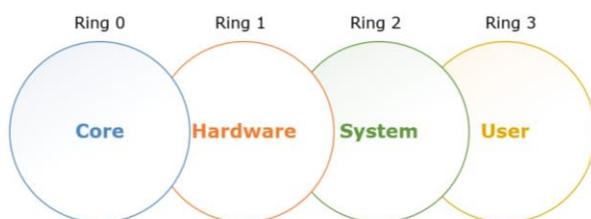
## 2. WHAT IS COSMOS OPERATING SYSTEM?

COSMOS is not a complete operating system, but a set of development modules that can form a new operating system. The development environment of this operating system is Microsoft Visual Studio. Basic COSMOS routines are mostly written in C# programming language. A minor part of the code is written using the assembly language X#. This programming language has been developed by Microsoft to make the development of COSMOS operating system easier. However, any programming language included in Visual Studio or .NET development environment can be used to further upgrade the COSMOS operating system.

Integration into Microsoft Visual Studio makes COSMOS significantly different from similar operating systems. As a result, the further development of the COSMOS operating system can be fully realized through Visual Studio. It is especially important that direct execution can be realized within Visual Studio. COSMOS is executed in a virtual environment that speeds up the development and testing of the operating system.

The basic virtual environment represents VMWare for ease of integration into the development project. In addition, other virtual environments, such as Bochs and VirtualPC, can be used. It is important to note that in addition to starting the operating system via a USB and a CD-ROM drive, booting can also be accomplished from a remote computer over the network, using the PXE (Preboot Execution Environment) technology [9].

COSMOS operating system has rings as its security feature [10]. There are four rings that differentiate areas of operation for adequate users. They prevent code in one ring from accessing fields in nonadjacent rings. The ring system in COSMOS operating system is represented in Fig. 1.



**Figure 1.** Ring system in COSMOS operating system

The bootloader that COSMOS is using is Syslinux [11]. It is used to boot COSMOS code in BIOS, and once it is done, the bootloader is removed from the memory. The filesystem COSMOS is using is FAT, but its implementation is still in progress.

Although COSMOS is using Visual Studio and .NET as its development environment, it cannot use their libraries. In order to run COSMOS on real hardware, all function calls that would normally use Windows API have to be replaced with COSMOS proprietary code. These codes are called plugs and they represent sections of code that hide assembly code running under the hood. They are C# class wrappers around assembly kernel handling code, but they can also be programmed in assembly or X#.

COSMOS appears in two types of distributions, DevKit and UserKit. DevKit is a version of the operating system developed directly by the COSMOS project team. Although DevKit contains the latest and most important features, there is a number of problems. However, there may be problems with the development of the operating system, and even the inability to start it up. On the other hand, UserKit is a stable version of COSMOS ready for installation. UserKit does not follow the development of DevKit because it is updated periodically. However, using UserKit is a great way to get acquainted with COSMOS operating system and its basic functionalities and modules.

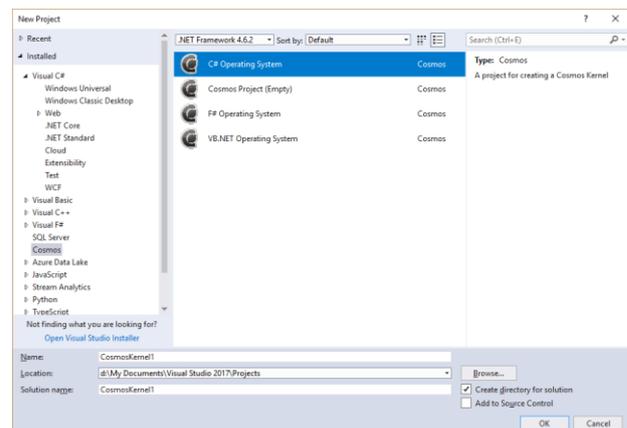
### 3. PROCEDURE FOR DEPLOYING COSMOS OPERATING SYSTEM

Due to the integration of the COSMOS operating system in MS Visual Studio, it is necessary that this development environment be installed. According to the official COSMOS Website, it is necessary to use MS Visual Studio 2017 together with .NET Core Tools and .NET Framework 4.6.2 Developer Pack [12]. This means that older versions of development tools do not support working with COSMOS Operating System.

The program code of COSMOS operating system, either the version downloaded from the official Website or the updated version, is translated using the .NET translator. During the translation, the source code is being translated into the Common Intermediate Language (CIL), native language of the .NET Framework. For translating .NET CIL into machine language, a translator of IL2CPU (Intermediate Language to CPU) was developed within the COSMOS project [13].

Within the Cosmos Builder application, the designer chooses an option that determines how the project will finally be made. Among other things, these options define the way the project is launched. The launching features are Quick Emulator (QEMU), Virtual PC, and VMWare.

After installation of the UserKit, Visual Studio 2017 is updated with Cosmos section. From there, the user can choose one of the four available options for creating COSMOS operating system in C#, F#, or VB.NET programming language (Fig. 2).

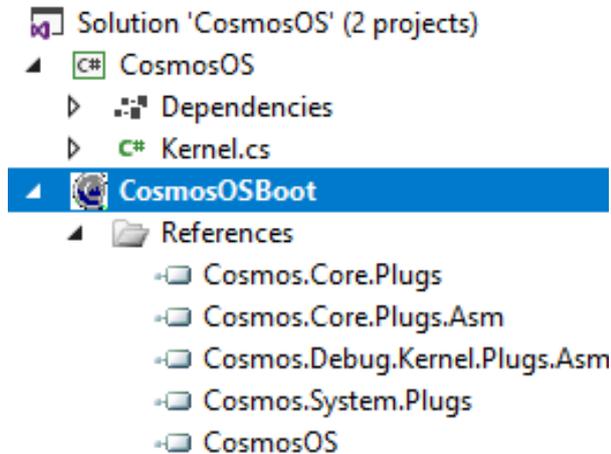


**Figure 2.** Visual Studio options for creation of new COSMOS operating system

We used C# as our programming language of choice. After naming the project, the user is presented with basic operating system with the functionality of getting input from the user and echoing it back.

The Fig. 3 shows the composition of the COSMOS OS Visual Studio solution. It is consisted of two projects, C# project with **Kernel.cs** main source file, and **CosmosBoot** project, referencing the

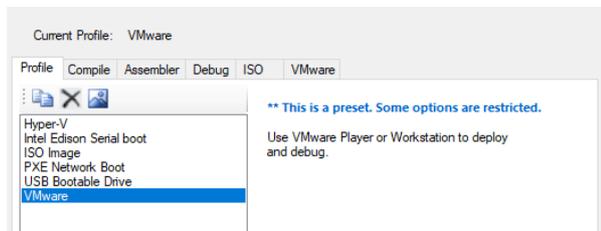
underlying core functionalities and user's C# project.



**Figure 3.** COSMOS OS Visual Studio solution constitution

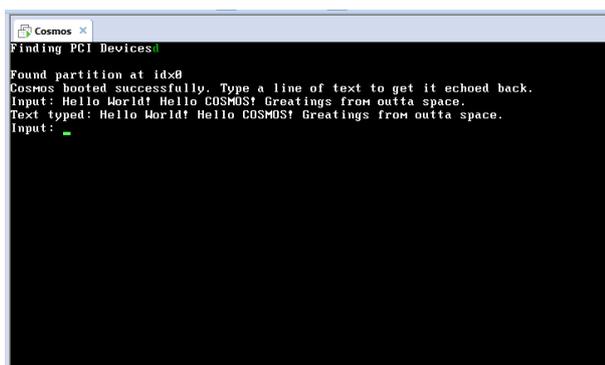
The main class is called **Kernel** and it inherits the **Sys.Kernel** class of **Cosmos.System** namespace. Two methods have to be overridden: **BeforeRun()**, that executes before booting up the operating system and **Run()**, that actually holds the key part of the operating system.

Deployment options for COSMOS operating system are given in Fig. 4. These are Hyper-V, Intel Edison Serial boot, ISO image, PXE Network Boot, USB Bootable Drive, and VMware. In our case, we used VMware, with option to deploy to VMware Player or Workstation edition. This is the easiest way for ongoing development and debugging.



**Figure 4.** Deployment profiles for COSMOS operating system

The solution is executed in debug mode and since VMware is our deployment option, a new virtual machine is created and COSMOS is booted (Fig. 5).



**Figure 5.** Output from simple COSMOS operating system

Default virtual machine options are as follows:

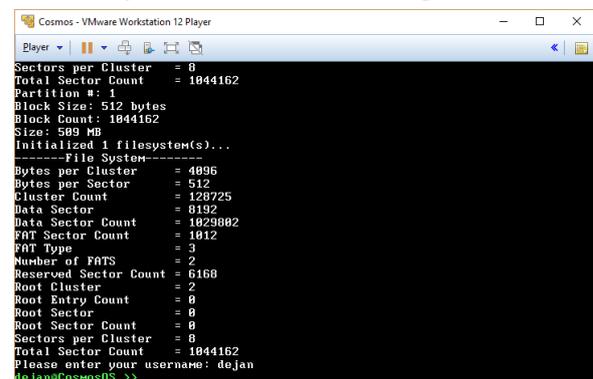
- Memory size: 256 MB
- Number of processors: 1
- Hard disk size: 512 MB
- CD/DVD: Using file ./CosmosOSBoot.iso.

Going beyond basic functionalities of COSMOS operating system is relatively difficult, since it requires writing separate modules for handling access to different rings. At the User ring, the program code can access only areas of User and System ring. Furthermore, usage of .NET methods is restricted to only few namespaces, and beyond that, the plugs have to be made.

We realized a simple command-line operating system with only four commands:

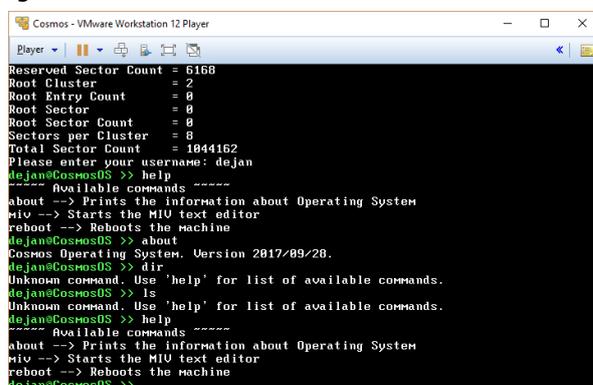
- **help**: shows the available commands
- **about**: prints the operating system UserKit version
- **reboot**: reboots the machine
- **miv**: enters MIV file editor [14].

In the **BeforeRun()** method, a file system is initialized and user is asked to enter his username. From now on, the system displays **{username}@CosmosOS >>** command prompt, where **{username}** is replaced with actual username provided, as shown in Fig. 6.



**Figure 6.** Welcome screen of COSMOS OS

An example of available commands is shown in Fig. 7.



**Figure 7.** An example of available commands

The most interesting part about realized operating system is its ability to use file system, create,

edit, and display content of text files. Usage of MIV text editor is shown in Fig. 8.

```

Cosmos - VMware Workstation 12 Player
Player
MIV - Minimalistic Vi
version 1.2
by Denis Bartashevich
Minor additions by CaveSponge
MIV is open source and freely distributable

type :help<Enter>    for information
type :q<Enter>      to exit
type :wq<Enter>     save to file and exit
press i             to write

Enter file's filename to open:
If the specified file does not exist, it will be created.

```

**Figure 8.** Welcome screen of MIV text editor

MIV text editor is accepting the following commands:

- **help**: display information
- **q**: exit text editor
- **wq**: save content to file and exit text editor
- **i**: write to file.

#### 4. CONCLUSION

Operating systems have passed a long way from batch processing, single-user, single-task command-line interface to multi-user, and multi-task graphical user interface with service-oriented realization. The knowledge of their principles of operation and realization is one of the fundamental part of the Computer Science students' education.

Modern operating systems that are most commonly used are either non open-source or too complex for research and teaching the principles of operating systems. Thus, the educational operating systems provide students with relatively easy way of getting to know their implementation and fundamental operation modes.

COSMOS operating system, presented in this paper, belongs to such group of educational operating system. It is complex enough to provide different access privileges through its system of rings and plugs, but on the other hand, relatively easy to implement some basic ideas and principles. In this paper, we developed a simple command-line operating system with few commands and file system functionality. Its connection with C# programming language and Visual Studio development environment facilitates its realization among students and other hobbyists that are used to Visual Studio development.

It should be noted that there are several successful implementations of COSMOS operating systems [15], some of which are with graphical user interface and large number of functionalities that can be found in modern day operating systems.

#### ACKNOWLEDGEMENTS

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# A Mathematical Learning Environment Based on Serbian Language Resources

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**Abstract:** *In recent years, in line with ever growing usage of Information technology, the learning environments are changing. The amount of available learning materials in various forms has increased. These new environments demand comprehensive learning systems, which enable management of the learning corpus with special attention paid to relevant lexical resources. In this paper we present the concept of a Mathematical Learning Environment in Serbian (MLES), which is based on a corpus of mathematical materials and various lexical resources, enabling semantic search of mathematical content. A specific use of the system is mathematical support in solving real life problems from engineering practice. To that end complex issues had to be resolved, such as mathematical text analysis, processing of mathematical content in different formats, search of mathematical materials, indexing of mathematical content using Serbian lexical resources, issues that are further complicated due to rich Serbian morphology. This paper outlines the structure and solutions for MLES, as well as the main features of its already developed components.*

**Keywords:** *mathematical content; text processing; mathematical formulae*

## 1. INTRODUCTION

Rapid development of information technology, resulting in a growing number and availability of learning materials, had a strong impact on changes in learning environments. New learning environments are needed, requiring appropriate technology to facilitate access to and management of learning materials in specific domains. Bearing this in mind, development of a Mathematical Learning Environment in Serbian (MLES) has been initiated. MLES is intended as a learning environment with the main goal of processing mathematical content in Serbian. The environment built around a corpus of mathematical content and provides mechanisms for processing and search of this content. It relies on existing lexical resources, morphological e-dictionaries and WordNet of Serbian, which have been developed within the University of Belgrade Human Language Technology group for several decades [1], as well as a newly developed glossary, Termini. The system is aimed at providing for enrichment of these resources with terms from the mathematical vocabulary, as well as offering support in understanding and solving some real life problems based on mathematical concepts. Source data for MLES corpus can vary considerably, as mathematical materials in Serbian are available in different formats, alphabets and dialects. Besides coping with different ways of writing mathematical

formulae, one of the main challenges in obtaining a searchable format of these materials is the conversion of source files, given specific Serbian letters.

MLES provides a semantic search engine, which allows for processing of various formats of user requests, effective matching and relevance ranking, and features a user friendly interface. There are also possibilities of linking to BAEKTEL - an Open Educational Resources (OER) platform under edX [2], as well as relevant educational courses under a Moodle platform [3] [4].

There are several projects reported which are similar to MLES. Three interesting systems are presented in [5],[6]. MMT is a system that includes the theory graphs as the modular representation paradigm for mathematical knowledge. MathHub.info is an archive system for encoded knowledge and MathWebSearch is an example of a search engine enabling the search of mathematical formulae on the Web. The engine harvests the web for content representation of formulae and indexes them with substitution tree indexing. MathWebSearch can process only materials based on MathML and OpenMath. The project Digital Library of Mathematical Functions presents a comprehensive search mechanism for a specific corpus [7]. The corpus is based on a digitalized handbook, which contains primarily mathematical formulae, graphs, methods of computation,

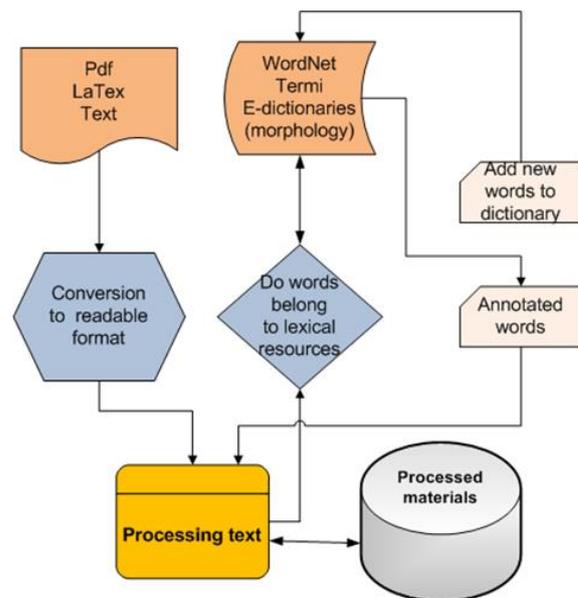
references, and links to software. The search offers feedback with appropriate concordances. Mathematical formulae are converted to LaTeX and then indexed. User requests are also converted to LaTeX, and the search proceeds as with ordinary text. Another relevant project is MathGo! that provides search and presentation of mathematical encoded text [8]. The software solution is based on the concepts of math block identification and vector representation, with special attention paid to the search of mathematical topics using clusters and relevance ranking. The system provides ranked listing of results, through a user friendly interface, which allows seamless interaction with users through a simple query mechanism. EgoMath is yet another software solution, which allows semantic search of mathematical content [9]. It supports indexing and search of mathematical content on the web using a full text search engine. To that end the solution uses linearization, transformation rules, generalization rules and ordering algorithm, which simplify the complex and highly symbolic mathematical structures into linear structures with well-defined symbols.

This type of support for Serbian is still not available. Existing Serbian lexical resources and tools enable efficient text search, including semantic and morphological expansion of user queries, the latter being very important in highly inflective languages, such as Serbian. Of special importance is LeXimir, a tool developed within this group that greatly enhances the potential of manipulating each particular lexical resource as well as several resources simultaneously [10]. Although the resources and tools have already been successfully used for a number of various language processing related tasks including query expansion, they need further improvement for management, named entity recognition, terminology extraction, and document indexing of mathematical content.

In the next section we give an overview of the MLES system, followed by a section outlining the main issues to be solved in its development. Section Four describes corpus processing results in MLES in more detail, while section Five offers the main features of the newly developed terminological resource, Termi. The paper ends with some concluding remarks.

**2. FLOW CONTROL**

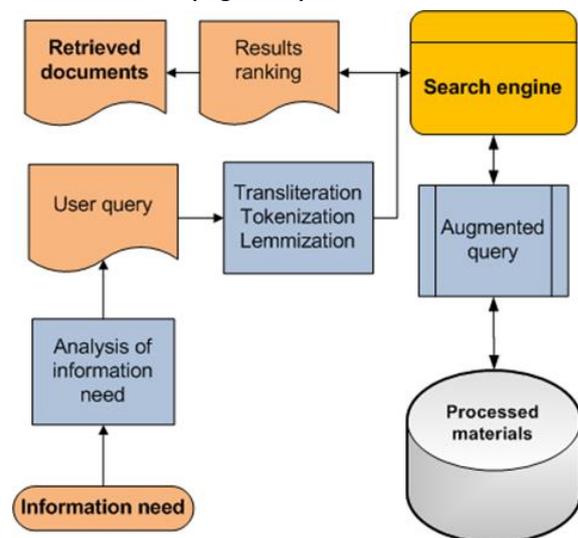
The architecture of the MLES system is based on three main components. The first component is dedicated to corpus processing and alignment with existing lexical resources. (Figure 1).



**Figure 1.** Structure of corpus processing

The obtained results are processed text, augmented dictionaries and annotated content. In this component a special challenge to corpus processing results from the use of two alphabets: Latin and Cyrillic, with different coding schemas and formats of source texts, as well as from various ways of expressing mathematical content. In order to resolve the problem of two alphabets, the entire corpus is transliterated into Latin alphabet. As for the various expression of formulas, mathematical content is converted to LaTeX, which allows for expression of mathematical formulae in text only format.

The second component handles user queries, semantic search, search expansion and ranking of results. This component proceeds in several phases, such as transliteration, tokenization and lemmatization of user queries, semantic search, query expansion, expanded search and ranked retrieval results (Figure 2).



**Figure 2.** Analysis of user query and semantic search

The third component handles application to real life problems from engineering practice based on mathematical concepts (Figure 3). Results of the third component are annotated and linked texts, where every mathematical term in the text is linked to the appropriate dictionary entry or relevant corpus content related to that term.

This system component also extracts mathematical concepts from problems related to engineering practice. The process is based on clustering, categorizing and defining mathematical concepts from the base of relevant engineering problems.

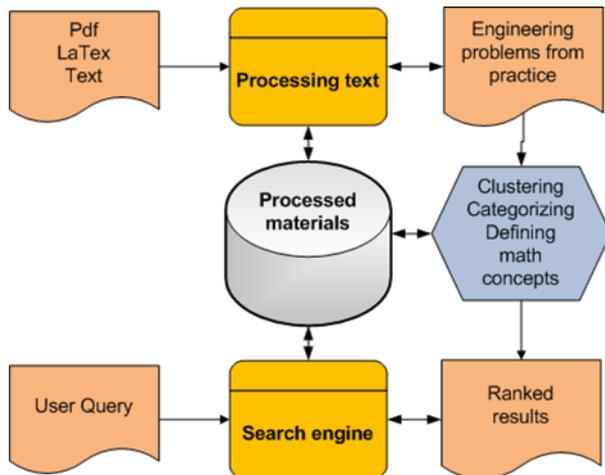


Figure 3. MLES application

### 3. GOALS AND CHALLENGES

Searching and processing mathematical materials is a complex problem. Standard text processors cannot recognize mathematical texts in a proper way. There is thus a need for developing new and adapting existing processors for that purpose. Processing of mathematical content requires the translation of source content into some searchable format such as MathML or LaTeX, as a precondition for search with a search engine. MathML is the mathematical markup language, which has the aim to integrate mathematical formulae into web pages and documents, while LaTeX notation is more in use among mathematicians in offline conditions. The idea of MLES is to convert all source materials from corpus to LaTeX format, where mathematical formulae will be presented as strings, which will facilitate processing and search of mathematical content.

One of the most important parts in processing mathematical content is semantic search of mathematical formulae. According to [5], [6] there are several challenges in searching and processing mathematical formulae, the main problem being different notation depending on the context. For instance there can exist different expressions for the same mathematical content, with the same meaning such as:

$$\frac{1}{x} = 1/x = 1/x = x^{-1}$$

On the other hand, an expression can represent different content depending on the context, such as the number  $\varpi$  (Pi), which can present the transcendent number  $\text{Pi} = 3,14159\ 26535\ 89793\dots$  or radian measure of angle. Such challenges are addressed by augmented annotation and search. During the processing of mathematical formulae, augmented annotation can be realized, which can cover different expressions of the same formula.

### 4. CORPUS PROCESSING RESULTS

Mathematical terminology in Serbian is unsatisfactorily represented in terminological resources. Thus for example, in the Dictionary of the Serbian Academy of Sciences and Arts, out of 200,000 dictionary entries only 369 are marked as belonging to the Mathematics domain. One of the aims of MLES is to contribute to a better representation of mathematical concepts in terminological resources.

The initial MLES corpus was produced from 243 PhD theses, 15 textbooks in various areas of Mathematics as well as 212 lecture notes. Special attention was paid to the validity of content.

For the purposes of lexical processing the entire corpus is converted to textual format. As the documents were in different alphabets and encodings, as well as in different formats, a tool was created for preprocessing and normalization of texts into the Latin alphabet. In textual format the corpus contains 1,802,519 simple forms of which 118,027 are different.

Existing Serbian morphological e-dictionaries of simple forms (DELAS) and inflected forms (DELAF) contain 135,000 lemmas [11], among which only 65 are marked as belonging to the mathematical domain. There are, however, more concepts from this domain, albeit without the corresponding semantic markers. One of the tasks of MLES is to enable that these markers are added.

Processing of the MLES corpus detected 5,111 unrecognized forms with a frequency greater than 1. Among them about 1,000 grammatically correct forms were identified, and on the basis of these forms 385 basic canonical forms or lemmas were produced, using the procedure described in (Krstev 2015). Among them 191 attributes (A), 174 nouns (N), and 7 verbs (V), such as the noun "ekstremum" (extreme value), represented in the DELAS dictionary of simple forms as ekstremum, N1+DOM=Math+FLX=N1 or the verb "faktorisati" (to factorize) represented in the same dictionary as faktorisati, V21+DOM=Math+FLX=V21. Some of the inflected forms of the noun esktrimum in the DELAF dictionary are:

```

ekstremuma,ekstremum.N:mw4q
ekstremumu,ekstremum.N:ms7q
ekstremumom,ekstremum.N:ms6q
  
```

A large number of terms in mathematics, as in other domains, are multiword expressions (MWE). Thus a procedure described in [12] has been used for semi-automatic extraction of MWEs on basis of lexical resources and local grammars developed for Serbian. Special attention is given to automatic inflectional class prediction for simple adjectives and nouns and the use of syntactic graphs for extraction of MWE candidates for termbases, their lemmatization and assignment of inflectional classes.

There were 2,900 MWE candidates extracted with a frequency over 5, covering 46,000 different forms. An example of a MWE is "diferencijalno-algebarska jednačina" (differential-algebraic equation), represented in the DELAC dictionary of compounds with the lemma:

diferencijalno-algebarska (algebarski.A2:aefs1g)  
jednačina (jednačina.N600:fs1q),  
NC\_2XAXN+SIN=2XAXN(sin)

This lemma provides for recognition of the inflected forms of this compound in the corpus, such as "diferencijalno-algebarske jednačine" or "diferencijalno-algebarskih jednačina", as well as all other forms generated by the transducer (local grammar) NC\_2XAXN.

Evaluation and filtering of all terms is underway, in order to generate candidate MWEs to be entered into the morphological dictionary.

Serbian WordNet (SWN) currently has 21,476 synsets [13], out of them that 232 in mathematics domain, while the Princeton WordNet has 607 in this domain, which means that at least another 375 synsets need to be added to SrpWN, such as:

ENG3013860281nimplication:4,

logicalimplication:1,

conditional relation:

ENG30-13859307-n difference:4.

The enrichment of morphological dictionaries and SWN should be complemented by content synchronization (entries and literals), as well as domain markers. In the existing dictionary only the marker +Math exists for Mathematics, but adding domain markers for specific mathematic subdomains, such as Algebra or Geometry is also planned. In addition to that, semantic markers will be developed for special functions, integrals, equations and the like.

For corpus management, we have used the IMS Open Corpus Workbench (CWB) as a collection of open-source tools [14] and an adaptation of CQPweb, a web-based graphical user interface designed specifically for CWB query processor - CQP [15]. CWB is suitable for encoding, indexing, compression and decoding large text corpora (up to 2 billion words) with multiple layers of word-level annotation. CQP is a powerful and efficient concordance system which can process query

patterns specified both at the character level (specifying a form of an individual word or an annotation) and at the token level (specifying syntactic relationships between tokens). Through CQP web users can both specify query patterns and get statistical information about corpus.

Within preparation of the MLES corpus to each word within the corpus the following information is assigned, in the following order:

- Word type (noun, verb, adjective, etc.) - POS tagging
- Lemma (nominative singular for a noun, infinitive for the verb, etc.) - lemmatization
- Values of inflective categories (gender, number, case, verb form, etc.), that is, inflective base and suffixes - grammatical annotation
- Marker for the semantic value - semantic annotation.

The advantages of corpus annotation are the following:

- Corpus search becomes more efficient due to the possibility of formulating more precise queries.
- When search results are concerned, annotation.
- Compensates for the information lost during corpus preparation (removed figures, tables, footnotes, etc.), as well as information that lack due to insufficiently wide context in which the search results are presented.

Annotation also alleviates the statistical analysis of the corpus, namely automatic assignment of the distribution of annotated linguistic properties.

## 5. APPLICATION TERMI

The Termi application has recently been launched to serve as a support for the development of terminological dictionaries in various fields. In MLES it is used for development of mathematical vocabulary. The realization of the application was based on the ASP.NET Framework for C# programming language and MVC design pattern, as well as HTML and JavaScript, whereas SQL Server served as support for the database.

The application is located at <http://termi.rgf.bg.ac.rs/> and consists of 5 specific units: browse, search, update, bibliography and profiles. Termi currently supports the processing and presentation of terms in Serbian and English, but support for other languages is also planned.

УНИВЕРЗИТЕТ У БЕОГРАДУ  
РУДАРСКО - ГЕОЛОШКИ ФАКУЛТЕТ

Аžурiranje SRPSKI

terminološki rečnik  
bibliotekarstvo  
geoinformatika  
inženjerstvo nafte i gasa  
jezički resursi i tehnologije  
matematika  
algebra  
analiza  
granična vrednost niza  
**Tejlorova formula**  
aritmetika  
geometrija  
Novi čvor  
Novi čvor2  
obrazovanje  
računarstvo i informatika  
rudarsko inženjerstvo  
statistika  
zaštita životne sredine

Status: Zaključan

Naziv: Tejlorova formula

Sinonimi: forma Tejlor, tejlorova formula u Šiemilih-Rošovom ostatku

Skracenica: Tejlorova f.

Opis: Neka funkcija  $f(x)$ , neprekidna sa svim svojim izvodima do  $n$ -og reda, zaključno u nekoj okolini  $U$  tačke  $c$ , ima izvod  $f^{(n+1)}$ -og reda u toj okolini. Ako je  $x \in U$  i  $p \in \mathbb{N}$ , onda važi formula:  

$$f(x) = f(c) + \frac{f'(c)}{1!}(x-c) + \frac{f''(c)}{2!}(x-c)^2 + \dots + \frac{f^{(n)}(c)}{n!}(x-c)^n + R_n(x)$$

$$R_n(x) = \frac{f^{(n+1)}(\xi)}{(n+1)!} (x-c)^{n+1}$$
 Neka funkcija  $f(x)$ , neprekidna sa svim svojim izvodima do  $n$ -og reda, zaključno u nekoj okolini  $U$  tačke  $c$ , ima izvod  $(n+1)$ -og reda u toj okolini. Ako je  $x \in U$  i  $p \in \mathbb{N}$ , onda važi formula:  

$$f(x) = f(c) + \frac{f'(c)}{1!}(x-c) + \frac{f''(c)}{2!}(x-c)^2 + \dots + \frac{f^{(n)}(c)}{n!}(x-c)^n + R_n(x)$$

$$R_n(x) = \frac{f^{(n+1)}(\xi)}{(n+1)!} (x-c)^{n+1}$$
 za svako  $\xi$  koje je između  $c$  i  $x$ . Prikazana formula se naziva Tejlorovom formulom u Šiemilih-Rošovom ostatku.

Figure 4. Display of mathematical content through Termi editor

On the Browse page all terms verified by editors can be viewed. The page is visible to all users regardless of whether they are logged in or not. On the left side of the page a hierarchical display of the vocabulary terms is available. Besides its name, each term has its synonyms, abbreviations, description and bibliography. In case that the description of a term contains a Latex fragment, the fragment will be interpreted, which helps in the presentation of mathematical formulae (Figure 4).

As for the Search page, it is meant for the search of terms, both in Serbian and English. This page is also intended both for users that are logged-in and those that are not.

The Update page is the most complex page in the application. This page can be accessed only by registered users, who can add, modify and delete terms both in Serbian and English. Thus, there is a possibility of updating terms either only in Serbian, or only in the English, or simultaneously in both languages. Term modification implies changes of the very properties of the term (name, abbreviation, synonyms and description) as well as modification of external connections of the term with the existing bibliography. Two more options are available on the Update page, namely spell check for the languages in which terms are entered, and the possibility that, depending on user needs, the term description is interpreted as a Latex document. On this page, akin to Browse page, on the left side of the screen a hierarchical view of the terms is available.

However, unlike the browse page, at the Update page all terms are visible, and not only terms that have been verified. In addition to update, this page offers the options of exporting data to Excel or TBX files [16]. A detail of such an export of a term is depicted in Figure 5. The Bibliography page contains a list of all bibliography units. Besides reviewing the bibliography, adding, modifying and deleting bibliography is also possible on this page.

As for the profiles, it is important to note that all logged users are divided into 4 roles: reader, editor, reviewer and administrator. The reader is a user who only has right to read, which is a role that is by default assigned to every user at registration. Editor and reviewer are users who have the task to update the contents of the dictionary, with the difference that in the hierarchy the reviewer is at a higher level. Reviewer is a user who has the exclusive right to initiate term verification (this is the advantage of reviewers in relation to the editors). As in most applications the administrator is the user who has all rights within the application. Finally, it should be noted that as a precaution logical deletion is performed not physical, while all changes are stored in a separate table. Naturally, only the administrator has the right for physical deletion.

```

<termEntry id="c110740">
  <langSet xml:lang="sr">
    <ntig>
      <termGrp>
        <term>Tejlorova formula</term>
        <termNote type="termType">entryTerm</termNote>
      </termGrp>
      <descripGrp>
        <descrip type="definition">Neka funkcija  $f(x)$ , neprekidna sa svim svojim izvodima do
         $f^{(n)}$ -og reda, zaključno u nekoj okolini  $U$  tačke  $c$ , ima izvod  $f^{(n+1)}$ -og reda u toj
        okolini. Ako je  $x \in U$  i  $p \in \mathbb{N}$ , onda važi formula:  $f(x) = f(c) +$ 

$$\frac{f'(c)}{1!}(x-c) + \frac{f''(c)}{2!}(x-c)^2 + \dots + \frac{f^{(n)}(c)}{n!}(x-c)^n + R_n(x),$$


$$R_n(x) = \frac{f^{(n+1)}(\xi)}{(n+1)!}(x-c)^{n+1},$$

        gde je  $\xi$  između  $c$  i  $x$ . Prikazana formula se naziva Tejlorovom formulom u
        Šlemilih-Rošovom ostatku.</descrip>
      </descripGrp>
    </ntig>
  </langSet>
  <langSet xml:lang="en">
    <ntig>
      <termGrp>
        <term>Taylor's formula</term>
        <termNote type="termType">entryTerm</termNote>
      </termGrp>
      <descripGrp>
        <descrip type="definition">Let  $f(x)$ , and its first  $n$  derivatives be continuous, and let
         $f^{(n+1)}(x)$  exist on the region  $U$  of point  $c$ . If  $x \in U$  and  $p \in \mathbb{N}$ ,
        then:  $f(x) = f(c) +$ 

$$\frac{f'(c)}{1!}(x-c) +$$


$$\frac{f''(c)}{2!}(x-c)^2 + \dots + \frac{f^{(n)}(c)}{n!}(x-c)^n + R_n(x),$$


$$R_n(x) = \frac{f^{(n+1)}(\xi)}{(n+1)!}(x-c)^{n+1},$$

        where  $\xi$  is between  $c$  and  $x$ . Hence this formula is named Taylor's formula in Scholmic-Roche residuum.</descrip>
      </descripGrp>
    </ntig>
  </langSet>
</termEntry>

```

Figure 5. Detail of the TBX for one term

## 6. CONCLUSION

In this paper the concept of MLES, which can be a purposeful learning environment at different levels of education in Serbian, is given. The salient feature of the system is strong lexical support. Within MLES various types of lexical resources are used as well as local grammars, with the aim to provide a comprehensive and searchable learning environment. Although the general lexica in Serbian is well covered, mathematical terminology needs further improvements. MLES presents a system that supports managing and usage of mathematical content in Serbian. The ultimate goal is the integration of real life problems from engineering practice in the system. Special attention is paid on the processing of mathematical content by usage of different tools which are still under development. The concept has several advantages such as: comprehensive learning environment, development of search engines which are suitable for mathematical content, processing of mathematical content and augmentation of term base of mathematical concepts. To that end a newly developed application Termini is used, as it represents a suitable dictionary for mathematical terms.

Further plans will tackle additional integration, development and testing of lexical tools and engines in MLES. Detailed evaluation of the entire system is planned, which will provide directions for further improvement of MLES.

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# **Session 3: Engineering Education and Practice**

**Notes:**

# Financial Literacy of Engineering Students - Waiting for PISA 2018 Results in Serbia

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**Abstract:** *Financial literacy is one of the necessary skills for all professionals in 21<sup>st</sup> century. Engineering students who are finishing their undergraduate studies are expected to be the leaders of development of every country, so it is important to investigate their level of financial literacy. The main goal of this research is to examine financial literacy of university students at engineering study programs using PISA methodology. The sample consisted of 71 engineering students of Faculty of technical sciences in Čačak, Serbia. The questionnaire consisted of examples of PISA financial literacy assessment questions described in detail in PISA 2015 Results; it consisted of 11 tasks, measuring five proficiency levels of financial literacy. The results show that majority of engineering students perform at Level 4 of financial literacy. Regarding the content of financial literacy the results suggest that money and transactions as well as planning and managing finances are the content categories that are more familiar to engineering students, while risk and reward and financial landscape are more challenging to them. Limitations and further educational implications of this research are discussed.*

**Keywords:** *Financial literacy; engineering students; PISA research.*

## 1. FINANCIAL LITERACY

### 1.1. Financial literacy as an essential skill for 21<sup>ST</sup> century

Financial literacy is not a skill owned by economists, accountants, financial managers only, but necessary for all professionals in order to make good financial decisions, in personal and business life also. Alongside the specific skills and key competencies of each profession, the importance of financial literacy is increasing all the time [1].

Living in 21<sup>st</sup> century, in which we meet new technologies and financial instruments every day, means that each individual, since early age has sufficiently developed competencies for using it. Many young people are already consumers of financial services; individuals make financial decisions for themselves at all ages: from children deciding how to spend their pocket money to teenagers entering the world of work, from young adults purchasing their first home to older adults managing their retirement savings. Globalization and digital technologies have made financial services and products more widely accessible and at the same time more challenging. As financial markets continue to evolve, individuals are faced with a wide variety of products, many of which are not easy to understand. Decisions made and outcomes experienced are not important only at the household level, but also for the economy as a whole [2, 3].

Financial literacy was the subject studied around the world by governments, financial entities and academic studies [4]. The first studies measuring

financial literacy came out more than a decade ago [5], and the results revealed lack of financial knowledge worldwide. Since then numerous studies were done, but the results shows that little has changed.

### 1.2. Financial literacy in education

Financial literacy training can arm individuals with the financial knowledge necessary to create household budgets, initiate savings plans, manage debt, make strategic investment decisions for their retirement or their children's education and maintain financial security through tax and insurance planning [6].

Youth faces very early with significant financial challenges, responsibilities and decision and that is why financial education has become necessary for successful functioning. Education has a vital role to play in developing the knowledge, skills, attitudes and values that enable people to contribute to and benefit from an inclusive and sustainable future. Education needs to aim to do more than prepare young people for the world of work; it needs to equip students with the skills they need to become active, responsible and engaged citizens [7]. Financial literacy should be recognized as a skill essential for participation in today's economy [8, 9]. Many studies found that financial education has significant positive impact on financial literacy [10, 11, 12]. Providing financial education for children and youth is an important component in the transition from childhood to adulthood and the development of financially responsible citizens [13, 9]. Introducing financial literacy in schools' programs will create good financial habits at an

early age and likely bring benefits to schooling, employment, and standards of living throughout adulthood [4].

Individuals who have participated in a financial education class or program - provided in high school or college, in the workplace, or by a community organization - had higher financial literacy than those who have not received financial education [2, 20].

Many governments are aware and agree that in order to reach financial stability within their countries; they should raise the financial literacy level of their citizens [3]. There are numerous initiatives in the world created with the goal to improve financial literacy, because research showed that even the most developed countries in the world have low level of financial literacy [16].

Global Financial Literacy Excellence Center (GFLEC), founded by Anamaria Lusardi, an early contributor to financial literacy as a field of study, develops personal finance education material for schools and the workplace and builds initiatives to advance financial literacy [17]. European banking associations, together with the European Banking Federation, organized the European Money Quiz, in order to make learning about money and finance more fun. The quiz took place for the first time in March 2018, as a Europe-wide competition, where thousands of kids from 30 countries were involved. Throughout one week in March each year, hundreds of activities are held in 20+ countries to promote financial literacy in Europe [18]. The Association of Serbian Banks will enable the realization of this project in Serbia, with support from the Ministry of Education, Science and Technological Development of Serbia. Programs for financial education did not exist earlier in Serbia, so Ministry of Education, Science and Technological Development with the support of VISA company, began a pilot project for systematic inclusion of financial literacy in education system, including all children, from preschool age to secondary school. FinPis project implies teaching through creating an environment for the development of functional knowledge in this field, as well as programs/subjects through which financial literacy, as a multidisciplinary competence, can be engaged and developed [19].

### 1.3. PISA framework of financial literacy

OECD in their PISA research defined financial literacy as *knowledge and understanding of financial concepts and risks, and the skills, motivation and confidence to apply such knowledge and understanding in order to make effective decisions across a range of financial contexts, to improve the financial well-being of individuals and society, and to enable participation in economic life* [14]. Financial literacy was tested for the first time worldwide in 2012. That year 18 countries/regions took part in the PISA test on financial literacy [14], while the second PISA assessment of financial

literacy in 2015 covered 15 countries and economies [15].

The PISA 2015 financial literacy assessment included items in the four content categories, the four processes and the four contexts [15]. The **content** categories comprise the areas of knowledge and understanding that are essential for financial literacy. The four content areas are: money and transactions; planning and managing finances; risk and reward; and the financial landscape. The **process** categories relate to cognitive processes. They describe students' ability to recognize and apply concepts relevant to the domain, and to understand, analyze, reason about, evaluate and suggest solutions. In PISA financial literacy, four process categories have been defined in no particular hierarchical order: identify financial information; analyze information in a financial context; evaluate financial issues; and apply financial knowledge and understanding. Finally, the **context** categories refer to the situations in which the financial knowledge, skills and understandings are applied, ranging from the personal to the global. The contexts identified for the PISA financial literacy assessment include: education and work; home and family; individual; and societal.

The single continuous scale of financial literacy constructed for the PISA 2012 assessment was divided into five proficiency levels in PISA 2015 [15]. Students proficient at **Level 1** display basic financial literacy skills. They can identify common financial products and terms, and interpret information relating to basic financial concepts, such as recognizing the purpose of an invoice. **Level 2** can be considered the baseline level of proficiency in financial literacy that is required to participate in society; students are expected to begin to apply their knowledge to make financial decisions in contexts that are immediately relevant to them. Students proficient at **Level 3** can apply their knowledge to commonly used financial concepts, terms and products to situations that are relevant to them. Students proficient at **Level 4** on the financial literacy scale can apply their knowledge of less-common financial concepts and terms to contexts that will be relevant to them as they move towards adulthood. Finally, students at **Level 5** on the PISA financial literacy scale can analyze complex financial products and take into account features of financial documents that are significant but unstated or not immediately evident. At each level, students are also expected to be proficient at the preceding level.

Results show that China outperforms all other participating countries/economies in financial literacy. The Flemish Community of Belgium, the participating Canadian provinces, the Russian Federation, the Netherlands and Australia have mean scores above the OECD average, in descending order of mean performance [15]. United States and Poland are at OECD average, while Italy, Spain, Lithuania, Slovak Republic, Chile, Brazil and Peru have mean scores below the OECD average. From ex-Yugoslav countries only Slovenia and Croatia participated in PISA 2012

testing and the results show that 15 year-olds in these two countries have significantly lower mean scores than the OECD average [14]. Both countries, as well as Serbia, skipped financial literacy assessment in 2015, so there are no comparable findings so far.

PISA 2018 is the third overall assessment of financial literacy and the first one in which Serbia will participate. 15 year olds in our country will be tested in financial literacy during April and May 2018 and the first results are expected in December 2019.

**3. RESEARCH METHODOLOGY**

The main goal of this research is to examine financial literacy of university students at engineering study programs using PISA methodology. Students who are finishing their undergraduate studies are soon to be the leading working force in the economy of every country, so it is important to investigate their level of financial literacy. Students at engineering study programs were chosen because financial education was not a part of their official curricula. Also engineering professions are often in the focus in the context of innovations and development.

The questionnaire consists of examples of PISA financial literacy assessment questions described in detail in PISA 2015 Results [15, pp. 52-63] and version in Serbian [21, pp. 11-19]. The questionnaire consists of 11 tasks, measuring five proficiency levels of financial literacy (level 5 is the highest and level 1 is the lowest, described in detail in previous section). Scoring table was developed for the purposes of this research (presented in Table 1).

**Table 1.** Score range of financial literacy proficiency levels

Proficiency levels	Score range
Level 1	0-36
Level 2	37-72
Level 3	73-108
Level 4	109-144
Level 5	145-180

Research question 1: What is the distribution of proficiency levels in financial literacy among engineering students?

Research question 2: In which content categories engineering students achieve better results and which one are the most difficult for them?

SPSS program was used for Statistical data analysis.

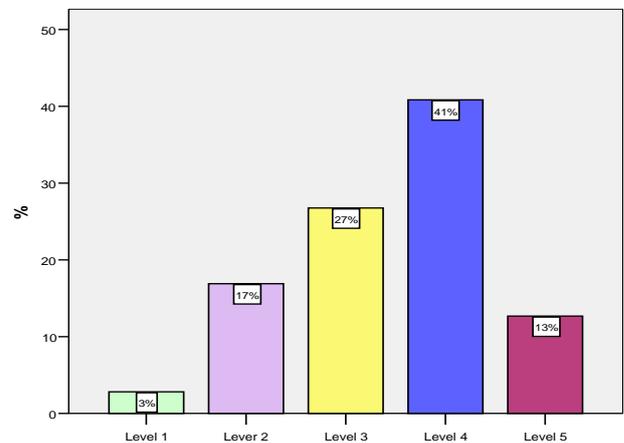
The sample consisted of 71 engineering students of Faculty of technical sciences in Čačak, Serbia. All students were in their final year of studies. Students' participation in this research was

anonymous and at voluntary basis. The research was conducted during April of 2018.

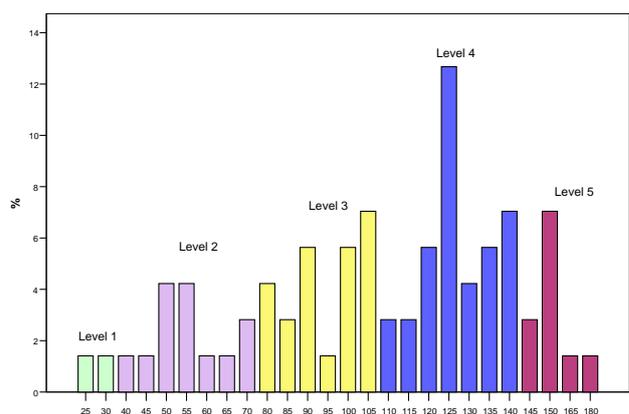
**4. RESEARCH RESULTS AND DISCUSSION**

Descriptive statistics in financial literacy score show that Mean value is 107, Median 115, Mode 125, all indicating that the test was not too difficult for participating engineering students. They show above average proficiency levels in financial literacy. Frequency distribution in percentages across all five proficiency levels is presented in Figure 1 and Figure 2.

The results show that majority of engineering students (40%) preforms at Level 4 of financial literacy. 26% of engineering students preforms at level 3, while 17% preforms at level 2. Only 3% of engineering students preforms at Level 1, which is far better than average score across OECD countries and economies with 22% of students perform at or below Level 1.



**Figure 1.** Levels of financial literacy of engineering students



**Figure 2.** Score frequencies in financial literacy of engineering students

When it comes to top performers, 13% of engineering students preforms at highest level of financial literacy proficiency. These results are in line with PISA 2015 findings that show that 12% of students across OECD countries and economies are top performers in financial literacy (proficient at Level 5). These students can analyze complex

financial products and solve non-routine financial problems; they show an understanding of the wider financial landscape, such as the implication of income-tax brackets and can explain the financial advantages of different types of investments [15].

The OECD also conducted an International Survey of Adult Financial Literacy Competencies [22]. They emphasize, however, that comparisons with PISA findings should be made with caution, as the evidence is drawn from different measurement tools and on different sets of countries; but the different country rankings across adults and young people might suggest a considerable generational divide in some countries. For instance, students in Russia perform relatively well at the international level, while adults in that country perform relatively poorly compared to adults in other countries [15]. Researching financial literacy of adults using PISA framework was done recently in Croatia, with sample of 900 people age 18 to 65 [23].

In Europe studies done in 2017 also revealed that people age 15–34 have the lowest financial literacy [5, 8]. Several studies showed that the level of financial literacy of students was low [1, 4, 26]. Research done in Slovak and Czech with student of different faculties showed that students' personal financial knowledge can benefit from the financial education [1]. It emphasizes the necessity to invest in financial literacy programs.

**Table 3.** The content categories of financial literacy across tasks

The content categories	Incorrect answers f (%)	Correct answers f (%)
<b>Money &amp; transactions</b>	<b>105 (25)</b>	<b>321 (75)</b>
At the market tasks	36 (25)	106 (75)
Invoice tasks	43 (20)	170 (80)
Pay slip tasks	26 (37)	45 (63)
<b>Planning and managing finances</b>	<b>49 (35)</b>	<b>93 (65)</b>
New offer task 1	17 (24)	54 (76)
New offer task 2	32 (45)	39 (55)
<b>Risk and reward</b>	<b>39 (55)</b>	<b>32 (45)</b>
Motorbike insurance task		
<b>Financial landscape</b>	<b>47 (66)</b>	<b>24 (34)</b>
Bank error task		

To answer the second research question, the content categories of financial literacy were analyzed (Table 3). The results show that *money and transactions* is the area of financial literacy in which the engineering students are the most knowledgeable at. *Planning and managing finances* is also the content that students show a solid percentage of correct answers.

The students were less successful in answering *risk and reward* task, while they were the least successful in answering the question regarding *financial landscape*. This is also a task that requires

a process of evaluation of financial issues. However, it appears that it is not the complexity of cognitive process the one that can explain this result, since the same process, at similarly high proficiency level, is required for task *New offer* and two thirds of students are successful in this task. It can be hypothesized that financial landscape in societal context is less familiar to engineering students than planning and managing finances in individual context.

## 5. CONCLUSION

Financial literacy is becoming more like reading and writing; as it was not possible in the past to participate in society without being able to read and write, so it is not possible to thrive in today's society without being financially literate [24]. Financial literacy is going to become one of the necessary skills for engineers, giving that the role of engineering profession is changing. Engineering is seen as an evolving profession that must adapt to suit its context and the needs of the community [25]. It is stated that it is necessary that engineering professions throws off the image of having a narrow technical focus and disinterest in how society works [25]. Professional engineers play a central role in developing, operating and managing technological enterprises, systems and projects; Engineers must be expected to lead and drive change across the entire innovation spectrum from setting policy to implementation and ongoing operations [25].

Overall, the results presented in this paper suggest that engineering students who participated in this research have above average proficiency levels in financial literacy. However, generalization should be done with caution, giving the two major limitations of this research - small sample size and a small items pool (i.e. our questionnaire consisted of 11 items while total of 43 items were used in 2015 PISA testing of financial literacy). It is more useful to consider this research as a pilot research in investigating financial literacy in adults in Serbia, one that can provide complementary data to PISA findings. Similar research are important because in order to create and implement financial literacy national policy it is important to conduct national measurement of financial literacy and to develop national strategies for financial education based on those results [23].

A growing number of countries is developing and implementing national strategies for financial education [27]. The experience of other countries shows that there should be founded an institution which would involve and coordinate the work of all stakeholders, especially in the field of introducing the financial education as regular educational content and its promotion; in Serbia that should be the Ministry of Education, Science and Technological Development with all institutional partners involved in implementation of financial literacy evaluation in Serbia as part of PISA 2018

[28]. Special attention should be paid on teachers, who are the central figures in introducing financial education, so it is necessary to raise awareness of teachers about the importance of developing financial literacy through formal education system. Teachers should be adequately trained and resourced, made aware of the importance of financial literacy and relevant pedagogical methods, and they should receive continuous support and training to teach financial literacy [29].

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# Dual/Cooperative Education in Higher Education

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**Abstract:** *Learning cycles in experiential education show a striking similarity to the plan-do-check-act-cycle in corporate problem solving. These similarities from plan-do-check-act-cycle to learning were realized in the development of a dual/cooperative study program "Production Technology and Organization" at University of Applied Sciences FH Joanneum. From the beginning in 2002 the dual/cooperative study program "Production Technology and Organization" had a strong emphasis on integrating small and medium sized enterprises with little or no previous cooperation with higher education.*

*Dual education is a good option to educate young engineers for future challenges within a company.*

*Several of the partner companies had not yet hired a college graduate but agreed to help educate students through dual/cooperative education.*

*The paper will present strategies and methods which were developed at study program of "Production Technology and Organization" and applied to meet growing requests from partner companies to extend this interaction to a wide range of issues, always concerning improvement and innovation in product development and production processes.*

*Meanwhile the dual/cooperative study program and the dual students play a central role in the Austrian industry – university relationship at FH JOANNEUM and for other regional universities.*

*Dual education has opened a completely new and innovative channel to small and medium sized enterprises regarding the promotion of innovation. The presentation shows the experiences in Austria, comparing them with activities at other universities and generating new ideas for further improvement of the role of dual programs as a partner to regional industry in coping with the present economic crisis in nations.*

**Keywords:** *dual education, production technology and organization, university of applied sciences, networking, partnership to industry.*

## 1. INTRODUCTION

We live in the age of aquarius and have to accept that not only the industrial landscape has changed. It is also the field of education, in our special concern higher education, which has to be reconsidered. The following findings show the experience of 15 years dual studying at the program of "production technology and organization (PTO)" [1].

## 2. EXPOSITION

**FH (=university of applied sciences) degree program "Production Technology and Organization (PTO)":**

**Study on the job - all in one**

"Production Technology and Organization (PTO)" comprises the entire production process of a company. To mirror and represent this process successfully there are a few required criteria for dual degree program which shall be introduced in the following. The dual degree program provides job-focused training and teaches technology, business and social skills to future engineers. The program lasts three years (six semesters) and students finish with the degree of "Bachelor of Science in Engineering (BSc E)", the consecutive

cooperative – dual master program "Engineering and Production Management" lasts two years (four semesters) The bachelor program provides the fundamental skill in engineering, logistics, quality assurance and economy and leadership whereas the Master program is more orientated to the needs in "Research and Development" (=R&D) and management.

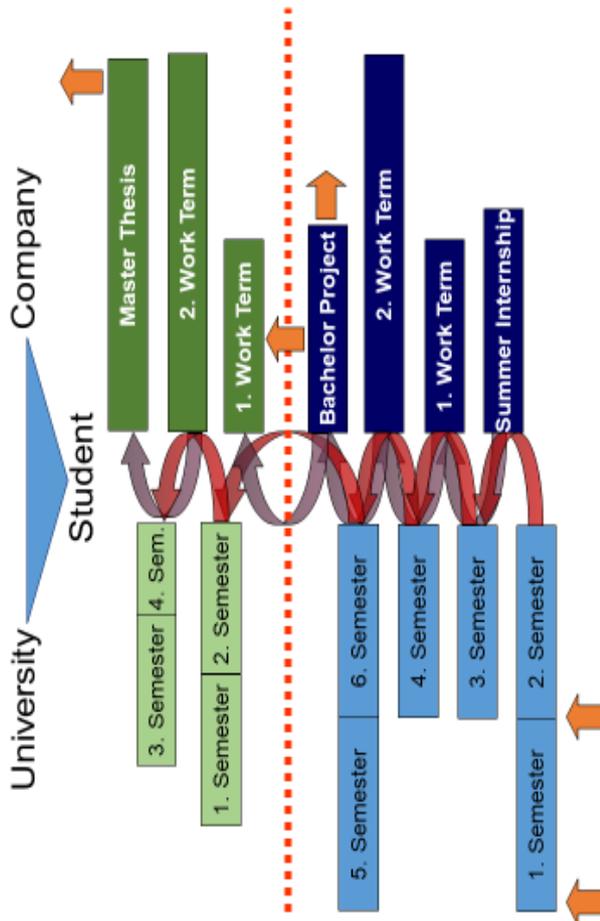
The choice of the program PTO originates from a need of skilled technicians by the producing industry in the Austrian province of Styria. In this region, industrial production not only has a long history but still makes up for more than 30 % of the GNP. More than 60 % of the production is exported to countries all over the world with Germany being the traditionally most important partner. The emerging countries of the European Union in the east are a hopeful strategic advantage for the future development of the country.

This educational program of PTO started in 2002 and was the first and by now one of six dual educational programs at university level in Austria. The organizational concept for PTO was adapted from the successful model of the "Berufsakademie" (university of dual education) in Stuttgart, Germany [2] and fit into the Austrian landscape of industry and system of tertiary education. Since many of the required criteria for degree programs

are perfectly suited to be met by elements of dual education, PTO receives broad attention among decision makers in Austrian industry and public education authorities.

Students of the FH degree program PTO study alternately – for three months respectively - at the FH JOANNEUM Graz and in a work placement with a partner training company (see fig. 1), where they immediately apply in practice what they learned during the semesters of theory before.

In return for this effort of direct know-how transfer from university to their companies, students are paid an appropriate salary of about 700 € per month (14 times a year, equivalent to a 50 % employment, based on a model contract developed for this program).

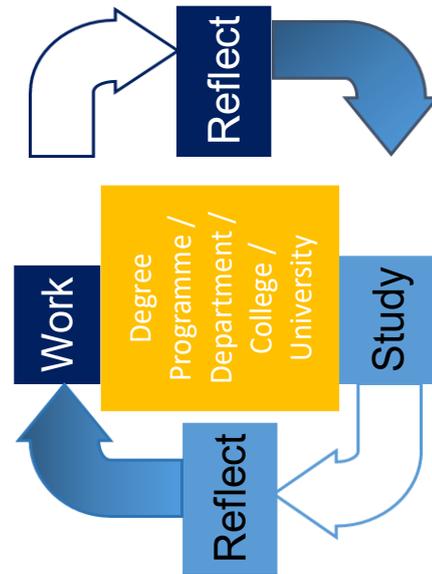


**Figure 1.** Structure of the bachelor and master program at the University of Applied Sciences FH Joanneum

Figure 1. depicts the structure of the dual bachelor and master program at the University of Applied Sciences FH Joanneum. There can be differentiated very well between practical terms in the university and theoretical parts in the company.

In Figure 2. the cycle of Work Integrated Education for the dual program shows the link between working and learning parts. The subjects, which the students learned at the program in the university, they can apply during their work term and after this

they have to reflect on it. It is always a rotation between working and learning and the student’s reflection. This cycle is according to the ideas of David Kolb [3].



**Figure 2.** Simplification of the cycle of Work Integrated Education in the dual program Production Technology and Organization

**New teaching opportunities within a company – platform**

Besides theoretical inputs by experts with industrial background and the practical experience from projects with the training companies, much of the learning comes from exchange of experiences among the 35 students of each cohort, being placed in production companies in all branches and sizes, excursions to the participating companies and joint interdisciplinary projects. A big emphasis is given to the development of social and organizational skills by offering coaching, specific training modules and individual and group supervising during all work periods.

The cooperation between companies and university starts with the application process. Companies announce the need for a student for the next term. Interested graduates from high school (most of them with a specific technical focus) have to pass through the official application process of the university (written test, hearing) and after being formally admitted, the FH Joanneum provides the opportunity of a further hearing with at least three companies of their choice in terms of giving contact details about these companies to the students.

By agreeing to a joint effort in teaching future academics in PTO the participating companies enter a network with frequent opportunities to exchange experiences, receive support in designing practical projects or in mentoring the students, in organizing on the job training abroad or, at the end of the three years, in providing a suitable topic for the bachelor thesis.

Companies have learned to value this “extra” input from the university and make more and more use

of it. As there are first successful experiences with a Japanese chain manufacturer KITO one of the next steps in the development of the dual education at the FH Joanneum will be to design a "Corporate College" to further open the doors to other employees of participating companies.

### Training companies for the first four courses

By engaging the companies for the practical aspects of the study program it is possible to include companies from a broad range of branches. By moving from university to company and back only every three months, companies can be located within a reasonable driving distance (about 400 km). Both factors play an important role in offering an exciting and multiple environment for dual education.

Industrial sectors include:

- Wood and paper products: e.g. HAAS Fertigungsbau, the affiliation of a German Manufacturer of prefabricated houses, Mondi Packaging – one of the world's largest producer of pulp and paper, Wall (member of the American MeadWestvaco Group)
- Food processing: e.g. Agrana Fruit – one of Europe's biggest fruit processing companies (a fast growing branch with production facilities mainly in eastern Europe)
- Electronics: e.g. AT&S (electronical parts for mobile phones), TDK (a world leading producer of ceramic sensors)
- Automotive: e.g. BMW Motoren Steyr, AVL List, MAGNA (Steyr, Fueltech, Powertrain and Heavy Stamping – a multinational supplier with headquarters in Aurora, Ontario and Austrian roots), KTM (off-road motorcycles), Robert Bosch (one of the founders of the "Berufsakademie" in Germany)
- Machine building and steel construction: several companies that are worldwide players in niche markets - EVG (mesh welding machines), Siemens VATEch (transformers and generators), VAB Sandvik (machinery for hard and soft rock mining)
- Metal working: e.g. Böhler Edelstahl (steel producing and forging), SMEs as suppliers for the large companies
- Logistics: e.g. Knapp Logistics, Schäfer PEEM
- A selection of other companies: ROCHE DIAGNOSTICS (headquarters of near Patient Testing in Graz, main production facility in Indianapolis), Atomic (most successful producer of skis and snowboards), Heineken Group as one of the biggest brewery concerns in Europe.

### Existing dual programs in Germany

1974 the first model of dual education in higher education was invented in Germany and therefore two universities of dual education were built in Stuttgart and Mannheim [4]. This invention had big success in the German industry and society. This can also be seen in the amount of participants. At the moment there are around 1,600 dual programs

in Germany. About 48,000 companies and 100,000 students are participating this dual system. Moreover, it can be expected that the number of participants in all three departments, university, student and company will increase in future. Germany with its accomplished knowledge is a pioneer in the section of dual programs. Other countries are recognizing this hype about dual education and try to develop dual programs. The need of those programs is getting higher and higher because of the need of well-trained employees in the companies. A dual program is a win-win-win situation. The students get an intense education and are trained on the job, which the company wants to have. Furthermore, the companies can get and stay competitive in the economy. The universities stay in touch with the needs of the industry and get more students and well-trained alumni with an outstanding image.

For a student the enriched experience leads to enhanced engagement in learning. Moreover, professional attitudes, behavioral skills like communication and relationship building can be intensified in a work term. Earning work experience helps students to get a greater understanding of the demands of the workplace and a better understanding of the functional units in an enterprise. The employment outcomes can be improved and the bridge between academia and world of work can be strengthened.

At the university the curricula can permanently adapted and held relevant according the aim to improve the employability of graduates. Furthermore, the contribution to social and economic development are supported.

The companies respectively the employers get fresh ideas and develop a higher level of critical thinking applied to real life problems. Dual programs offer new recruitment opportunities, because of the access to university resources. A corporate social responsibility can be improved.

### Dual programs in East-Europe

As a result of moving to foreign countries in the eastern parts of Europe, German companies recognized a need of well-trained employees especially engineers. To supply those needs universities started to cooperate with the companies and other Austrian and German universities with the existing knowledge in this issue. Study program of PTO is in partnership with several universities in the east of Europe like the agricultural and economical university KINEU in Kostanay/Kazakhstan, the Politechnica Pula/Croatia, the TU Gabrovo as well as the TU Varna in Bulgaria. The TU Gdansk/Poland and the TU Lucian Blaga in Sibiu/Romania are in cooperation through projects with the program of PTO at FH Joanneum to earn the knowledge, how a dual program could be developed and how it could work. The excessive demand of dual programs is existent in Europe and to face those needs especially the countries of east Europe form alliances with Austrian and German pioneers to learn from them.

### **Expectations of participating companies of dual program alumni and the higher educational institution**

The Erasmus+ project aCIRET (=Apprenticeship Cluster for Industry-Ready Engineers of Tomorrow) [4] deals with the development of a dual program in the field of mechatronics in Bulgaria at the TU Gabrovo and in Poland at the TU Gdansk. Below, the focus groups like students, companies and university specified their perspective and wishes about a dual program. Regarding this project, it can be said that the discrepancies between university education and business demands can be traced back to inconsistent ratio between theory and practice. This mostly is caused by a poor communication between industry and university. They dual education is able to bridge this gap. While teaching theory, there were no references to practice provided and the learning content was often not well visualized. University teachers pointed out that university labs were not equipped with state-of-the-art machinery, which prevented students from keeping up with the advanced technologies and equipment used in companies. Overqualified specialists in theoretical subjects are not needed, since there is a problem of skill-experience mismatch in industry. In both countries, in Bulgaria as well as in Poland they need a better balance between theory and practice to achieve a higher skill match and better market tailored graduates.

Companies expect fundamental knowledge of engineering subjects, equipment and machinery components, as well as computer modelling (CAx technologies) from the graduates. They want them to earn programming skills, recognition and proper selection of measuring instruments, assembling and disassembling equipment components. Moreover, soft skills like self-performance, rhetorical, organizational and presentation skills and leadership qualifications form the perfect graduate according to the participants in the survey.

The key areas can be improved by dual programs, e.g. in mechatronics in different ways. The students point of view is working on communication, teamwork, maintenance and repairs, as well as assembling and disassembling equipment components, as well as a clear defined career path, experience in industry and own earned money. The TU Gabrovo in future wants to produce industry-ready engineers, closer cooperation between University and industry and a better image. Direct contact with industry, attractive courses and an outstanding image are the wishes of TU Gdansk. The industries needs are the availability of upskilled engineers to stay competitive and a higher education tailored to their needs.

### **Distinct features of cooperative and work integrated education**

First, it can be said that education is the key priority of the dual program. Curricular tools like faculty qualification, competency orientation, workload calculation, modularization and assessment should

be applied. Moreover, companies should redefine themselves as a learning and teaching environment for student and university. Next step should be to introduce formal entrance requirements and a final degree or rather a possible job description.

For a good cooperation it is important that the partnership between an educational institution and company happens "at eye level". The well-defined tasks and duties for the participating partners promise a good cooperation. Both, company and university, represent a special environment and within this learning environment is created. Furthermore, open information policy and clear allocation of cost elements permit a functional cooperation between different partners.

At least the integration of work terms in a study program is to create a distinctive education "third culture" with both elements of working and studying. There should prevail a constant reflection in action and on doing (not only for the student!) for a growing and functional partnership and also for a constant development. A good integration is made when all experience of students transcended with the quality of work and study.

### **Current situation R&D in Austria**

Referring to the current situation of R&D in Austria three important things can be said. First, it can be said that the contribution from companies is declining continuously for several years. This also seems to be for programs of the EU. Furthermore, research organizations and universities fail to connect to small and medium-sized enterprises (=SMEs). The Research & Development is more and more concentrated to international corporations. The SME structure, as well as innovative products and processes are vital to sustaining production in Austria. Therefore, a well-balanced partnership between industry and university is very important to strengthen the connection between those partners.

### **3. CONCLUSION**

The dual system in higher education has opened a completely new and innovative channel to SMEs regarding the promotion of innovation.

The survey shows the experiences in Austria, comparing them with upcoming activities at other universities and countries. They are generating new ideas for further improvement of the role of dual programs as a partner to regional industry and a missing link between universities and industries in coping with the present economic crisis in nations. Other universities from Europe learned to know the advantages of dual programs and try to get in touch to industry. Even companies meanwhile understand the benefits of dual education for their business. Different EU projects open new doors for other countries in the eastern Europe like Bulgaria, Poland, Croatia and others. The dual education was undervalued a long period of time, but now everyone is recognizing its benefits and it is starting to get a hype in higher education.

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# Innovation of University Courses in The Field of Manufacturing Technologies Based on The Implementation of Dual Education

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**Abstract:** *In this paper is presented the project that was realized within the framework of the activity "Development of higher education". The project is supported and financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia. The project is a set of activities to improve theoretical and practical content of teaching courses belonging to the field of manufacturing technologies, through the implementation of dual education. Teaching courses, whose improvement is the aim of the project, exist on the bachelor and master studies Mechatronics at the Faculty of Technical Sciences Čačak.*

**Keywords:** *higher education, manufacturing technologies, practice, dual education*

## 1. INTRODUCTION

Technical faculties around the world pay great attention to the careers of their students [1,2]. One of the segments of this process is the organization of professional practices and visits to the industry during the studies.

Many researches deal with the presence of practice in the curriculum. Chen et al (2012) presented the integration of theoretical knowledge and hands-on experiment to solve proposed problems, and thus have drawn great attention worldwide. As one of the typical and innovative teaching modes in mechatronics in China, mechatronics teaching in Beihang University has formed a "One main line, two links, three practical points" mode and methodology, which emphasizes on the links and mapping relationships between theoretical teaching and practical teaching [3]. Cohen and Katz (2015) point out that mechanical engineering (ME) curriculum does not include courses that teach ME students essential professional knowledge needed to become a design engineer [4]. Loschilova et al (2015) presented a pedagogical model of professional training of bachelor's in mechanical engineering based on networking, which facilitates the demand for graduates in labor market was designed [5]. Suzdal et al. (2015) presented the consideration of the problem of qualified engineering personnel training in the mechanical engineering industry [6]. Hoernicke et al. (2017) presented the importance of exchanging between industry and academia. One effective but not often considered form of exchange is inclusion of guest lectures by industry experts in the syllabus [7].

The idea of the project presented in this paper is the integration of industrial practical activities of students into the teaching process. The overall objective of the project is to innovate a group of existing teaching courses in the programs of university courses of the bachelor and master studies of Mechatronics. Innovation will include a group of courses belonging to the scientific field of Manufacturing Technology, four courses in bachelor studies and one course in master studies. The planned courses for innovation on bachelor studies are: CAD/CAM technology, Program control of machines, Unconventional technologies and Technological processes. Master studies will offer an improved course New manufacturing technology. Innovating of a group of courses will encompass several individual goals that belong to a group of program objectives of the Ministry of Education, Science and Technological Development of the Republic of Serbia. Innovating will involve the improvement of theoretical and especially practical content of the courses through intensive and detailed planned cooperation with the industry. This will improve the competencies of teachers and associates and raise the quality of the educational process through creating better conditions for the realization of teaching. Cooperation with the industry will enable the implementation of the concept of dual education through well-organized practices. Each of the improving courses will include industry practice, within which one project will be implemented. Projects realized within practice will be evaluated with a certain number of points. Implementation of dual education will present to business entities, in which the practice

is realized, the potential of students and it will open the possibility of their employment upon completion of studies. In this way, the innovative programs of university courses, through a strong correlation with the industry, will respond to the needs of the labor market in the field of industrial production.

## 2. PROJECT ACTIVITIES

Project activities (there are nine in total) are defined by the set of project objectives. Their realization is planned within five months, as needed for the project realization.

The first activity (A1) contains an analysis of the content of the same or similar courses at the programs of university courses at prestigious world technical faculties. Related courses were analyzed at the following twelve universities around the world: Faculty of Engineering Science and Technology/UiT The Arctic University of Norway (Tromsø, Norway), Swinburne University of Technology (Melbourne, Australia), Faculty of Science, Engineering and Computing/Kingston University (London, England), Greenville Technical College (Greenville, USA), Hennepin Technical College (Minnesota, USA), Department of Mechanical Engineering National Institute of Technology Karnataka (Karnataka, India), Department of Mechanical Engineering, Faculty of Engineering/University of Sheffield (Sheffield, England), University of Nottingham (Nottingham, England), Michigan Technological University (Michigan, USA), Brno University of Technology/Faculty of Mechanical Engineering (Brno, Czech), University of Ottawa/Faculty of Engineering/Department of Mechanical Engineering (Ottawa, Canada), SMU/Lyle School of Engineering (Dallas, Texas, USA).

The second activity (A2) contains the analysis of software tools used in teaching processes from the same or similar courses at the programs of university courses of prestigious world technical faculties.

The third activity (A3) contains the analysis of practical teaching applied within the same or similar courses at the programs of university courses of prestigious world technical faculties. Practical teaching were analyzed at the following universities: University of Coventry (UK), Faculty of Mechanical Engineering, University of Texas (USA), University of Toronto (Canada), Faculty of Mechanical Engineering, McGill University, Montreal (Canada), University of South Australia, Adelaide (Australia).

The fourth activity (A4) contains an innovation of theoretical contents of teaching courses in accordance with contemporary and generally accepted literary sources.

The fifth activity (A5) includes the alignment of theoretical and practical teaching, and the formation of a work plan for working weeks.

The sixth activity (A6) includes detailed planning of practical teaching.

The seventh activity (A7) encompasses a trial one-month practical training in the industry with a selected group of students.

The eighth activity (A8) contains a detailed analysis of the realization of practical teaching.

Finally, the ninth activity (A9) contains potentially corrective action in the formation of the content of the innovated courses. The realization overview of these activities is given in Table 1.

**Table 1.** Realization of activities (A) by months (M)

	A1	A2	A3	A4	A5	A6	A7	A8	A9
M1	x	x	x						
M2	x	x	x	x					
M3					x	x			
M4							x		
M5								x	x

## 3. PRACTICAL TEACHING

After realization of activities A1-A5, detailed planning of the practical teaching courses (CAD/CAM technology, Program control of machines, Unconventional technologies and Technological processes and New manufacturing technology) was conducted. One-month practical training was realized for the course CAD/CAM technology. The students of the fourth year of the bachelor studies of Mechatronics realized the trial practice. Ten students realized a practical part of the teaching process in the company "Sloboda" A.D. Čačak. Practical teaching were organized in four blocks.

Content of the first block of practical teaching is design of technology for making work on CNC milling machine. Applied technological sequences: surface milling, profile milling, volume milling, hole making. Expected outcomes of the first block of practical teaching:

1. Students successfully follow and understand segments of teaching related to practical work.
2. Students acquire knowledge and gain the ability to independently design the required technological sequences.

Content of the second block of practical teaching is: Creating of a CL file (CUTTER LOCATION FILE). Postprocessing. Making work on CNC milling machine. Expected outcomes of the second block of practical teaching:

1. Students successfully follow and understand segments of teaching related to practical work.
2. Students acquire knowledge and ability to independently generate a file containing the

tool path and post-presetting for the appropriate control unit.

3. Students create documentation with their activities.

Content of the third block of practical teaching is design of technology for making work on CNC turning machine. Applied technological sequences: turning, facing, grooving, thread making. Expected outcomes of the third block of practical teaching:

1. Students successfully follow and understand segments of teaching related to practical work.
2. Students acquire knowledge and gain the ability to independently design the required technological sequences.

Content of the fourth block of practical teaching is: Creating of a CL file (CUTTER LOCATION FILE). Postprocessing. Making work on CNC turning machine. Expected outcomes of the fourth block of practical teaching:

1. Students successfully follow and understand segments of teaching related to practical work.
2. Students acquire knowledge and ability to independently generate a file containing the tool path and post-presetting for the appropriate control unit.
3. Students create documentation with their activities.

After a one-month practice, students evaluated the practice in the form of a survey. Every block of practice was evaluated, and the overall rating was generally satisfying. The conducted analysis through the A8 activity gave a clear demonstration of the success of the trial practice and marked the parts to be corrected. The degree of autonomy of students during practice is the most important segment that needs to be improved by the joint action of teachers and mentors in the industry. The general conclusion is that this segment should be improved through the establishment of practical project tasks, which are in line with current manufacturing programs of the company.

#### 4. INNOVATED TEACHING COURSES

In this part of the paper, an overview of the innovated teaching courses is given, within the framework of the realized project. Improvements to the teaching courses are based on introduction of industry practice as a part of teaching process. In this way, the concept of dual education has been promoted, with a significant impact on practical activities within the teaching course.

##### 4.1. CAD/CAM technology

Objective of teaching course. The main goal of the course is mastering computer technologies for modeling products in order to support production processes (CAM). Students acquire knowledge in the field of 3D modeling of products, design of manufacturing processes using modern software

packages and creating postprocessor code for CNC machines.

Learning outcomes. Students will be trained in creating a 3D solid model of finished products, working models necessary for designing manufacturing processes, designing manufacturing processes, generating postprocessor code and corresponding technological documentation.

Contents of theoretical teaching. Basic of CAD/CAM technology. Principles of CAD/CAM design of technological processes. Technological design bases (technological sequences, technological parameters, etc.). Systems of tools in CAD/CAM technologies. CAD systems: modeling and visualization, parametric modeling, types of geometric models, wired, surface and solid models as the basis for generating tool paths, creating 3D models, reference and work models as the basis of CAM systems. CAM systems: work setting, production setup, define NC sequences, generation of data paths, and NC data documentation. CAM technology is being studied for follow machining processes: turning, milling and drilling.

Contents of practical teaching. Exercises in a computer classroom using CAM/CAM software packages. Practical part of teaching in industry.

Knowledge check. Knowledge testing involves several activities that participate in the final assessment, which are: activity during classes (5%), realization of tasks in computer exercises (25%), project in industry (40%) and oral part of the exam (30%).

##### 4.2. Program control of machines

Objective of teaching course. The objective of the course is to acquire knowledge about: control of machine systems, program and adaptive control systems, elements of program and adaptive control techniques, their application, and especially for machine tools with CNC control. As a further logical step, students should master the basic methods of technological preparation, and in particular the methods of programming machine tools with CNC control.

Learning outcomes. Students will gain knowledge of machine tools, applied control systems, and especially machines based on CNC technology. Students will also be trained in programming machine tools with applied CNC control in the technology of turning, milling and drilling etc.

Contents of theoretical teaching. Mechanical systems with control shafts, copier systems, cyclical systems and numerical control systems, i.e. conventional (NC), computer numerical control (CNC) and distributive numerical control (DNC). Adaptive control (Adaptive Border Control Systems - ABCS and Adaptive Systems of Optimal Control - AOC). Numerical control elements (CNC control units, drive systems, machine tools as a control object and measuring systems). Application of CNC

technology for machine tools (lathes, milling machines, drills, machining centers, plastic deformation machine tools, ultrasonic processing machines, laser processing machines, machines tools with parallel kinematics, measuring machines etc.). Programming machine tools in NC code, APT machine programming system and basics of CAD/CAM methodology of machines programming.

Contents of practical teaching. Exercises in a computer classroom using software for different types of CNC machine control units. Practical part of teaching at industry.

Knowledge check. Knowledge testing involves several activities that participate in the final assessment, which are: activity during classes (5%), realization of tasks in computer exercises (25%), project at industry (40%) and oral part of the exam (30%).

#### 4.3. Unconventional technologies

Objective of teaching course. The main objective of the course is to familiarize students with technological processes of metal and non-metal processing in unconventional procedures for obtaining finished products (Ultrasonic Machining (USM), Abrasive Jet Machining (AJM), Water Jet Machining (WJM), Abrasive Water jet Machining (AWJM), Electrical Discharge Machining (EDM), Electron Beam machining (EBM), Plasma Arc Machining (PAM), Laser Beam Machining (LBM)...). Through lectures, exercises and project design, students are trained to apply theoretical and practical knowledge in the realization of various unconventional technologies.

Learning outcomes. Students gained the necessary theoretical and practical knowledge from Unconventional metal and non-metal processing technologies. They are able to: recognize and distinguish certain unconventional processing methods and the corresponding technological parameters, define the technological process of manufacturing for simpler practical examples.

Contents of theoretical teaching. Unconventional Machining Processes. Ultrasonic Machining (USM), Abrasive Jet Machining (AJM), Water Jet Machining (WJM), Abrasive Water jet Machining (AWJM), Electrical Discharge Machining (EDM), Electron Beam machining (EBM), Plasma Arc Machining (PAM), Laser Beam Machining (LBM). Comparison of unconventional machining processes and characteristics of treated areas.

Contents of practical teaching. At auditory exercises students determine the acquired theoretical knowledge. Part of the exercise is done in a laboratory for machine processing on a laser engraving machine. Students are trained to define technologies and procedures for the manufacturing process. Practical part of the teaching is at the industry where students are introduced to the selection and work of machines, accompanying

equipment and defining and selection of processing parameters.

Knowledge check. Knowledge testing involves several activities that participate in the final assessment, which are: activity during classes (5%), realization of tasks in auditory exercises (20%), project at industry (30%) and oral part of the exam (45%).

#### 4.4. Technological processes

Objective of teaching course. The main objective of the course is to familiarize students with all technological processes of metal processing in conventional methods of obtaining finished products (cutting and deformation processing). Through lectures, exercises and project design, students are trained to apply theoretical and practical knowledge in the realization of various technological processes.

Learning outcomes. Students gained the necessary theoretical and practical knowledge from the technological processes of metal processing. They are able to: recognize and differentiate the individual processing operations and the corresponding technological parameters, define the technological process of manufacturing for simpler practical examples.

Contents of theoretical teaching. Technological process. Basics of cutting. Processing procedures (turning, drilling, milling, grinding, thread making, etc.). Theoretical basis of the deformation processes, stresses, deformations, velocities etc. Processing of sheet metal by separation. Sheet metal processing bending. Deep drawing. Volumetric design. Technological processes and control, technological documentation.

Contents of practical teaching. Laboratory exercises are performed in a laboratory for machine processing. Students are trained to define technologies and procedures for product development, tools, machines, processing parameters and creating technological documentation. Practical part of teaching in industry.

Knowledge check. Knowledge testing involves several activities that participate in the final assessment, which are: activity during classes (5%), realization of tasks in auditory exercises (20%), project in industry (30%) and oral part of the exam (45%).

#### 4.5. New manufacturing technologies

Objective of teaching course. The main objective of the course is to introduce students to the basics of rapid prototyping, as well as to learn about the technologies realized within the CNC system (computer numerical control), DNC (distributive numerical control), FMS (flexible manufacturing systems), ITS (intelligent technology systems).

Learning outcomes. Students gained the necessary knowledge of the rapid prototyping technology and technologies that are realized within the CNC system, DNC system and FMS system.

Contents of theoretical teaching. Rapid prototyping technology, CNC system (computer numerical control), DNC (distributive numerical control), FMS (flexible manufacturing systems), ITS (intelligent technology systems).

Contents of practical teaching. Practical part of teaching is realized in the industry and in the laboratory.

Knowledge check. Knowledge testing involves several activities that participate in the final assessment, which are: activity during classes (5%), project in industry (50%) and oral part of the exam (45%).

## 5. CONCLUSION

The paper presents realization of a project that showed great importance of practical teaching for subjects in the field of production technologies. Initiation of practical teaching, i.e. students' visits to the industry, significantly improved the teaching process and increased students' interest and motivation. The success of the students who have implemented the practice is best represented through passing the exam. During the examination period after the realization of teaching course in the field of CAD / CAM technology, all students (ten of them) who participated in implementation of probationary practical training passed the exam. Their achievement in the exam is as follows: three students got grade 10 (ten), which is the highest grade in higher education institutions in Serbia, two students got grade 9 (nine) and five students got grade 8 (eight), i.e. their average grade was 8.80 (eight and 80/100).

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# A Constructive Approach to Teaching with Robotino®

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**Abstract:** *The current level of technological development and an increasing need for Information Technology (IT) staff open up opportunities and impose a need for a different approach in students' education. Instead of classical, theoretically-oriented, transfer of finished knowledge, the focus is put on interactive learning through student's own experimental work. Modern mechatronic systems offer the possibility of changing the way of acquiring technological knowledge and developing programming skills. This paper presents some possibilities of mobile robotic system Robotino® of Festo Didactic intended for education and research. It is an open, flexible learning, platform that enables entry into the world of mechatronics and information technology for students of a different level of prior knowledge. In the paper, more details are given about the drive subsystem.*

**Keywords:** *education; Robotino®; mobile robot; drive system*

## 1. INTRODUCTION

The fourth industrial revolution imposes the need in the education of students of technical faculties to move the focus toward mechatronics and IT. For example, in mechanical engineering, a certain saturation has been achieved in terms of traditional constructive solutions. Research is mainly based on new materials and application of IT in the development of various smart devices. Systems become more and more hybrid and represent a combination of different technical areas.

Changes are needed not only in areas that being studied but also in the way that these new areas are presented. Students are required to actively participate in classes. This raises the question of how to motivate students for interactive work, and how to attract them to enroll, in general, technical faculties in greater numbers. Predictions are that in the future will be an increasing need for mechatronics engineers and IT technology.

Research in recent years [1-3] show that application of mechatronic and robotic systems in education can improve teaching and attract a greater number of students of IT and engineering disciplines in general. It has been shown that even for students of computer orientation, robot programming is more attractive than, for example, web application.

Application of such systems change traditional teaching methods and the role of involved actors in the learning process. Instead of traditional knowledge transfer, a good part of learning responsibility is shifted to the learners

themselves. Carefully selected examples, with friendly and fun working environment, can positively influence to their interest and motivation, and thus to more actively participate in education in a self-directed manner.

## 2. MOBILE ROBOT Robotino®

Robotino® (Fig. 1) is mobile robot system made by Festo Didactic [4]. It is, primarily, intended to acquire practical knowledge and skills in the field such as robotics, mechatronics, measurements, wireless control, signal processing, and programming, etc.



**Figure 1.** Mobile robot system Robotino®

Some of the properties:

- autonomous motion in all directions with identifying and avoiding obstacles;
- embedded sensors and actuators;
- wireless communications with other devices;
- the possibility of upgrading new components by using mounting tower;
- open sources concept and software interfaces for different programming languages;

All these features of the Festo mobile system enable course participants, through practical, interactive work, to get acquainted with different areas in the field of automation technology. Although Robotino<sup>®</sup> is also used for research in the field of industrial production, transport, logistics, in this paper, the attention is devoted to its application in education.

### 1.1. Robotino<sup>®</sup> subsystems

The mobile robot consists of several subsystems:

#### *Control subsystem*

To control the whole system it is used an embedded PC, according to the COM Express standard. The OS (Linux, Ubuntu) and all user data are stored on an SSD disk, which facilitates the replacement of an existing PC with a new one with more computing power. For communication, the standard connectors are used: USB, PCIe, RS232, Ethernet, VGA. The embedded PC is connected to a 32-bit microcontroller that controls the motors and the I/O interface of the robot. A FPGA module is used for additional signal processing.

#### *Drive subsystem*

For the robot motion, multidirectional drive (omnidrive) is used, which allows planar motion in any direction without having to rotate. Translation speeds up to 10 [km/h] are possible. More about this subsystem will be discussed below.

#### *Sensors*

The standard configuration of robot system contains a whole range of sensors that allow to get a detailed picture of the environment and autonomous motion. There are available:

- infrared distance sensors;
- inductive sensors;
- optical sensors;
- gyroscope;
- rubber protection strip with built-in collision-protection sensor;
- color camera with USB interface;

#### *Supply subsystem*

This subsystem provides autonomy to the mobile robot up to four hours. Power is supplied via two serial connected 12 V rechargeable batteries. The system is automatically switched off if the supply voltage is too low. We can develop control program or carry out experiments with restricted motion while batteries charging.

#### *Software subsystem*

This subsystem is probably the most important grummet of the whole robot system. Through it, the user's creativity is realized from the beginning

level to the advanced programming. Robotino<sup>®</sup> supports the open-source concept. The source code of all Robotino<sup>®</sup> software is freely available. Robot control can be realized at one of three levels:

#### *Level 1: Web interface*

Using this interface, it is possible to control the movement of robot without programming. Embedded web server with a graphical user interface (GUI) can be accessed by any device with WLAN communication and Internet browser. Besides for motion control, web server is used to monitor status, set operating parameters, and on-line help.

#### *Level 2: Software tools*

For programming beginners, software tools with graphical interfaces (*Robotino View*, *EA09View*) are available. Using these tools it can be achieved easy control and monitoring the on-line process parameters via WLAN network. For all hardware components (motor, encoder, sensors, I/Os, camera, gripper, robot arm) *Robotino View* contains the corresponding functional blocks classified into libraries (Fig. 2). By using these modules we can control the robot motion and process signals from the sensor in the graphical environment according to the GRAFCET standard. In addition, the user can write his own functions using *Lua* scripts or C++ programs.

Robotino View can be installed and used either on external PCs or on embedded PCs.

#### *Level 3: Application programming interface*

For advanced users, interface functions (APIs) are available for a variety of programming environments. User programs can be written using: C/C++, JAVA, .Net, LabVIEW, MATLAB/Simulink, ROS and Microsoft Robotics Developer Studio.

To communicate with Robotino, any device with a supported wireless communication can be used (PC desktop, laptop, tablet, mobile phone, Arduino, Raspberry). The external access point supports the IEEE 802.11g WLAN standard. By selecting a mode of operating (master or client), different combinations can be performed in the local network: multiple mobile robots can be controlled by one external device or by multiple external devices it can be controlled one Robotino<sup>®</sup> (Fig. 3) [5].

Robotino SIM tool can be used to test the written program (Fig. 4). This tool enables simulation of robot motion in virtual 3D environment that we create ourselves. This helps us to detect errors in the program before it is used on a real robot.

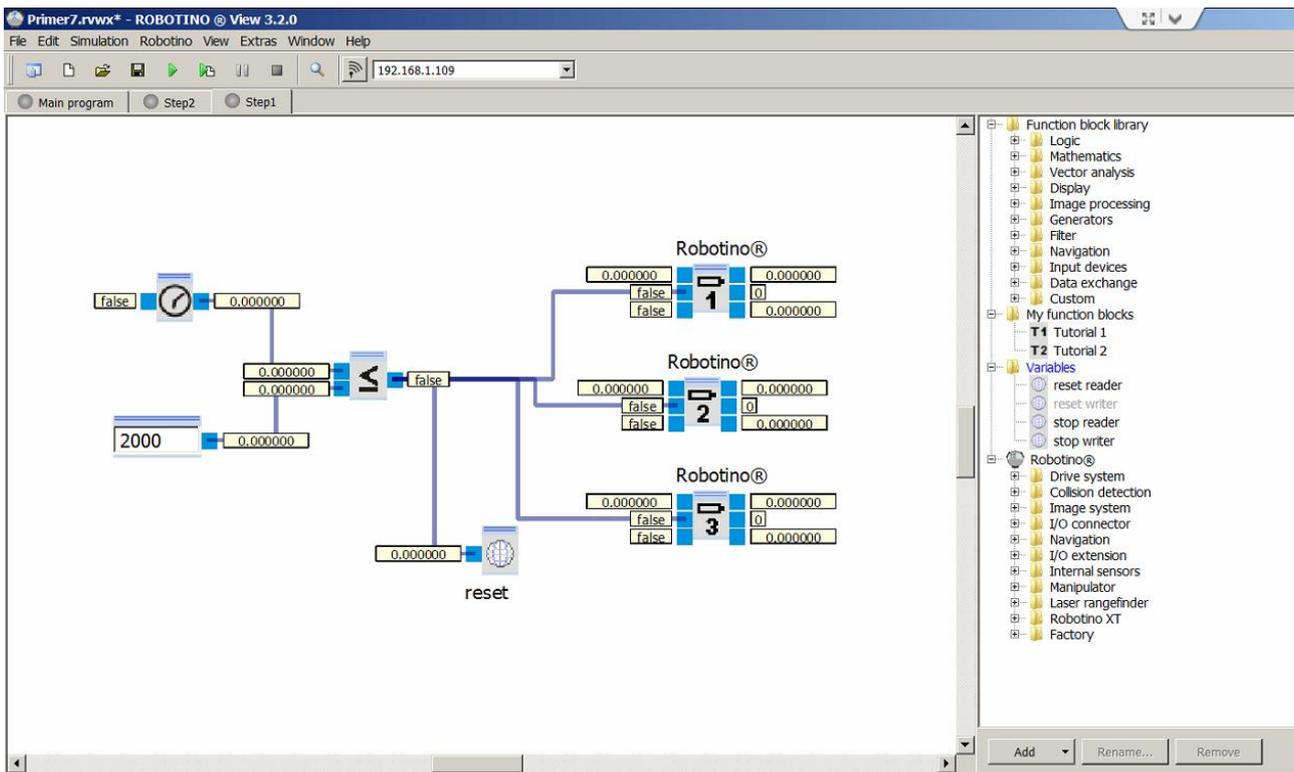


Figure 2. Robotino View programming environment

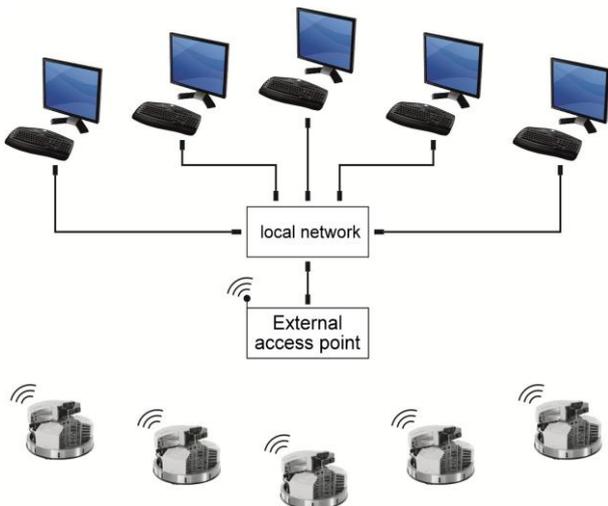


Figure 3. Different ways to setting up LAN [5]

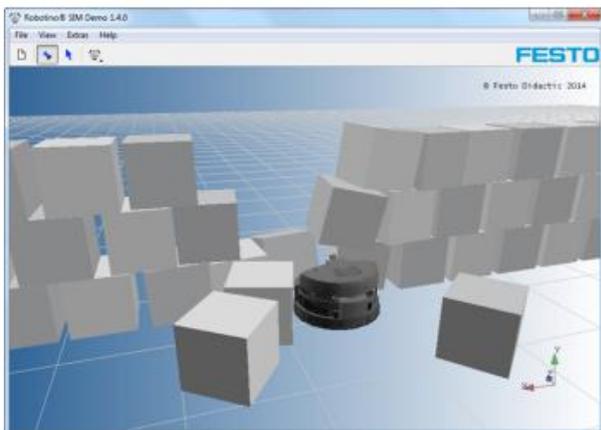


Figure 4. Robotino SIM tool

Constructivist approach to teaching [6] supposes taking into account the learner's existing

knowledge and skills during the learning process. We intend to demonstrate, in the case of the drive subsystem, the possibility of choosing the level of control complexity, depending on the individual knowledge and experience of the students.

### 3. DRIVE SUBSYSTEM

Drive subsystem consists of three independent drive units with its own power. Each unit consists of a servomotor, a gear unit and a main wheel. The main wheels are placed at an angle of  $120^\circ$  (Fig. 5).

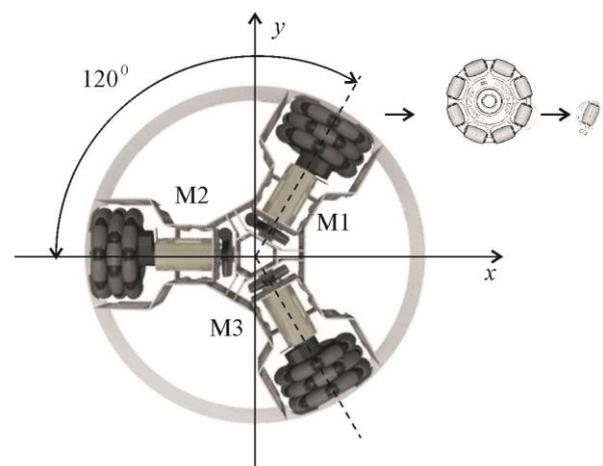


Figure 5. Robotino® omnidirectional drive

Auxiliary omnidirectional wheels (or casters) are tangentially built in the circumference of the main wheels. Auxiliary casters are barrel-shaped and enable the movement of each wheel practically in any direction with rotation on the spot. Thanks to

them, friction forces are reduced in the lateral movement of the drive wheels. Each of the main wheels has an active movement of its own drive motor and the passive lateral movement of the two remaining drives. Three brushed DC motors used as drive are controlled with feedback control loop. The rotational speed is measured by the incremental encoder. The information from the encoder is also used to determine the position of the mobile robot. A microcontroller connected to the FPGA module is used as a control unit. It can realize different control algorithm. A planetary gear unit with a transmission ratio of 32:1 is used between the drive shaft and the wheel.

The motors are controlled by independent control signals so that Robotino® has three degrees of freedom, two translational and one rotational motion. Rotation around the vertical axis is possible in both directions. The turning circle is equal to zero. There is no need for shunting.

Movement can be controlled in several different levels depending on the knowledge, experience, and purpose of the course. At the initial level, without any programming, you can use some of the standard Internet browsers through a desktop computer or one of the mobile devices. The GUI is used for communication, is shown in Fig. 6.



Figure 6. Web interface for manual control

After adjusting the desired motion speed  $V_{el} [m/s]$  and  $R-V [deg/s]$ , one of the directions of translational or rotation motion, is set. If necessary, Robotino® can be stopped at the current position. The interface in the circle on the left, with color change, indicates the presence of an obstacle. Signals are received from nine infrared distance sensors arranged in scope. Depending on the proximity of the obstacle, the radius colors change from blue (no obstacle) to red (the obstacle is very close).

For the first steps in Robotino® programming, the use of the *Robotino View* software tool is recommended (Fig. 2). For controlling of each of the servomotors, it is used one functional block (Engine #n) from the library *Drive system*. Fig. 7 shows the functional block for control of the motor No1.

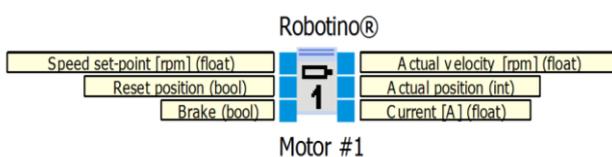


Figure 7. Motor #1 Function block

The interface of this block consists of three input (left side) and three output ports (right side). At the first input port we define desired rotation speed of the motor in [rpm]. This value can be constant or variable, positive or negative, and is stored in the variable of type float. The positive speed of each motor causes rotation of the robot in a counterclockwise direction. The actual motor speed can be read at the first output port. Boolean variable to the second input port resets the value of the incremental encoder of the motor. A reset signal can be generated by software or via one of the digital inputs. In relation to the position, when the reset is performed, the second output port shows the number of pulses (int) generated by the encoder. For one full turn of the motor shaft, the encoder generates 2048 pulses. On the basis of this data, the path that was passed by the appropriate omniwheel can be calculated. The relationship between the indication of the encoder ( $n_e$ ) and the angle of rotation of the motor ( $\varphi_m$ ) is given by the equation (1):

$$\varphi_m = \frac{\pi}{2^{10}} n_e \quad (1)$$

while the relation between the encoder value and the angle of rotation of the omniwheel ( $\varphi_w$ ) is given by the equation (2):

$$\varphi_w = \frac{\varphi_m}{2^5} = \frac{\pi}{2^{15}} n_e \quad (2)$$

Although encoder generates discrete signals on changing the angle, the resolution is high and practically register very small changes in angle. With omniwheel, they are less than 1/100 part of the degree.

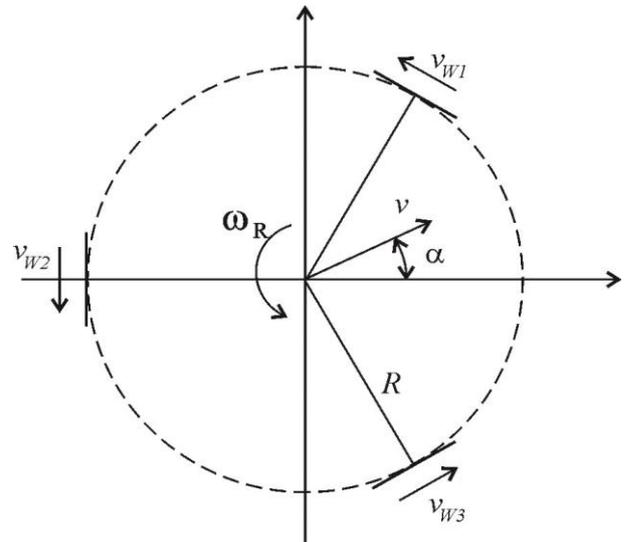
On the third output port, load current of the motor is measured. Using this information, trajectory optimization, in terms of electricity consumption, can be performed. The presence of a logical unit at the third input port stops the motor. As with the encoder reset, this signal can be generated by software or hardware through the I/O interface. Changing the direction of the motor rotation and sudden stop is realized by the H-bridge circuit. Moving the robot depends on the control signals on all three motors. The resulting velocity vector is equal to the sum of the velocity vectors of each omniwheels. Table T.1 gives a few examples of the relationship between robot motion and speed set-point ( $n_{sp}$ ) each of motors.

For predefined directions of motion, which are determined by the position of the motor in Robotino chassis, the speed set-point can have an arbitrary value. The speeds ratio of individual motors is only important. In order to establish a

connection between the movement of the robotic system and the rotation of the motor, it can be used the functional *Omnidrive* block shown in Fig.8.

**Table 1.** Relation between robot motion and motors speed set-point

Direction of the robot motion	Motor 1 [rpm]	Motor 2 [rpm]	Motor 3 [rpm]
Linear travel at the angle $0^0$	$-n_{sp}$	0	$n_{sp}$
Linear travel at the angle $60^0$	0	$-n_{sp}$	$n_{sp}$
Linear travel at the angle $120^0$	$n_{sp}$	$-n_{sp}$	0
Linear travel at the angle $180^0$	$n_{sp}$	0	$-n_{sp}$
Linear travel at the angle $240^0$	0	$n_{sp}$	$-n_{sp}$
Linear travel at the angle $300^0$	$-n_{sp}$	$n_{sp}$	0
Rotation on spot (counterclockwise direction)	$n_{sp}$	$n_{sp}$	$n_{sp}$



**Figure 10.** Relations between robot speed and wheel speed

i.e. the angular speed of the motor 1 [rpm] :

$$n_{M1} = \frac{1920}{\pi d} \left[ \frac{R\pi}{180} \omega_R - v \cos(\alpha + 30) \right] \quad (4)$$

Speed of wheel 2  $v_{W2}$  [mm/s] :

$$v_{W2} = \frac{R\pi}{180} \omega_R - v \sin(\alpha) \quad (5)$$

i.e. the angular speed of the motor 2 [rpm] :

$$n_{M2} = \frac{1920}{\pi d} \left[ \frac{R\pi}{180} \omega_R - v \sin(\alpha) \right] \quad (6)$$

Speed of wheel 3  $v_{W3}$  [mm/s] :

$$v_{W3} = \frac{R\pi}{180} \omega_R + v \cos(\alpha - 30) \quad (7)$$

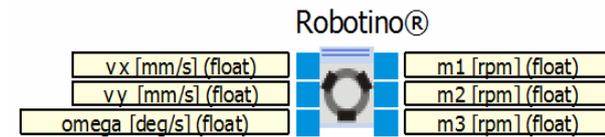
i.e. the angular speed of the motor 3 [rpm] :

$$n_{M3} = \frac{1920}{\pi d} \left[ \frac{R\pi}{180} \omega_R + v \cos(\alpha - 30) \right] \quad (8)$$

Fig. 11 shows the program written in Matlab® using equations (3) - (8) to realize the oscillatory motion along x axis according to the law:

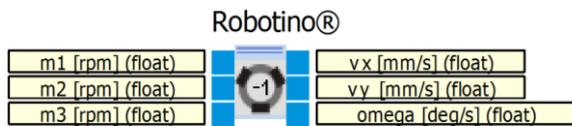
$$n_M = 200 * \sin\left(2 * \frac{2\pi}{T_{kraj}} * time\right) \quad (9)$$

Fig. 12 shows the changes of the reference/actual speed of Motor #1.



**Figure 8.** Functional block Omnidrive

At the input ports the speeds of translational motion along the x and y axis and speed of rotation around the vertical axis are set. As a result, the rotation speed of each motor is obtained at the output. The purpose of the Omnidrive functional block (inverse) (Fig. 9) is the opposite. Based on the speed of motor rotation, the motion speed in plane is determined.



**Figure 9.** Functional block Omnidrive (inverse)

If an additional analysis of robot movement is desired, e.g. in Matlab®, analytical relations that describe the relationship between these movements are given below. For the arbitrary motion of the mobile robot defined by the translation  $v$  [mm/s] and rotation  $\omega_R$  [deg/s] (Fig. 10), the speeds of the motors can be determined as follows.

Speed of wheel 1  $v_{W1}$  [mm/s] :

$$v_{W1} = \frac{R\pi}{180} \omega_R - v \cos(\alpha + 30) \quad (3)$$

```

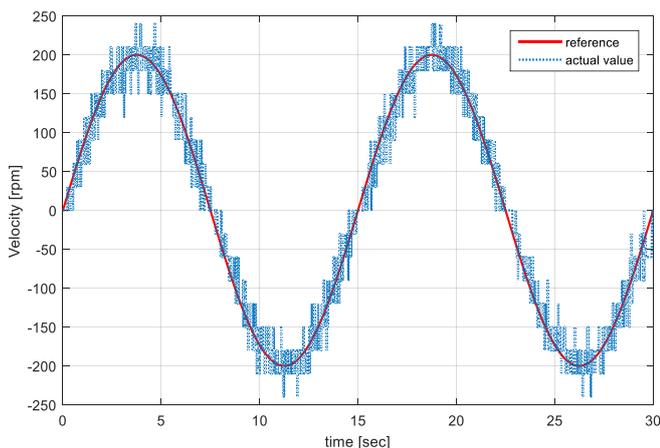
%Motor control
PridruziBiblioteke;
IPAdresa='192.168.1.109';%IP address
ComId = Com_construct; %Kanal za komunikaciju
Com_setAddress(ComId, IPAdresa);
Com_connect(ComId); %komunikacija
Motor1Id = Motor_construct(0);
%...
Motor_setComId( Motor1Id, ComId );
%...

tstart=tic;
k1=1;
Tkraj=30;
while toc(tstart)<=Tkraj
    time(k1)=toc(tstart);
    W1z(k1)=200*sin(0.3*time(k1));
    W2z(k1)=W1z(k1); W3z(k1)=W1z(k1);
    Motor_setSetPointSpeed( Motor1Id, W1z(k1));
    %...
    W1(k1)=Motor_actualSpeed(Motor1Id);
    %...
    k1=k1+1;
end

Motor_destroy(Motor1Id);
%...
Com_disconnect(ComId);
Com_destroy(ComId);

```

**Figure 11.** Matlab® program for motor speed control



**Figure 12.** Reference/Actual speed of Motor #1

#### 4. CONCLUSION

After a one-year experience, our impression is that the concept of Robotino® learning system is well-designed and consistent with state-of-the-art didactic equipment in the field of automation

technology. This is understandable because it is the product of one of the longstanding leaders in this field. However, the realization of this concept has not yet been brought to the end, especially in terms of accessory equipment (e.g., Robot arm) and supporting documentation (e.g. Manual) for more advanced applications. The documentation must be much more detailed for educational equipment. There are two reasons that justify this lack somewhat. First, Robotino® based technologies are developing rapidly and are in constant change. The only way to answer them is online support that is constantly updated. For example, for a home appliance, it is desirable that the instructions do not change anything. However, for one education-oriented system, improvement of opportunities is expected. It is interesting that online documentation of each Robotino® subsystem can also be accessed through its own web server. Secondly, Robotino® is a flexible system and is open to change. In addition to standard applications, illustrated by interesting project tasks, users are encouraged to develop their use case study. If the price is neglected, Robotino® is certainly a good choice for involving young generations into the Industry 4.0 flows.

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# Application of the RobotStudio software package for programming assembly robots

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**Abstract:** *Changes in world trade in goods and services, directed towards the globalization of the market and the desire of manufacturers to meet the demands of each individual customer, imposes ever more stringent demands on existing technology systems. The application of robotic systems in assembly significantly improves the performance of this technological system, reduces the time of assembly, increases the productivity and quality of assembled products. The paper presents the application of the RobotStudio software package for programming the work of the robot for assembly. An analysis of the assembly technology of the sub-assembly of the shaft was done, which is necessary in order to get the code used by the robot in the software package.*

**Keywords:** *Robotic systems; robot programming; assembly; modeling;*

## 1. INTRODUCTION

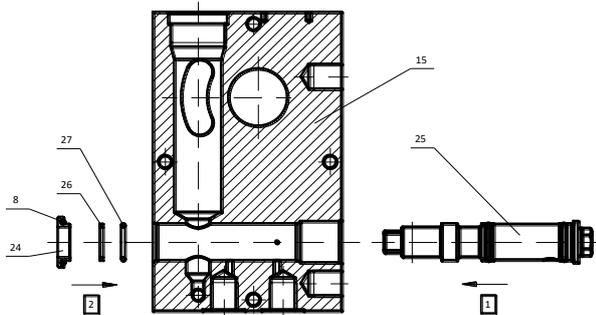
Nowadays, the world faces an accelerated development of science and technology and is in one of the stages that we often call the stages of revolutionary change. The development of the technique and the means of production was not even. The periods of accelerated development and relative stagnation were shifted. The most famous developmental jump, known as the Industrial Revolution, took place at the end of the eighteenth and early nineteenth century. It began in 1733 with the emergence of mechanized looms for weaving. The next major invention was a steam engine (1769), followed by a boom in the development of the technique and the means of production, from which came the name industrial revolution. Historically, there are a number of inventions and scientific achievements that have markedly marked the technical development of the world in certain periods. The development of science and new technologies, suggesting qualitative changes in production and society in general [1].

One of the essential factors of the new revolution is flexible automation, the inseparable part of which is robotic systems. The idea of robots originated first in science fiction. Even today, in discussions about robotic systems and everything they bring, it is difficult to avoid vision in the field of science fiction. Of course, robots are looking much more practical today because the stage of technology development allows this. These are very complex devices that could have arisen when those branches of science were developed on which today's robotics are based: machine theory, automated control theory, computer technology,

so-called methods. artificial intelligence, as well as sensor and converter technology. Robots are now seen as devices that allow for further and more flexible automation. They replace a man primarily in dangerous, monotonous and difficult jobs. Man remains jobs that require more intelligence, knowledge and creativity. Thus, robot systems contribute to the simultaneous increase of productivity and humanization of labor. The cost of product assembly significantly affects the total costs of its production and, therefore, the profit of the company. This is one of the reasons why it is necessary to make improvements and, in some cases, reengineering the process of assembly of the products of the metalworking industry. Based on the analysis carried out in the assembly sector of the 355 German companies in the machinery industry, it is pointed out that the main potentials of rationalization lie in designing the products, which are oriented towards assembly, and in the automation of assembly operations [2].

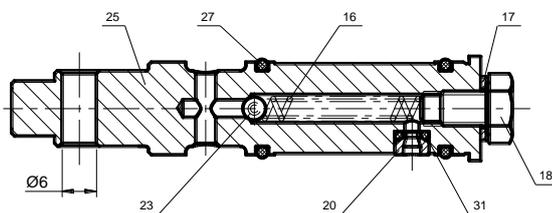
## 2. ANALYSIS OF THE TECHNOLOGY OF DISTRIBUTION OF THE DISTRIBUTION SHAFT

The mounting assembly consists of the pump body (position 15), the distributor shaft sub-assembly (position 25), the gaskets (positions 27 and 8), the ring (position 26), and the sub-assembly of the pad (position 24), Figure 1.



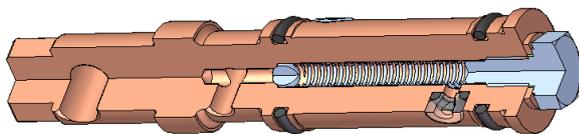
**Figure 1.** Assembly Plan of distribution shaft

The subassembly of the distribution shaft (Figure 2) consists of: a distribution shaft (position 25), a ball (position 23), two seals (position 27), springs (position 16), screw (position 18), washers (position 17), seals (position 20), and O-ring (position 31).



**Figure 2.** Distribution axis (cross-section)

The distribution shaft (position 25) is made of CuZn20.00 (brass), the outer cylindrical surfaces are machined with scraping and straight (quarter) milling. Holes and openings are made by drilling and depending on the class of roughness, expansion and expansion. The opening of the edges of the opening is carried out by the roller and conical feeders. The dimensions of the distribution shaft are  $\text{Ø}18\text{h}82,5\text{mm}$ . The  $\text{Ø}6 / \text{Ø}2,5, \text{Ø}5,2 / \text{Ø}3$  and  $\text{Ø}3,5$  holes on the distribution shaft are through which the working fluid passes. These are openings that divide the working fluid according to the corresponding openings on the body of the pump.



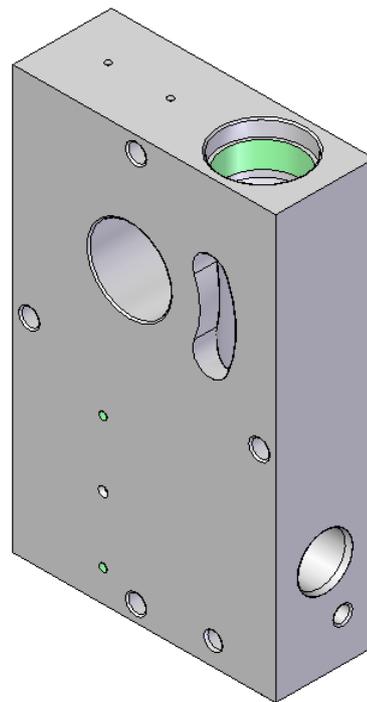
**Figure 3.** 3D model of distribution shaft (cross-section)

The sub-assembly of the distribution shaft performs the key role of pump management. A handle is mounted in the opening  $\text{Ø}6$  by means of which the control shaft is operated, i.e. the distributor shaft is rotated to the appropriate position to allow the flow of the working fluid through appropriate barriers on the distribution shaft and the body of the pump.

The pump body (position 15) is made of synthetic gray cast iron without oligo-elements (SL25). Flat surfaces are machined with milling. The holes, openings and edging of the edges are performed as

with the distribution shaft. The groove is made by milling. The dimensions of the pump body are  $80\text{h}30\text{h}130\text{mm}$ . The hole for mounting the distribution shaft is  $\text{Ø}16$ , the roughness class N6, which is extended to the  $\text{Ø}18$  at the front, 17.5mm in length from the edge of the opening, which is  $1/15^\circ$ . Between the diameters  $\text{Ø}16$  and  $\text{Ø}18$ , a transitional cone is

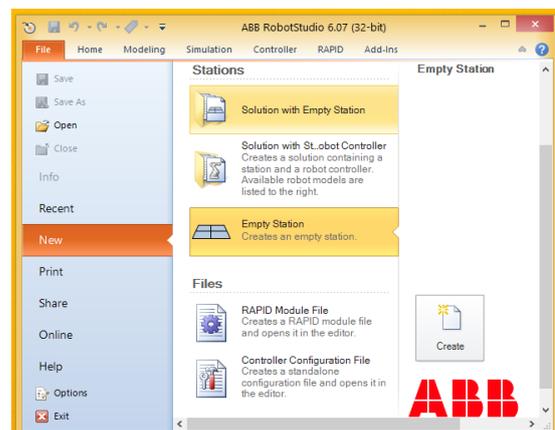
made of  $1.8 / 45^\circ$ . The other side of the opening is  $1.8 / 15^\circ$ . There are also openings for the inlet and outlet of the working fluid.



**Figure 4.** 3D body model of the pump

### 3. STARTING AND SELECTING A ROBOT SYSTEM IN THE ROBOT STUDIO SOFTWARE PACKAGE

The simulation was made in the RobotStudio software package (hereinafter RS), version 5.15.02, of the ABB company whose robot is used. After starting the program, select Create new station, and then the Empty station project (Figure 5).



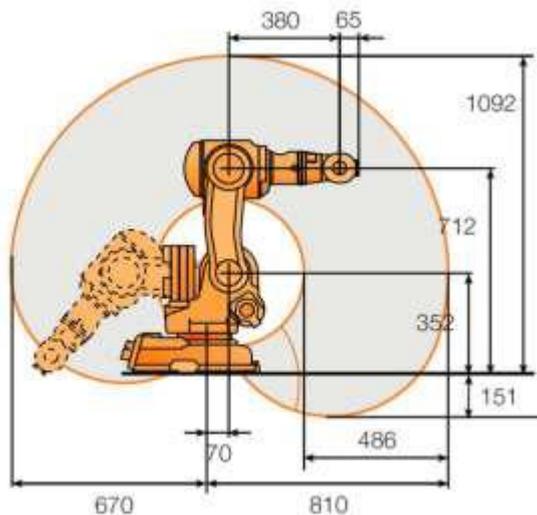
**Figure 5.** Create a new empty project

According to the task the robot needs to do, we choose the desired robot for assembly. In our case, this will be the robot IRB 140, from a series of small industrial robots. The IRB 140 has a load of 6 kilograms. It is primarily intended for work: assembly, packaging, cleaning, material handling, etc. (Figure 6).



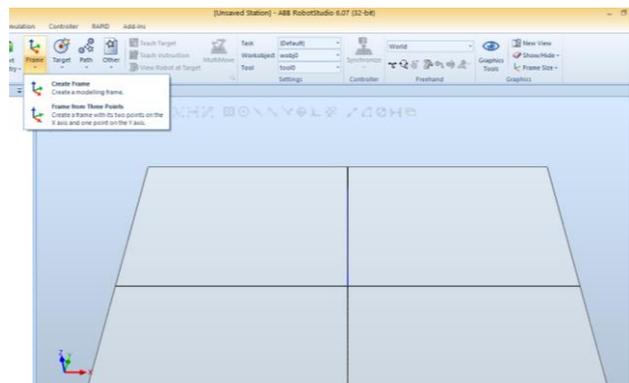
**Figure 6.** ABB robot IRB 140

When introducing robots into the technological system of assembly, a number of technical and technological criteria should be considered. It is necessary to pay attention to the robot working space defined by the manufacturer [3] (Figure 7).

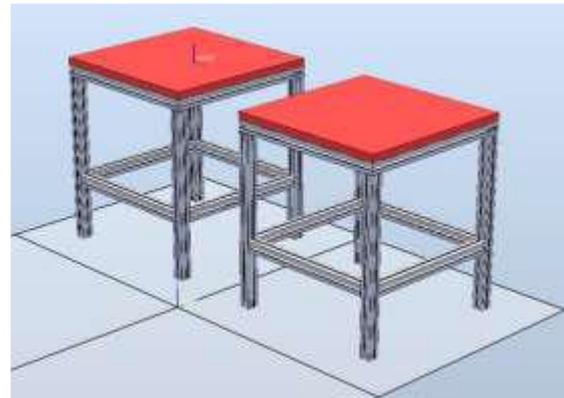


**Figure 7.** Robot working space ABB IRB 140

In order to introduce the robot model into the workspace, in the RS software package, it is necessary to use the ABB library option and select the robot IRB 140. After that, it is necessary to introduce into the program of the robot stand and the table where the assembly process takes place. In RS, we use the Import Geometry option by importing table models converted into the appropriate format (.SAT). Imported models are positioned relative to the robotic coordinate system (Figure 8, Figure 9).

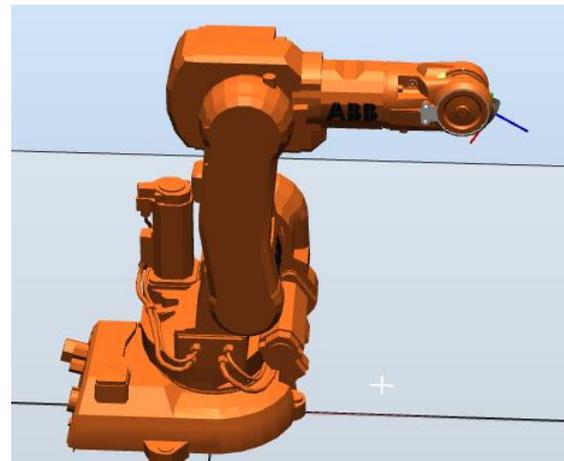


**Figure 8.** Positioning of the imported geometry



**Figure 9.** Positioned tables in the workspace

After positioning in the workspace, which is important for us to know exactly where the object is located, we place the IRB 140 robotic arm on the first working table with the Set position option. It is necessary to install the components to be installed on the second table (Figure 10).



**Figure 10.** Positioning the robot on the desk

When placing robots and deciding about the position of the working model, it is necessary to take into account the maximum range of robots (the IRB140 has a maximum range of 810mm) and this robot can perform the assembly process.

The robotic arm has the ability to attach various mounting tools. It is important to pay attention to the central point of the tool (TCP; tool center point) ie. its coordinate system. At that point, the robot has a clamp where mounting tools are installed [4] (Figure 11).

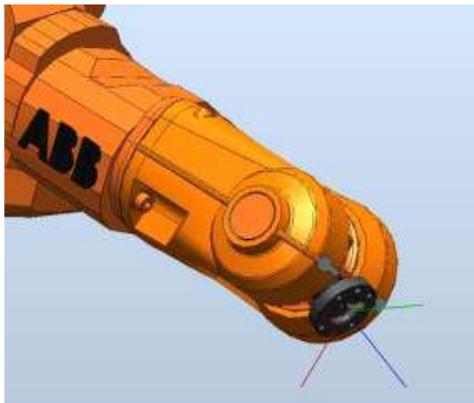


Figure 11. Display TCP and tooltip

#### 4. Application of Robot Studio software package for determining the path of robots for mounting the distribution shaft

To be able to "drive" a robot at the desired installation path, we need to "learn" where these paths are. Consideration should be given to the installation technology so that the robot's paths during installation are as simple as possible. The main option of the RS to generate the path of a robotic arm is Path, AutoPath. It is located in the Home window, in RobotStudio (Figure 12)

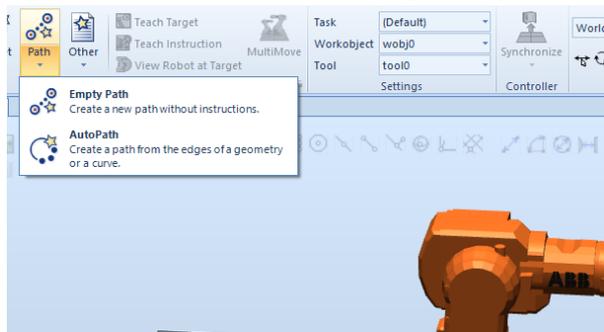


Figure 12. AutoPath option to generate routes

After marking all the desired paths for mounting, it is in order to set the basic orientation of the PKI mounting tool. We set this position to be in line with the central tool robot point. This was done in a way that we marked the position ie. target number 10 (Target 10), and with the Modify Target tool, Set rotation, determine the position of the mounting tool (Figure 13).

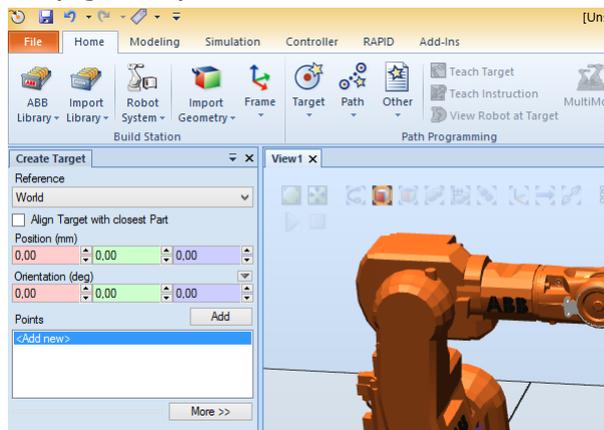


Figure 13. Setting the basic position of the tool

After positioning as in Figure 13, right-click the same target (target) and select the Copy Orientation option from the drop-down menu. The next step is to mark all the positions (targetes) in the dropdown menu of our work object (workobject) and right-click to open the drop-down menu and apply the same orientation to the whole set (Apply orientation). After the correct basic orientation, the necessary step is to re-mark all the positions of the mounting tool (target) and use the option to check the availability of all positions (Reachability). We see a check in Figure 14.

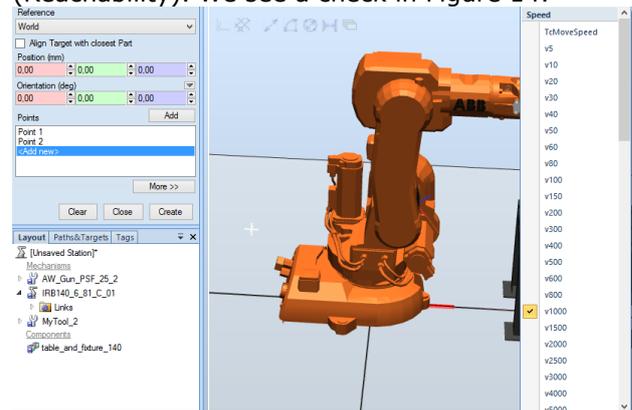


Figure 14. Check availability of movement position

With the availability of all robotic arm positions, we begin with the configuration of the path of the robotic arm towards the chosen path. This will be done by marking the path of the robot arm from the Path tools category, select the Auto Configuration tool (Figure 15). After choosing a robot path configuration, we can repeat the use of the Auto Configuration tool to see the simulation of robot traffic along a given path.

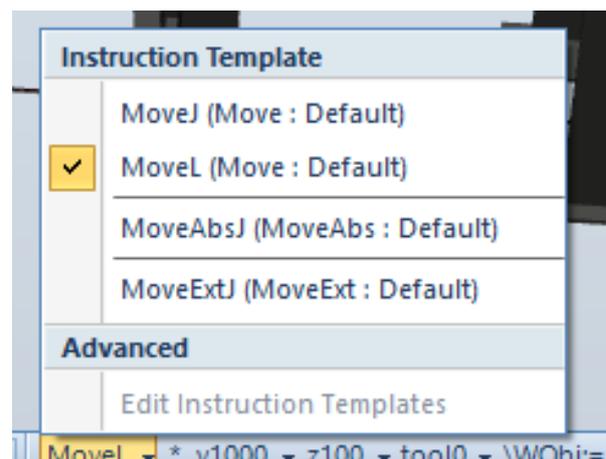


Figure 15. Configuring the movements of a robotic arm

The procedure is repeated for each path. Check the available movement and possible gestures in the gestures. It is possible that the robotic arm, using a linear movement, can not reach the desired position. Then the first option is to define motion as a movement of a joint (MoveJ; move joint). This is done by choosing Move; Path and using the Modify instructions to change the type of motion from the linear to the joint, (Figure 16). In the presented

Modify Instructions, it is also possible to change the speed of the movements of the robotic arm.

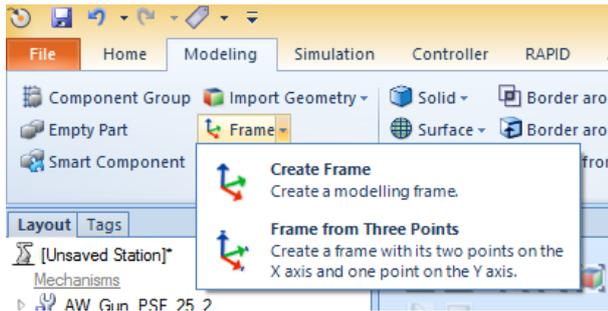


Figure 16. Option to change instructions

**5. Simulation of the assembly process in the Robot Studio software package**

After making the path, it is necessary to create a simulation of the given assembly. First, we need to choose the robotic system that we will use, in our case, this is the IRB 140. We do this in the way that under the Home part of the RS, we select the Robot System option, and set the system for our selection of the robotic arm.

The next step is synchronization with the virtual controller in RS. In the program under the part RAPID, we use the Synchronize to VC option, marking all the options, starting the synchronization (Figure 17)

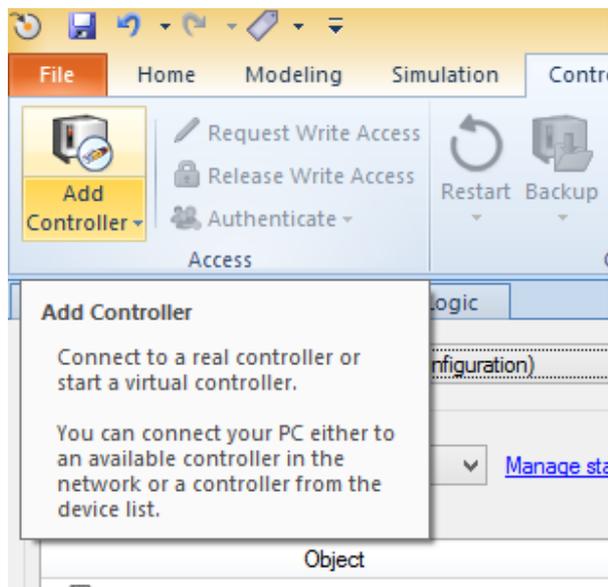


Figure 17. Synchronization of the virtual controller

After the synchronization has been performed, it is necessary to set the order of installation according to the set paths. This is done under the part of the RS program, called Simulation. Select the Simulation setup option. In the newly opened window, from the available Procedures for assembly, we route the routes to the main sequence of the robotic arm (Main Sequence T\_ROB1). By selecting Active Tasks, by marking our previously created robotic system, it is possible to select the execution of the main sequence continuously or only one cycle (Figure 18).

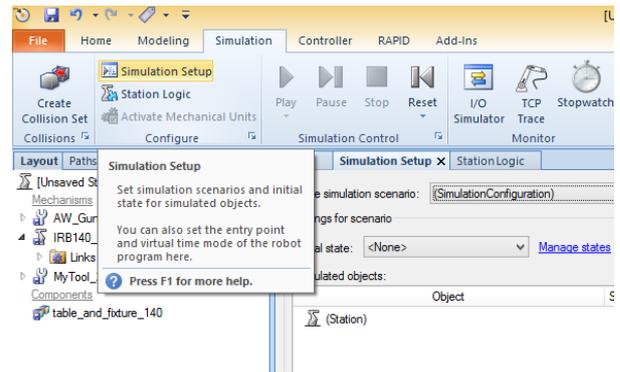


Figure 18. The main sequence of the simulation

After selecting the routes for executing the main sequence of the robotic arm IRB 140, it is only necessary to run the assembly simulation process, simply by commanding the Play command from the simulation part of the RS program. The robotic arm performs assembly by default, with minimal error, high precision and high speed.

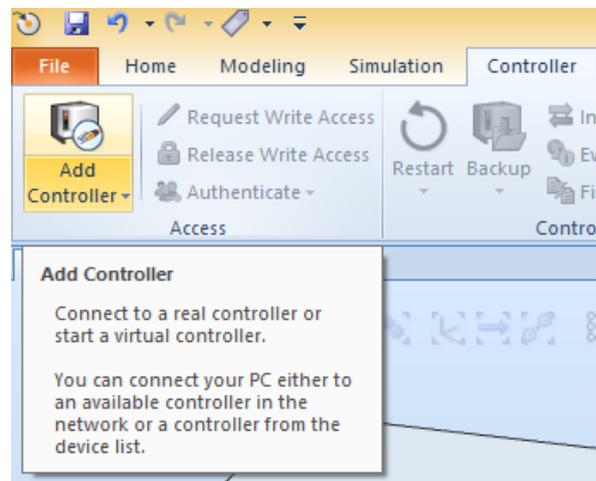


Figure 19. Synchronization of the virtual controller

The environment in which the assembly process takes place is shown in Figure 20.

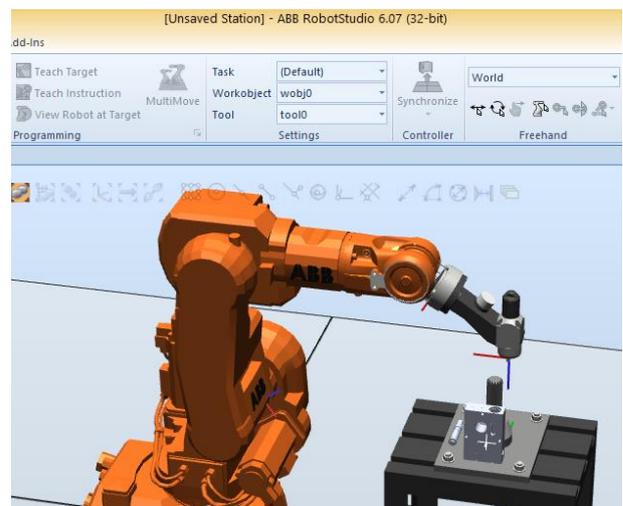


Figure 20. The main sequence of the simulation

## 6. Conclusion

Application of the robotic system in the assembly process significantly reduces the time of assembly and increases the productivity of the company. It is necessary to analyze the installation technology of the product itself so that the robot performs the assembly process in the shortest possible way and in the best possible way. Robot programming itself is very easy with graphic support in the form of images that simply describes what needs to be included in a program for simulating the robot operation, and then generates the code for managing the robot operation.

This paper discusses the process of assembling a single sub-assembly, but this robot programming process can be applied to assemble the entire manual pump. Two robots working simultaneously can be programmed.

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# Creating an Android Weather Forecast Application in the Android Studio

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**Abstract:** A large number of requests that can be made on a computer can now be realized on smartphones or tablets. Because of their high hardware performance, mobility and low cost, smart mobile devices take on the primacy of classical computers in many spheres of life. The smart mobile software market is rapidly increasing, and the need for experts in this field is enormous. In this paper an analysis of operating systems of mobile devices was performed, the most commonly used development environment for application programming, and the process of development of weather forecast application on the Android platform is shown.

**Keywords:** Android; Java; smartphones; application

## 1. INTRODUCTION

The development and application of information and communication technologies (ICT) brings major changes in all segments of the society. Expansion of the development of smart mobile devices at the beginning of the 21st century has opened a new large software market, ranging from the development of operating systems to the development of applications for various applications. The leader in the mobile operating system market is the Android platform with 74.23%, followed by the iOS platform with 20.84%, while all other mobile operating systems have a negligible small market share ([1], March 2018). Various development environments are used for programming mobile applications: Firebase, iOS SDK, Visual Studio, OutSystems, Xcode, Fabric, Android Studio and others. It is very important to define basic knowledge and modern software packages necessary for the development of software in the field of mobile devices. As the changes in Information Technology (IT) are very fast, it is necessary that the school system at all levels is flexible and modular, so it can quickly respond to the needs of the economy and society.

## 2. DEVELOPING A MOBILE ANDROID APPLICATION FOR WEATHER FORECAST

This paper presents the process of developing a mobile android application for the weather forecast. To create this application, the development environment Android Studio, as well as the Java programming language, was used. In addition to Java, starting with Android Studio 3.0.0, the Kotlin programming language is

officially supported. Within this work, Android Studio 3.0.1 and Java programming language was used. When creating each application, it is necessary to create a new project first. Creating a new project takes place in a few simple steps. When launching Android Studio, we should select the "Start a new Android Studio project" option and assign the name for project, in this case it will be "WeatherApp" (Figure 1).

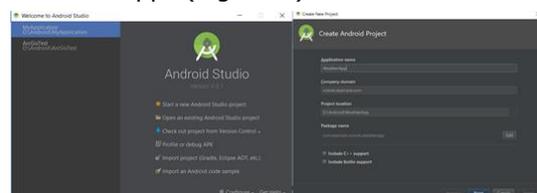


Figure 1. Development environment Android Studio 3.0.1

In the next step, we choose for which type of devices the application is going to be made: mobile smartphones and tablets, smart watches or televisions, as well as versions of the android operating system (Figure 2). In the final step, there is a possibility that the new project has pre-defined dedicated screens, such as the Google Maps screen, the Login screen, the Settings screen, and etc.

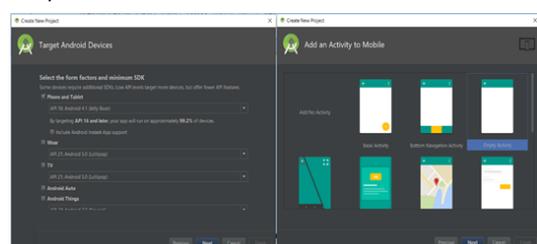


Figure 2. Device and android version selection

If no pre-defined screens are required, we select "Empty Activity" option and assign name for the activity, after which the process of creating a new project is completed. Before the development of application, it is necessary to get acquainted with the basic components that are used when creating android applications. These are "Activity", "Service", "Broadcast Receiver" and "Content Provider" [2]. Activity is one screen of the application. It consists of two part, one is the xml file, which represents the user interface, a screen that is visible to the user. The second part is a java class that responds to events when a user interacts with the screen. Each multi-screen application generally has different activity for each screen. The service is similar to activity, with the difference that it does not have an xml file and serves to perform tasks in the background so that the performance of the application would be better. The selected service is executed on the main thread, but with certain classes such as "Handler" or "AsyncTask" the code executed in the service can be transferred to the background thread. The service can be used to play music in the background, download data from the server, etc. Broadcast receivers are used to reply to broadcast messages that are sent from other activities or the android system itself. For example, if an application needs to know if the phone's screen is turned on or off, it can register and listen to the messages sent by the system, in this particular case, the messages for "SCREEN\_ON" and "SCREEN\_OFF" in order to get the appropriate information. Content providers serve to obtain certain data and are mainly used to communicate with the database. For example, using the content provider, we can get SMS messages that are stored on the device or missed calls.

Another important element in creating android applications is knowledge of the life cycle of the activity. Each activity has its own life cycle and phases in that cycle. There are several stages in which an activity can be found and through the predefined methods it informs the programmer in which phase it is located. Figure 3 shows the life cycle of the activity.

The "onCreate()" method is called when activity is first created. In this method, the initialization of the objects being used is mainly carried out. The "onStart()" method is called when activity is first visible to the user. When the "onResume()" method is invoked, the user can interact with the application. When the application switches to the background, the method "onPaused()" is called. The "onStop()" method is called when the application is no longer visible to the user after which either "onDestroy()" or "onRestart()" is called. If the application is "killed" by the user or system, the "onDestroy()" method is called, and if

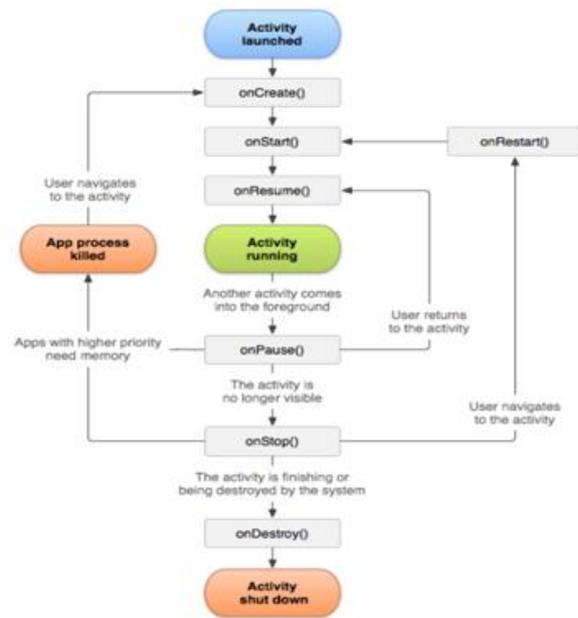


Figure 3. The Activity Lifecycle [3]

it is restarted, the "onRestart()" method is called after which the "onStart()" method is immediately invoked. To create a weather app, we need one of the services that provide information about the current weather forecast for a specific location. There are various services that provide this information, some are free, some are commercial, and there are also those that represent a combination of these two types, there are parts of the information that are the free, and also the parts that is paid. During the implementation of this application, the service "Dark Sky" was used, which can be found at <https://darksky.net/forecast/40.7127,-74.0059/us12/en>. The first step is to create an account on the site using email addresses and passwords. After creating an account, the key that is necessary for obtaining information about the weather is obtained. The site provides details on the information that can be obtained and how this service works. Data is obtained as a json file. Figure 4 shows the process of obtaining a key.

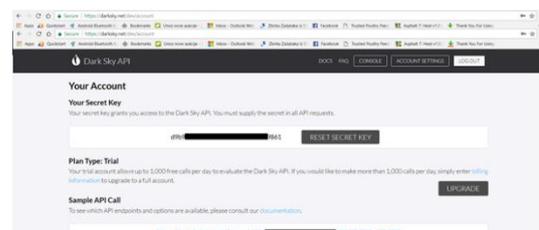
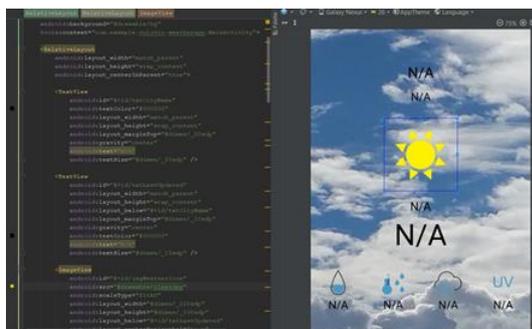


Figure 4. Creating account for „Dark Sky" service

When creating a new project, the activity for application is automatically generated and it is called "Main Activity". As already mentioned, it consists of a java class called "Main Activity" which inherits the "Activity" class and the xml file that will represent the user interface called

"activity\_main.xml". The next step in developing this application is to create a user interface using the xml file and certain components such as "TextView", "ImageView", and components that allow the layout of components on the screen such as "RelativeLayout" and "LinearLayout". These components can be added via xml file or via java code in the java class. In this case, the components are added directly to the xml file. As the names themselves suggest, "TextView" is used to display text, and "ImageView" to display images. Each component serves to display certain information on the screen. From the above, it is necessary to add more "TextView" components that will be used to display the text and also weather information for the location for which we search weather forecasts, the time of the last update, a brief description of the weather forecast, the current temperature, as well as the humidity, pressure, wind speed and UV indexes. "ImageView" are used to display graphic elements on the interface, such as background images, graphics that represent the current weather situation and etc. The size and color of the text as well as the size of the images are also defined in the xml file. After adjusting and positioning the components on the screen, we need to connect the elements from the xml file with the java class, in order to be able to display the data that is obtained, and also we need to implement the logic for collecting data from the server. It is important to note that each component added to the xml file must have its unique "id" so that it can be connected to the java class. Figure 5 shows the created xml file.



**Figure 5.** Creating xml file

After creating the interface, it is necessary to connect the xml file with the java class, as well as the components that are used in the xml file. When creating a new activity, the connection process of java classes and xml files takes place automatically by calling the "setContentView (R.layout.activity\_main)" method that is called in the "onCreate()" method. The next step is to connect a component from an xml file to a java class by creating an object of the appropriate type and calling the "findViewById (int id)" method. Connecting a component for displaying text can take the following form: `TextView txtTemperature = findViewById (R.id.txtTemperature)`. It is

important that each component in the xml file has its own unique id so the connection would be successful. The same principle applies to connecting other components, such as `ImageView`. After this step, it is possible to dynamically display text on the screen by simply calling the "setText (String s)" method using the `TextView` object. The "setImageResource (Resource id)" or "setImageBitmap (Bitmap bm)" can be used to set up images using the `ImageView` object.

In order to display the desired textual and graphical data on the user interface, it is necessary to load these data from the service on which the user account is created. Information about current temperature, brief description of current weather conditions, pressure, humidity, wind speed and direction data are required. To obtain these data, an auxiliary class is created under the name "MyWeather". This class will contain all the information that is needed for display on the screen. The object of this class is initialized when the application receives a response from server. Before communicating with the server, it is necessary to determine the geographical length and width of the place where the user is located. To obtain these data, it is necessary to grant the appropriate permissions: "android.permission.ACCESS\_FINE\_LOCATION" and "android.permission.ACCESS\_COARSE\_LOCATION". Also, for the communication with the server, the "android.permission.INTERNET" permission is required. After the granting this permission, using the "LocationManager" we can detect the current geographic position of the user. The current location information is obtained in the pre-defined method "public void onLocationChanged (Location location)" that passes the "Location" object. Using "Location" object, we can get location information and then the request is sent to the server to get weather information. The request is sent via the auxiliary `AsyncTaskHelper` class that inherits the `AsyncTask` class. The reason for using the class that inherits the `AsyncTask` class is that in this way, the request will be sent to the server in a background thread, so the main thread of the application is not affected. This class has its own method "String doInBackground (Void ... voids)" within which the request is defined, and depending on the performance of this method, it returns the corresponding string as a return parameter. Sending requests is done by writing the following code:

```
URL url;
URLConnection urlConnection = null;
try {
    url = new URL(query);
    urlConnection = (URLConnection)
        url.openConnection();
```

```

BufferedReader r = new BufferedReader(new
InputStreamReader(urlConnection.getInputStream()
));
StringBuilder total = new StringBuilder();
String line;
while ((line = r.readLine()) != null) {
total.append(line);
}
ParseJSON(total.toString(),myWeather);
return "OK";
}
catch (Exception e)
{
return "Error";
}
}

```

Using "HttpURLConnection" and "URL", a request is sent to a specific address, in this case it is the address provided by the Dark Sky service, after which desired data is received. Data is obtained in the form of an json file and using the method "ParseJSON(String data, MyWeather myWeather)" we perform data parsing that is received from server and at this point we initialize the "MyWeather" object. The following code is created for data parsing:

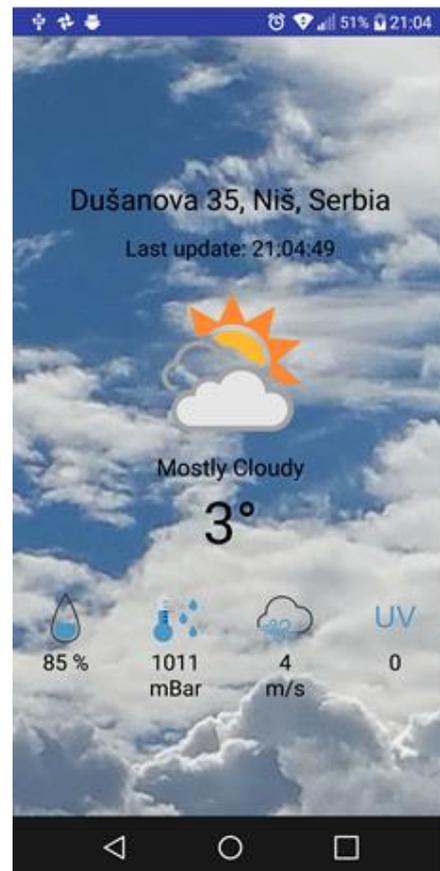
```

private void ParseJSON(String data,MyWeather
myWeather)
{
try {
JSONObject jsonObject = new
JSONObject(data);
JSONObject currentWeather =
jsonObject.getJSONObject("currently");
myWeather.setLastUpdate(currentWeather.getInt("t
ime"));
myWeather.setDescription(currentWeather.getStrin
g("summary"));
myWeather.setIcon(currentWeather.getString("icon"
));
myWeather.setTemperature(currentWeather.getDou
ble("temperature"));
myWeather.setHumidity(currentWeather.getDouble(
"humidity"));
myWeather.setPressure(currentWeather.getDouble(
"pressure"));
myWeather.setWindSpeed(currentWeather.getDoubl
e("windSpeed"));
myWeather.setUvIndex(currentWeather.getDouble("
uvIndex"));
} catch (Exception e) {
e.printStackTrace();
}
}
}

```

If there is no error in communicating with the server or during data parsing, the return parameter is string "OK", and if an error has occurred, "Error" string is returned. AsyncTaskHelper has another important method, "onPostExecute (String s)" that is called when the "doInBackground" method is executed. This method is important because it reads the return parameter that is sent from "doInBackground" method. If there were no errors, the main activity is notified that new weather information has been received and the user interface is refreshed. In

order to communicate with the activity, an auxiliary interface has been created, which has two methods, "onResultSuccess (MyWeather myWeather)" which is called if "OK" is received from the "doInBackground" as a return parameter. In the event that the string "Error" is returned as the return parameter, the "onResultFailed ()" method is used to inform the main activity that an error has occurred. In the end, using "Populate(MyWeather myWeather)" method main activity displays the data on the user interface. The appearance of the user interface after successful acceptance of data is shown in Figure 6.



**Figure 6.** User interface for weather application

Below is a presentation of the "Populate" method, which displays the data:

```

private void Populate(MyWeather myWeather)
{
txtCityName.setText(myWeather.getCityName());
txtLasUpdate.setText(myWeather.getLastUpdate());

txtDescription.setText(myWeather.getDescription())
;
txtTemperature.setText(myWeather.getTemperatur
e()
);
txtHumidity.setText(myWeather.getHumidity()
);
txtPressure.setText(myWeather.getPressure());
txtWindSpeed.setText(myWeather.getWindSpeed())
;
txtUVIndex.setText(myWeather.getUVIndex());
imgWeatherIcon.setImageResource(getResources().
getIdentifier(myWeather.getIcon(),"drawable",getPa
ckageName())); }

```

### 3. CONCLUSION

The development of a modern information society must be based on the application of new ICT technologies. The use of smart mobile devices in all segments of society requires the development of new mobile applications. The global software market in this area is growing at a tremendous pace, so the need for education of IT specialists is very high. This trend of the development of modern technologies enables the rapid development of the economy in the IT sector. Of great importance is the advancement of the educational system, which must be modular and dynamic, so that it can quickly implement new technologies into plans and programs in all of the levels of education.

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# Simulations of Analog Circuits in Multisim Software Suite

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**Abstract:** *In the field of Electrical Engineering students' education, the experiments including hardware and software components have an important role. Students mostly gain theoretical knowledge with some or none actual experience, so the development of various simulations if the actual hardware is unavailable can in some part satisfy the need for the practice. In this paper, we elaborated the topic of creating simulations of real analog circuits in Multisim software suite, and their analysis with NI Elvis II+ hardware platform. The students were interviewed about their opinion on these simulations, and their answers confirmed their satisfaction with the realized experiments.*

**Keywords:** *analog circuits; hardware simulations; Multisim; NI Elvis II+; software simulations;*

## 1. INTRODUCTION

Every theoretical analysis of the systems can be complicated for the students of engineering if they are not familiar with software simulations of these systems or actual hardware components. National Instruments' Multisim software package is easy to use and achieves real time simulation of analog circuits. This software is accompanied by NI Elvis II+ hardware device which can be used in laboratory while exercising the simulations, measurements, and designs of real life systems. The aforementioned device, together with LabVIEW and Multisim, can be used as an excellent replacement for many other laboratory devices, such as digital multimeters, oscilloscopes, Bode analyzers, function generators, etc. The idea of the experiments given in this paper is to familiar students with certain analog circuits' mode of operation. Furthermore, they are meant to provide an answer to question if the software simulations are sufficient compared to actual hardware simulations, and to facilitate the study and understanding of theoretical concepts of these circuits.

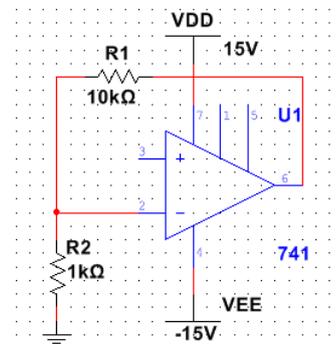
## 2. ANALOG CIRCUITS

The students throughout their entire education get in touch with the systems comprised of analog circuits, and that's the reason for studying these circuits. Since passive and active electronic elements are relatively cheap nowadays, the exhibition exercises with real circuits are feasible, involving the students' activities regarding the oscilloscope measurements and tracking of the signals emerging in these systems. For every circuit realized in this paper, whether in Multisim software

or with real elements, the passive and active electronic elements were used, such as resistors, capacitors, and operational amplifiers (LM 741 circuits).

### 2.1. Non-inverting operational amplifier

The schematic of the non-inverting operational amplifier is shown in Fig. 1.



**Figure 1.** *The schematic of the non-inverting operational amplifier*

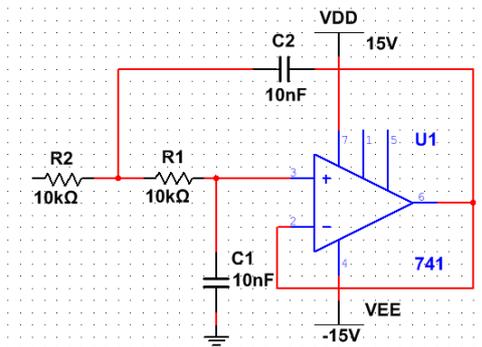
The feedback, realized with  $R_1$  and  $R_2$  resistors, returns the signal from output to the inverting input in order to achieve the final gain of the operational amplifier. It is of extreme importance that the gain does not depend solely on the operational amplifier, but on the choice of values for  $R_1$  and  $R_2$ . The output signal is in phase with the input signal, and equation that describes gain [1], [2]:

$$A = 1 + \frac{R_1}{R_2} \quad (1)$$

The values of resistors in the selected example are  $R_1 = 10 \text{ k}\Omega$  and  $R_2 = 1 \text{ k}\Omega$ , so the total gain is then  $A = 11$ .

### 2.2. Low-pass filter

The Fig. 2 shows the schematic of the low-pass filter.



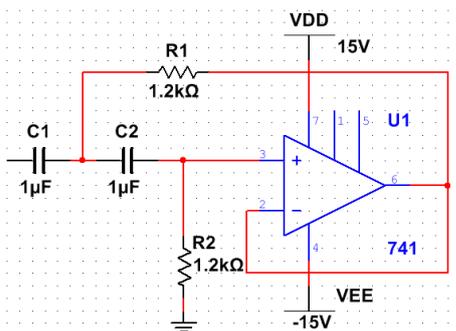
**Figure 2.** The schematic of the low-pass filter

The low-pass filter passes the frequencies lower than the cutoff frequency  $f_g$  which is calculated as [1]-[3]:

$$f_g = \frac{1}{2\pi\sqrt{R_1R_2C_1C_2}} \approx 1591.5 \text{ Hz} \quad (2)$$

### 2.3. High-pass filter

The Fig. 3 shows the schematic of the high-pass filter.



**Figure 3.** The schematic of the high-pass filter

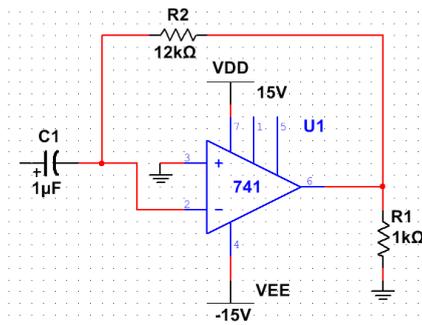
The high-pass filter passes the frequencies higher than the cutoff frequency  $f_g$  which is calculated as [1]-[3]:

$$f_g = \frac{1}{2\pi\sqrt{R_1R_2C_1C_2}} \approx 132 \text{ Hz} \quad (3)$$

### 2.4. Differentiator

The Fig. 4 shows the schematic of the differentiator.

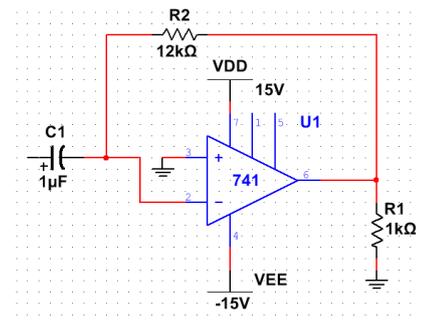
The differentiator is an electronic circuit in which the output voltage is directly proportional to the rate of change (time derivative) of the input voltage [1], [2].



**Figure 4.** The schematic of the differentiator

### 2.5. Integrator

The Fig. 5 shows the schematic of the integrator.



**Figure 5.** The schematic of the integrator

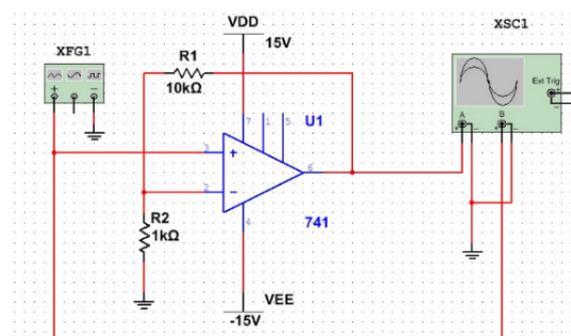
The integrator is an electronic circuit in which the output voltage is directly proportional to the time integral of the input voltage [1], [2].

## 3. MULTISIM SIMULATIONS

All aforementioned analog circuits are simulated in Multisim software. The realization of the analog circuits is done by interconnecting the basic components, and the simulation can be monitored in virtual oscilloscopes and Bode diagram analyzers [4].

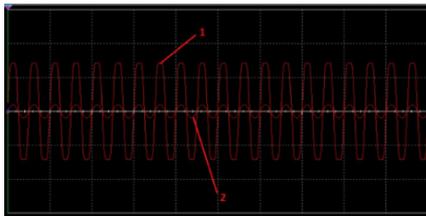
### 3.1. Non-inverting operational amplifier

The Fig. 6 shows the realization of the non-inverting operational amplifier in Multisim.



**Figure 6.** The realization of the non-inverting operational amplifier in Multisim

The Fig. 6 clearly shows the function generator and the oscilloscope that is connected to the output of the amplifier and to the function generator. In this way, the oscilloscope will display two signals for their comparison. The oscilloscope display is shown in Fig. 7.

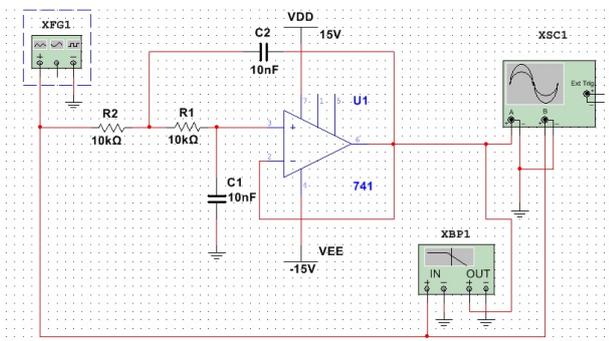


**Figure 7.** The oscilloscope display for the non-inverting operational amplifier

As can be seen from Fig. 7, the oscilloscope displays two signals: (1) output signal from the amplifier, and (2) input signal to the amplifier (function generator signal), with frequency of 100Hz and amplitude of 1 V.

### 3.2. Low-pass filter

The Fig. 8 shows the realization of the low-pass filter in Multisim.



**Figure 8.** The realization of the low-pass filter in Multisim

Along with the function generator and oscilloscope, in order to show the amplitude and phase characteristic of the filter, the Bode analyzer is added.

The Fig. 9 shows two signals: (1) input to the low-pass filter (output from the function generator), signal with frequency of 5000 Hz and amplitude of 2 V, and (2) output of the low-pass filter.



**Figure 9.** The oscilloscope display for the low-pass filter

As can be seen from Fig. 9, the output amplitude characteristic of the filter is significantly lower than the input amplitude characteristic, because the frequency of the input signal is much greater than the cutoff frequency of the filter.

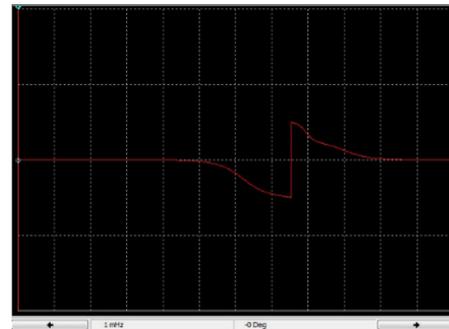
The Fig. 10 shows the amplitude characteristics of the low-pass filter. The blue line intersects with the amplitude characteristic at the point of -3dB and that point represents the filter cutoff frequency. The calculations in (2) showed that the cutoff frequency is 1591.5 Hz, and the Fig. 10 shows that

this parameter has the value of 1022 Hz. Thus, it can be said that even though these circuits are simulated, they actually represent the real hardware circuits.



**Figure 10.** The amplitude characteristics of the low-pass filter

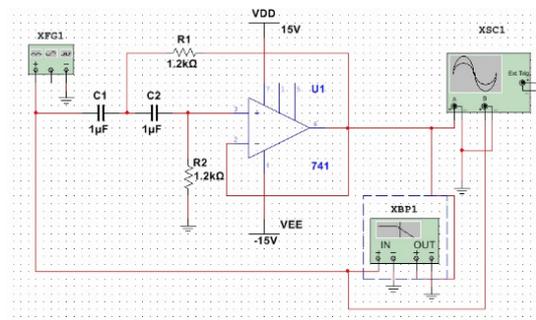
The phase characteristics of the low-pass filter is shown in Fig. 11.



**Figure 11.** The phase characteristics of the low-pass filter

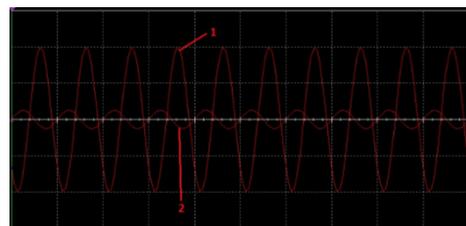
### 3.3. High-pass filter

The Fig. 12 shows the realization of the high-pass filter in Multisim.



**Figure 12.** The realization of the high-pass filter in Multisim

The Fig. 13 shows two signals: (1) input to the high-pass filter (output from the function generator), signal with frequency of 50 Hz and amplitude of 2 V, and (2) output of the high-pass filter.



**Figure 13.** The oscilloscope display for the high-pass filter

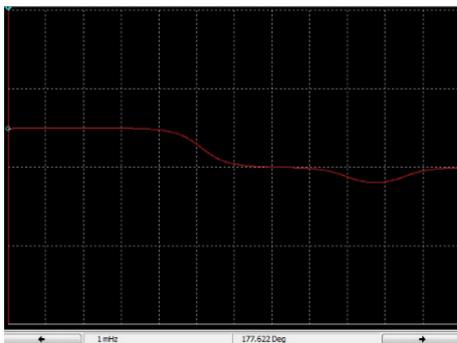
As can be seen from Fig. 13, the output amplitude characteristic of the filter is significantly lower than the input amplitude characteristic, because the frequency of the input signal is much lower than the cutoff frequency of the filter.

The Fig. 14 shows the amplitude characteristics of the high-pass filter. The blue line intersects with the amplitude characteristic at the point of -3dB and that point represents the filter cutoff frequency. The calculations in (3) showed that the cutoff frequency is 132Hz, and the Fig. 14 shows that this parameter has the value of 210Hz which again signifies the imperfection of the hardware elements and the realistic simulation.



**Figure 14.** The amplitude characteristics of the high-pass filter

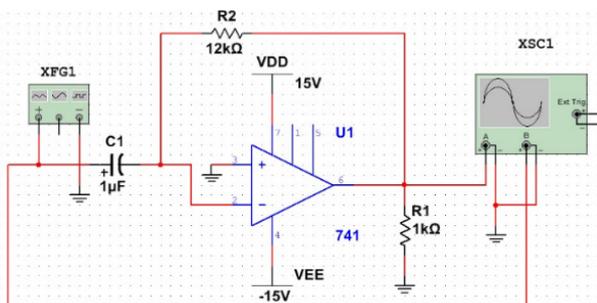
The phase characteristics of the high-pass filter is shown in Fig. 15.



**Figure 15.** The phase characteristics of the high-pass filter

### 3.4. Differentiator

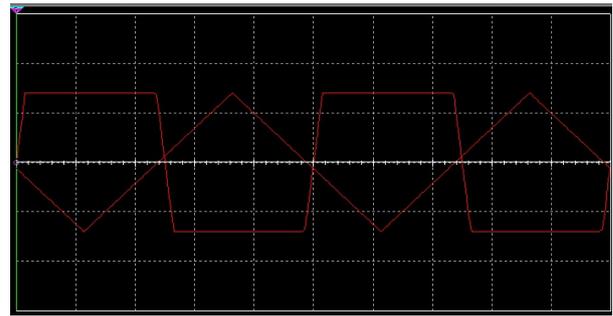
The Fig. 16 shows the realization of the differentiator in Multisim.



**Figure 16.** The realization of the differentiator in Multisim

The input signal is sawtooth wave and has the frequency of 1000 Hz and amplitude of 7 V. Duty

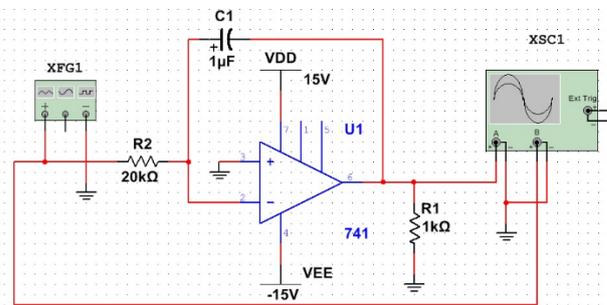
cycle is 50%. The output signal is square wave and this is shown in Fig. 17 that shows the oscilloscope readings.



**Figure 17.** The oscilloscope readings of the differentiator circuit

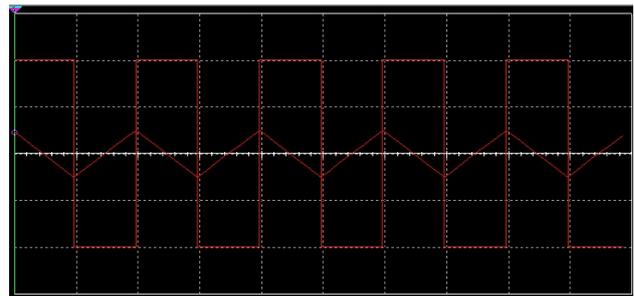
### 3.5. Integrator

The Fig. 18 shows the realization of the integrator in Multisim.



**Figure 18.** The realization of the integrator in Multisim

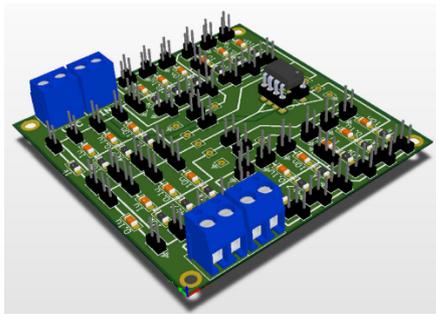
The input signal is square wave and has the frequency of 50 Hz and amplitude of 10 V. Duty cycle is 50%, and the rise/fall time of the input signal is 10ns. The output signal is sawtooth wave and this is shown in Fig. 19 that shows the oscilloscope readings.



**Figure 19.** The oscilloscope readings of the integrator circuit

## 4. The simulations with NI Elvis II+ hardware device

The here mentioned simulations are realized with NI Multisim software tool and with real hardware elements, tested on NI Elvis II+ platform. With this in mind, the educational board is developed. It incorporated one operational amplifier with passive elements (resistors and capacitors). The layout of the board is shown in Fig. 20.



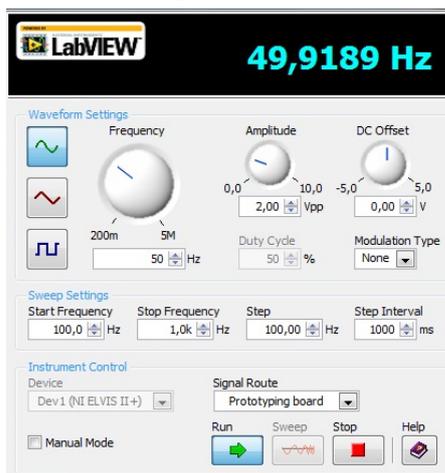
**Figure 20.** The layout of the educational board for implementation of the analog circuits

NI Elvis has provided the oscilloscope, as well as the function generator, Bode analyzer, and operational amplifier power sources. The Elvis II+ platform is shown in Fig. 21.



**Figure 21.** The NI Elvis II+ platform

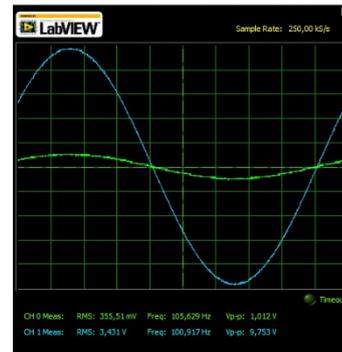
The platform is connected to the PC via USB and all the measurements are displayed on the computer using the virtual instruments. During these measurements, the function generator signals are passed through analog circuits using the embedded functionalities of the platform. The appearance of the virtual instrument for the function generator control is shown in Fig. 22.



**Figure 22.** The NI Elvis function generator layout

#### 4.1. Non-inverting operational amplifier

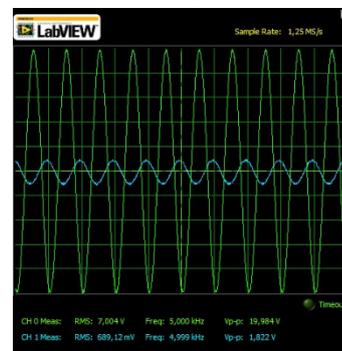
The analysis of the non-inverting operational amplifier is made with the real circuit and the characteristics of the input and output signals are shown in the Fig. 23. As with the simulated circuits, the voltage and the frequency of the input signal are remained unchanged. The green line represents the input signal, and the blue line the output signal.



**Figure 23.** The oscilloscope reading from the non-inverting operational amplifier circuit

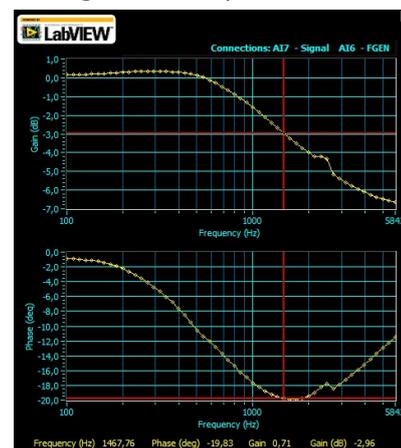
#### 4.2. Low-pass filter

The characteristics of the input and output signals of the low-pass filter circuitry are shown in the Fig. 24. The green line represents the input signal, and the blue line the output signal.



**Figure 24.** The oscilloscope reading from the low-pass filter circuit

The amplitude and phase characteristics of the low-pass filter using Bode analyzer is shown in Fig. 25.



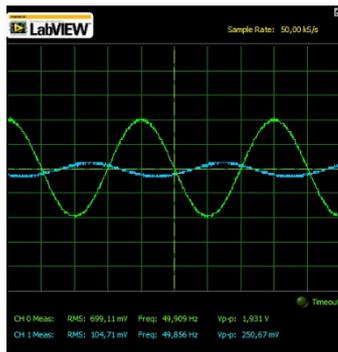
**Figure 25.** The amplitude and phase characteristics of the low-pass filter

At -3dB the cutoff frequency is approximately 1478Hz, which is relatively good result considering that this cutoff frequency is closer to the calculated frequency.

#### 4.3. High-pass filter

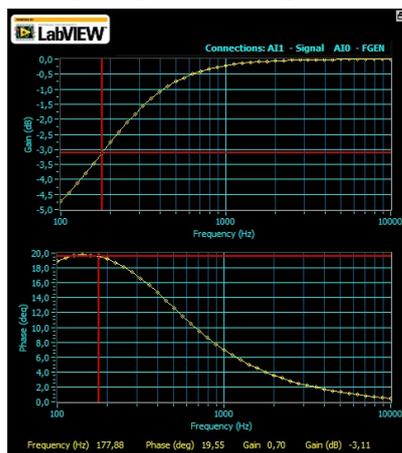
The characteristics of the input and output signals of the high-pass filter circuitry are shown in the Fig. 26. As with the low-pass filter, the signals with

frequencies out of filtering range are weakened. The output signal (blue line) is significantly lowered compared to the input signal (green line).



**Figure 26.** The oscilloscope reading from the high-pass filter circuit

The amplitude and phase characteristics of the high-pass filter using Bode analyzer is shown in Fig. 27. It can be seen that the cutoff frequency is approximately 178 Hz, which is also better than the simulated circuit, and the deviation from the real, calculated frequency, isn't so big.



**Figure 27.** The amplitude and phase characteristics of the high-pass filter

#### 4.4. Differentiator

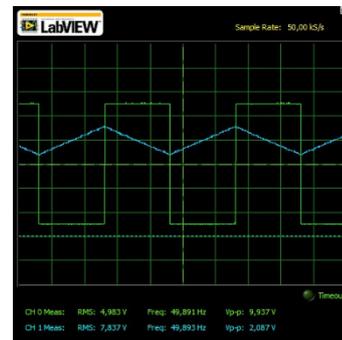
The input signal is sawtooth wave (green line), and the output signal is square wave (blue line), same as with the Multisim simulation. The both signals are shown in Fig. 28.



**Figure 28.** The oscilloscope reading from the differentiator circuit

#### 4.5. Integrator

The input signal is square wave (green line), and the output signal is sawtooth wave (blue line), same as with the Multisim simulation. The both signals are shown in Fig. 29.



**Figure 29.** The oscilloscope reading from the integrator circuit

### 5. The student analysis

In order to better understand the here mentioned circuits and simulations, the students from the departments of the Power Engineering and the Computer Engineering were interviewed.

#### 5.1. Survey on the students of the Power Engineering

The questions that the students of the Power Engineering were asked were related to the application of the real hardware experiments and whether along with hardware experiments the software experiments are needed as well. The total of 18 students was interviewed and the topics were as follows:

1. The visualization of the theoretical concepts in the Signal and Systems course using hardware platforms is fine.
2. The hardware simulations have helped me to improve my knowledge from the Signal and Systems course.
3. Along with hardware platforms, the software experiments simulating real devices are needed as well.
4. Along with hardware platforms, the simulations in a software suite are needed as well.
5. In your opinion, what should be the ratio between the software simulation experiments and experiments with real hardware devices?

The students were able to respond to these topics by selecting one of the following statements (applied to topics 1-4):

- (1) Strongly agree,
- (2) Somewhat agree,
- (3) Neither agree nor disagree,
- (4) Somewhat disagree,
- (5) Strongly disagree.

For the fifth topic, the students ought to choose one of the following given answers:

- The software simulations should have precedence over hardware simulations;
- The software simulations should have equal status with hardware simulations;
- The hardware simulations should have precedence over software simulations;
- I don't know.

**5.2. Survey on the students of the Computer Engineering**

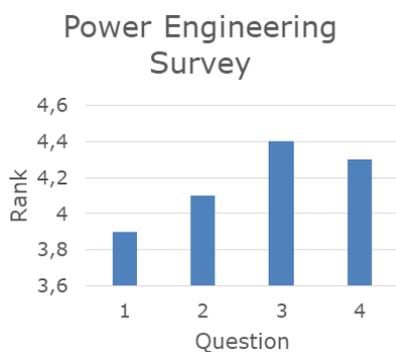
The main subject in this survey were software simulations and whether the hardware experiments are needed as well. The interview included the following topics:

1. The visualization of the theoretical concepts in the Signal and Systems course using software platforms is fine.
2. The software simulations have helped me to improve my knowledge from the Signal and Systems course.
3. Along with software platforms, the hardware experiments with real devices are needed as well.
4. Along with software platforms, the simulations in hardware platforms are needed as well.
5. In your opinion, what should be the ratio between the software simulation experiments and experiments with real hardware devices?

The answers to these questions were given the same as for the students of the Power Engineering.

**5.3. Survey results and discussion**

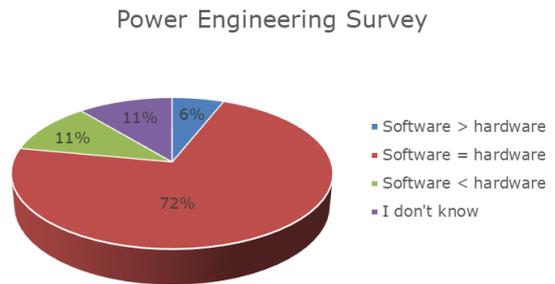
The Fig. 30 shows the results of the survey for the students of Power Engineering. The total of 18 students were interviewed. The question rank was calculated in a way that the answer "Strongly agree" had a score of 5, descending to a score of 1 for the answer "Strongly disagree".



**Figure 30.** Power Engineering students' survey results for the questions 1 - 4

As can be seen from Fig. 30, the students of Power Engineering mostly agreed with the third question, and mostly disagreed with the first question. The students in general agree with the statement that

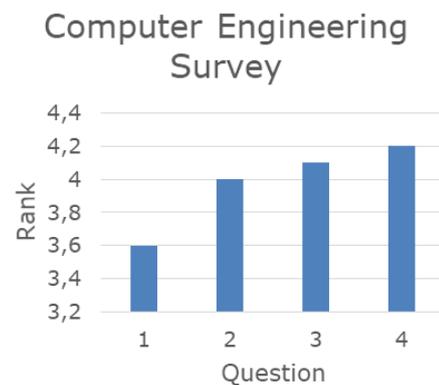
laboratory exercises are needed. The survey got good results, since all answers tend to the upper limit. The answers to the fifth question are given in the Fig. 31.



**Figure 31.** Power Engineering students' survey results for the fifth question

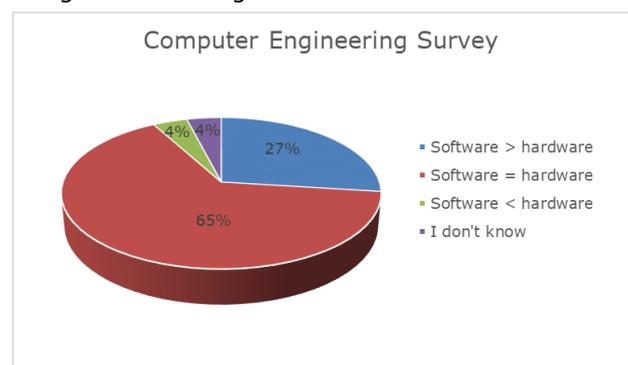
The students clearly expressed the desire that both hardware and software experiments have the equal ratio.

The Fig. 32 shows the results of the survey for the students of Computer Engineering. The total of 26 students were interviewed. The question rank was calculated in the same way as before.



**Figure 32.** Computer Engineering students' survey results for the questions 1 - 4

As can be seen from Fig. 32, the students of Computer Engineering mostly agreed with the fourth question, and mostly disagreed with the first question. The students in general agree with the statement that laboratory exercises are needed. The survey got good results, since all answers tend to the upper limit. The answers to the fifth question are given in the Fig. 33.



**Figure 33.** Computer Engineering students' survey results for the fifth question

The students clearly expressed the desire that both hardware and software experiments have the equal ratio, like their colleagues. However, the students of Computer Engineering expressed greater desire to have more software than hardware simulations (27%, compared with only 6% for the Power Engineering students). This result is somewhat anticipated, since the students of Computer Engineering have more software courses in their curriculum.

## 6. CONCLUSION

The students of Electrical Engineering nowadays have more theoretical knowledges than practical ones in the subjects of their primary interests. This is the motivation for this paper, to give the students more hands-on experience with real hardware devices and their usage through hardware and software simulations.

Several experiments were realized that used actual hardware components, NI Elvis II+ platform, and NI Multisim simulation software. All experiments were conducted successfully. The students of Power Engineering and Computer Engineering were interviewed about their view on these experiments.

As it turned out, students gave positive feedback on these simulations, and answered that they would need almost equal amount of software simulations and experiments with actual hardware devices. This was the result that was anticipated and we'll gladly move on with bringing some more experiments for students' practical exercises.

## ACKNOWLEDGEMENTS

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# Differences in Radio Broadcasting between Europe and America: two Separate Models and the Advent of the Digital Audio Broadcasting System

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**Abstract:** *The analog model of RF broadcasts was a domain more or less easily regulated by policy makers and the state authorities involved in the terrestrial range of its service provision. Channels were granted to legal entities or entrepreneurial consortia that were subject to public law applicable in that region. However, the advent of new mobile and digital technologies creates an amalgam of free on-line media providers and expensive, state regulated public goods that attests general state provisions to be scornful to many ambiguities and legislative gaps. Contemporary technology forcibly trends to deregulated models of supply and demand, with mixed results thus far. Diminished entities get, as of now, the better.*

**Keywords:** *European and American Models of Broadcasting Services, Mobile and Digital Technologies, Radio Frequency Transmissions*

## 1. INTRODUCTION

Innovations and rapid changes in the whole spectrum of communications technology have somewhat obliterated older media process and have put in affliction the whole traditional (aka "old") media industry.

Ink-on-paper media are in doubt after the digital media explosion and all of its up-to-the-minute contents that are more or less free of charge. They more serve as customary repositories of reportorial psephologists or outlets for acolyte adherents, seen as devotional donors rather than readers.

Devices like the analog radio are now almost extinguished from the households and have been replaced with other hardware devices which the individuals and users need to upgrade frequently. The need to obtain efficient and modern devices has relocated the transfer of funds, from editors and owners of media to manufacturers and hardware developers. Despite the fact that analog radio emissions have survived in style for more than a century, the death seems almost inevitable. The radio industry, however, has its own different story and is surely affected by the digitalization of news and the media sector on the whole.

### 1.1. A brief story for the Americas and Europe

In 1920's, when the initial broadcasts appeared for first time in human lives, there was not yet shaped a certain opinion in the public about the implications, and moreover, the future of this new medium. Out of nowhere, a new device was entering people's homes, having the prospect to "speak" to them. The public opinion was divided and ready to confront the new medium with suspicion. The first licensed radio station was KDKA in Pittsburgh; it was operating from the top of the Westinghouse Electric factory, which possessed all the links of the chain, from the station up to the constructed radio collectors. For all intents and purposes, however, nobody possessed a radio set on the crucial electing-decision night of that year; KDKA managed, though, to communicate the news of Warren G. Harding's triumph in the presidential race, going along returns called in from the nearby daily paper. The quantity of authorized communicative stations surged from five out of 1921 to 500 by 1924. Radio rapidly turned into a purchaser fever [1].

In Europe, the efforts for establishing radio as a news medium started in England. The first idea was to create a British Broadcasting Company that was able to create a control system for both the

content of the broadcasting and also the equipment. This also reveals why America and Europe created each a very different radio broadcasting system as shown next in the paper. The general idea was that manufacturers were going to create the company to have the "exclusive right to sell radio sets" [2]. Therefore, the well-known BBC started as a non-public company, owned and funded by radio manufacturers who were licensed to exploit the broadcasting system. In this particular group of radio manufacturers was included Marconi himself. People who had owned a radio were paying each year a contribution which was separated in half between the Post Office and BBC.

### 1.2. American and European Models of Radio

Before indicating the major differences between American and European broadcasting services, it must be noted that both two models had as main target the equal chances to accessibility and the unbiased expression of every single opinion [3]. Furthermore, an alternative goal was to defend and advocate the national interests. This is mainly shown from the fact that during WWI, for security and safety reasons, the management and control of radio industries were undertaken by the American government and only after the war the control was restored to the private sector [4]. Novice stations alongside any business station for which there was no predictable utilization from the Navy forces of America were to be totally closed down, or to be totally disbanded if the radio transmitter of an amateur was in use. Business and private radiophony was consequently totally closed down for the length of the war, and for the main time in American history, a full government imposing business model was exerted.

The American broadcasting companies had the privilege since their birth to be funded by sponsorships and commercials. That was the main keystone for broadcasting enterprises to expand and establish a normal route through recognized news and entertainment media peers. Moreover, American broadcast companies were mainly broadcasting in local frequencies and also the content transmitted had primarily an entertaining character because the main pecuniary resources, the advertisers, wanted to produce a pleasant feeling to the audiences. This light atmosphere produced by the entertaining character would allow commercials to appear in a more regular way into the broadcasting programs. That was the main goal of the premature broadcasting enterprises in America: to gain attention through entertaining programs and then to produce advertisements and commercials for the audiences. For that particular reason, a listener of the first radio shows can observe major differences in the language and the shape of the

radio-shows. American radio was mainly commercial whereas European had a more direct and strict direction to news, alone. Despite the pathway of radio broadcasts in America, Europe had created and established a somewhat very different model of functioning in broadcasts. The differences were not just in technical issues (American radio was transmitting in restricted locations when European was transmitting in national level). The content of the European radio was regulated by the principles of social public services whereas in the American radio the nature of the programs was basically entertainment [3]. This specific process that the European radio stations engulfed promoted one-way communication from the transmitter (radio station) to the receiver (the audiences, the public). The way that BBC was established in England, albeit being considered a non-public company, was ensuring that the state and government would have the major share of "cultural and political control over broadcast content" [2]. As stated before, American radio was lead (in a way) according to the preferences of the public. On the other hand, European radio was directed by the leaders of the social public services [5]. In other words, the state or even the government was deciding what was important the public to hear. In the European pathway of radio broadcasting the key stone of national radiophony was the product of the nation itself [3]. Finally, it must be noted that, in the first attempt of European major powers to own a radio broadcasting company (BBC, England), there was a clear control system over the content and the distribution not only from the monitoring system of the company itself, but also from sub-committees appointed by the British Government. As pointed in Tworek's "The Savior of the Nation? Regulating Radio in the Interwar Period" [2] in p.470 "...the control of such a potential power over public opinion and the life of the nation ought to remain with the State." (Sykes Broadcasting Committee)

## 2. DIGITAL AUDIO BROADCASTING

The digital radio and all of its aspects have changed radiophony, concerning its analog form. Based on that belief, the communities involved in the broadcasting enterprises and their corresponding audiences have established a new way of interacting with the phenomenon of digital radio. The usage of digital broadcasts can be made through the receivers of digital television (so the user has to open a TV connected by satellite or in cable with the digital transmissions and listen the radio with that current way) or to connect to the Internet via several ways (through desktop, laptop, mobile phones etc.). The augmentation of digitalization to radio was

guaranteed to finish a procedure which had been entrenched in different parts of the varying media creation chain, which included advanced sound generation, recording and mixing procedures [6]. By the mid-1980s, the pervasiveness of computerized innovation in proficient radio generation conditions, supplanted more established sound generation procedures, and in addition to wide infiltration of advanced buyer organizations, for example, mp3 and the Compact Disc design, had made the idea of computerized sound and its related advantages generally known in both regular and expert settings for radio and sound media [7]. At the midpoint of the 1980s, given the instigating force for digitalization in various regions, for example, media communications (Integrated Services Digital Network, ISDN), capacity media for sound (Compact Disc), etc., it was broadly contended in industry circles that radio sound telecom had a promising potential for additional development [8]. The digitalization of communicative transmission frameworks, commencing from radiophony, had been vital for furthering scientific knowledge and technical design issues for a broad timeframe. In the domain of sound transmission, improvements, for example, Near Instantaneous Companded Audio Multiplex (NICAM) stereo sound for TV in the mid 1970's and computerized transmission advancements for satellite radio in the mid 1980's, produced a critical force in the look for substitution advancements for customary AM and FM broadcast services [9]. The more noteworthy the effectiveness of transmission, reducing costs for telecasters and transmission arrangement, the more noteworthy recurrence productivity occurs, permitting better use of range and the capacity to cover more administrations; as a result, the objective of computerized broadcasting foreshadows as essential and appealing for both controlling authorities and governments [7]. There was additionally promoted (and keeps on being so) a solid business model for radio to end up as an advanced medium, which however is only a part of the pattern, i.e. the fully computerized assembly within the media market. As noted in a later European Commission investigation for the advanced media industry, radio is ignored regularly when contemplating intuitive media (Screen Digest et al., 2006, retrieved from [7]).

The entry of the changing form of radio was first introduced with a European research project that ended up with the form of DAB (Digital Audio Broadcasting) [6][7][8]. The basic project was called "Eureka" and under this program the system of DAB was developed. The initial project had several parties involved along with radio producers, broadcasting staff and a variety of developers working for manufacturers. The first pilot DAB channel was launched in Norway in

September 1995 from the Norwegian Broadcasting Corporation (NRK). Few months later, in September 1995, BBC and the Swedish Radio (SR) launched the first digital radio broadcasts for these countries. Digital Audio Broadcasting was envisaged as the modern and the advanced alternative system for the analog FM transmissions of the radio industry. FM transmissions had major advantages in the sound quality and were preferred by audiences, when compared to AM transmissions, albeit the latter having much longer ranges. The new Digital Audio Broadcasting system had the same and even better technical characteristics in the quality of sound and furthermore, the length and the range of the signals that could be sent from stations could reach both national and local locations. The development of the signal process would allow the audio-user to read basic information displaying on his/her screen of the device, easier way to adjust to setting of tune and mainly to have access to a wider and larger number of radio stations.

The prospect was that, while DAB would remain essentially an innovation for the conveyance of radio services, the information carried on by DAB transmissions could likewise incorporate mixed media information, and that the radio would turn into a more refined device, capable of getting graphics data and the capacity to store and replay communicative sound [10].

### 3. NEGATIVE POINTS OF DIGITAL RADIO

Despite the opportunity presented with receivers of digital TV or even the Internet and mobile phones, digital radio is not one of the first choices for the audiences. The public is preferring to make use of other possibilities when in front of a TV screen or a smartphone and surely not just listen to a radio station. The era of a wide range of multimedia apps, more friendly-to-users, like screens with video, commenting online, etc. has been inaugurated, and activities that put the digital radio in a concessive position are put aside.

Furthermore, digital radio has some disadvantages as far as the portability factor is concerned [10]. It is not easy to stream online in order to get a chance for a clear and crystal sound through a connection with a digital station. Especially when mobile companies, in Greece particularly, do not support bulky enough data connections through a mobile phone. Therefore, there is still a problem existing when trying to web-stream a digital station through mobile devices.

## 4. DISCUSSION

### 4.1. Web, Satellite and Digital Radio: impact on individual users

Concerning the listener, the immediate relation with the local point of RF broadcasts is quite

disappearing with usage of digital radio. When there is a huge variety of stations around the world to listen, the listener is most likely to stick to something different and not a local station or a local news outlet. Otherwise, the user wouldn't probably use the digital broadcasting services at all. The incentive for going digital is to hear something else than local radio stations.

This may lead to the expansion for the phenomenon of citizens absents not only from the political life but also from issues that are in more direct affect to their daily life. Like the matters of their municipality, or even affairs related to daily traffic protests on the street etc. This will make the individual overall far more absent from the public issues of his/her society. Moreover, not listening co-citizens through a local radio station will gradually cause the problem of not hearing the public opinion at all. Then, the individual for a variety of social themes will not have a formed opinion or idea. On the other hand, listening broadcast services around the globe will make the auditor to hear and learn issues with an international perspective. This may be a decisive step regarding globalization. Digital radio is a key factor when heading full steam towards ecumenical perspectives. Hearing and learning issues from every single spot of the planet will make the auditor more sensible to international matters and affairs. Every single listener can transform himself/herself into a capable administrator of international affairs and good policies.

#### 4.2. Community Radio

Another positive outcome that the digital broadcasting experience may provide to the listener is the higher access to community radios. Community radio is a radio administration offering a third model of radio telecom, notwithstanding business dependencies and ferventing open broadcasting. In general, community radios serve geographic groups and groups of common interests. They communicate content that is mainstream and important to a neighborhood or small community whose gatherings under normal circumstances would pass unnoticed by businesses or broad communications schemes. Group radio stations are tuned-up, claimed, and impacted by the groups they serve. They are for the most part non-profit organizations and give a component to empowering people, gatherings, and groups to recount their own particular stories, to share encounters and, in a media-rich world, to end up makers, benefactors and owners of media. In numerous parts of the world, community radio goes about as a vehicle for a group and an associated with it willful area, a common society, offices, NGOs and subjects working within an organization to assist group improvement points, notwithstanding its communicating channels. It is

legitimately characterized group radio (as a particular broadcasting division) in numerous nations, for example France, Argentina, South Africa, Australia and Ireland [11]. A great part of the enactment has included expressions like "social advantage", "social destinations" and "social pick-ups" as a feature of the definition. Group radio has grown distinctively in various nations, and the term has fairly unique implications in the United Kingdom, Ireland, the United States, Canada and Australia, where the right to speak freely under common law, jurisprudence and case law is subject to varying interpretations. From this perspective, the listener is able now, in the digital age, to get informed, to be motivated and to react in various situations concerning social issues through the usage of community outlets and their digital radio streams (Figure 1).

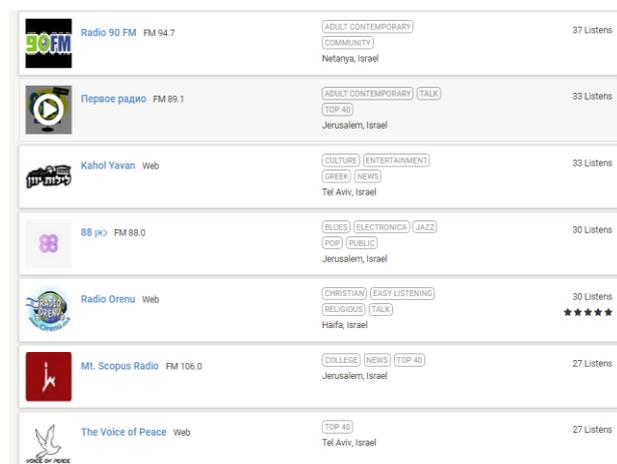


Figure 1. Community radio in Israel

The millions of short-staying visitors, alongside permanent residents, all using low cost mobile phone broadcasting services, are serviced based on their national, religious or cultural characteristics.

#### 4.3. "Our own show"

Moreover, there is another positive outcome that may rise, if not already popular through the usage of digital audio broadcasting systems. Using the techniques and the freedom the Internet world provides to every single person, there is an obvious chance to enhance Internet radio to the level of each one individual communication system. Meaning in practice, there is no need for creating a show from scratch and seeking for the appropriate spokesperson to guest and host or even attracting commercials and income. Through digital radio, there is an opportunity to create your own show using the appropriate tools.

There is plenty of expertise and many special platforms readily demonstrate how this is achieved under the most stringent circumstances. Supporting a "show" is financially savvy; what's more, contemporary communication platforms

may incorporate one's dialogues, either with speech communication or in textual form (i.e. SMS, mail, messages, etc.) with its guests or his hosts. Making and facilitating your own show is likely the most intriguing choice to consider.

Most Web radio portals that provide adequate "Radio 101" training materials and expenses are by any means insignificant. BlogTalkRadio offers a 30-day trial and its most advanced production bundle is \$99 every month or \$999 yearly. An almost free choice to communicate outside prime time is likewise accessible.

As radiophony experts assess Web radio's potential, amazed by its versatility and polyploidy, they seek to divert its scalability towards new interaction schemes that will make listening to the radio a completely new experience, in terms of Human-Computer Interaction metrics.

Setting customers, guests and listeners on interactive programs allows radio producers to shape their personal broadcasting style and their emission's communicative profile [12].

## 5. CONCLUSION

New technologies and new broadcasting models create rifts in the equilibrium of established, well balanced, thus far, news and entertainment RF based broadcasting outlets. The advent of innovative "on air" activities that use mobile, landline, Internet and IPTV multinational communication schemes seems to be bringing to surface new trends in listening to radio emissions.

However, some countries still employ obsolete and general provisions in their attempts to regulate by means of their public law arsenal the RF broadcasts within their jurisdiction, not consolidating the global footprint of corporate social responsibility. While most European countries still comply with the conformance model for state regulated goods, contemporary technology leads to new ways for exploiting communal, educational or entertainment schemes with radio emissions.

The hypotheses of this survey and its extrapolations for modern societies were cross-examined in the oasis of Deir Hajla, Israel. It is a predominantly Arab speaking region close to "the most ancient city of the world", Jericho, near the border with Jordan, just a few km away from the northern bank of the Dead Sea. The classic model of RF broadcasts used in Europe and the Americas fails to provide FM regional coverage, since within this plain three jurisdictions mingle together, two interstate and two international. Even further, the steep inequalities within the financial, linguistic, cultural and religious background of the people frequenting in this region proved to be inhibitory of a viable solution in RF broadcasting terms.

However, the advent of digital communication, combined with the extensive use of affordable mobile devices, has provided the general public of the region and the millions of its tourists with new means for conveying multimedia content either of "aired" broadcasts or "on demand" multicasts of interactive educational, informative or recreational content, cropped out of vast web based repositories.

It has proved to be a tolerant, co-existential melting point for a cradle of civilizations that suffered thus far from a biased partitioning of its analog resources.

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# Arduino Platform Capabilities in Multitasking Environment

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**Abstract:** *Arduino platforms are one of the most popular bases for the development of embedded devices. The ability to independently design an interface with the environment, gives the Arduino modules characteristics of an "open hardware" device. At the same time, the existence of the Arduino IDE development environment enables easy and stable development of software. The structure of the Arduino program does not provide direct support for the operation of such devices in the multitasking environment. This problem has been partially overcome by the development of libraries, such as, for example, a library that allows the use of the FreeRTOS concept with the Arduino device. The paper presents the elements of realization of multitasking in the Arduino system operations with the support of the FreeRTOS system concept.*

**Keywords:** Arduino concept; multitasking; real – time operating systems; integrated development environment.

## 1. INTRODUCTION

In recent years, there have been significant changes in the development of computer hardware. Especially in the so-called embedded systems. In addition to the classic development systems, designers also have devices that can be called open-source hardware systems. Such devices have a predefined processor-memory structure. Regarding the implementation of the input/output subsystem, designers have at their disposal a number of analog and digital inputs that can be used in accordance with the specific requirements of the application. Due to the standardization of computer devices communications with the environment, such devices also have predefined communication interfaces such as UART, SPI, I<sup>2</sup>C, etc. One of the most famous devices of this type is the Arduino module family [1].

The Arduino concept, as a program for students, was designed at the Interaction Design Institute Ivrea in Ivrea, Italy [2]. The goal was to provide a cost-effective and easy way to design devices that connect with the environment through various sensors and actuators. The Arduino concept is a typical representative of the device with open hardware. Most Arduino modules are based on Atmel 8-bit AVR microcontrollers (ATmega8, ATmega168, ATmega328, ATmega1280, ATmega2560). The microcontrollers that are built into Arduino modules have a boot loader that makes it easy to upload the developed program into a program flash memory. Each Arduino module has a number of digital and analog I/O

pins. As a rule, a subset of digital I/O pins can be used to generate PWM (Pulse Width Modulated) signals.

Arduino programs can be written in any programming language for which there are compilers who can generate a machine code for the desired processor. Since Arduino modules are based on Atmel microcontrollers for the program development, the appropriate development environments, AVR Studio and Atmel Studio, can be used. The Arduino project offers an integrated development environment that has a simple mechanism to compile and upload programs into Arduino module. The Arduino IDE development environment is based on the Wiring IDE platform and the programming language Processing [4].

The great success that the Arduino concept has achieved has led to the fact that a large number of development systems, which are being designed and implemented today, has the same interface to the environment as in Arduino. Thus, the I/O interface of the Arduino UNO module has almost become standard.

When defining the Arduino concept and developing the appropriate IDE software, no direct support is provided for working in the multitasking environment. With this in mind, one of the important challenges, in the further development and application of the Arduino concept, was finding the possibility that devices based on the Arduino module work in multitasking mode. The aim of this paper is to point out the possibility of developing programs for Arduino based devices,

which will be able to work in a multitasking environment.

The main efforts are focused on adding libraries with functions designed to support multitasking elements. Special attention is given to the work in the multitasking environment based on the FreeRTOS operating system.

## 2. ARDUINO PROGRAM CONCEPT

Developing a program for Arduino module has been made very easy, by including necessary libraries and writing functions that use them, maintaining simple and short source code. Because programming in Arduino is based on manipulation of different sensors and actuators, the manufacturers that develop them mostly write libraries. Those who do not have previous experience in programming can just call libraries inside of Arduino code, without needing to understand how they work. On the other hand, more experienced programmers can change Arduino libraries or make new ones, following simple set of rules made by Arduino team.

Arduino libraries and programs are written in C and C++ programming language and the editor that is used for programming Arduino modules is cross-platform Arduino IDE software. Structure of simple program for Arduino is based on two functions, *setup()* and *loop()*. After including libraries and defining variables that will be used in the program, the setup function is created for initializing and setting initial values. This function is only run once, when program is first started. The second function, loop, allows program to change and respond by looping constantly functions described in it. Usually in the end of loop function, *delay()* function is called to postpone the next running of functions inside loop. Figure 1 shows the layout of the Arduino program's initial form (new sketch).

```

sketch_apr11a | Arduino 1.8.5
File Edit Sketch Tools Help
sketch_apr11a $
1 void setup() {
2 // put your setup code here, to run once:
3
4 }
5
6 void loop() {
7 // put your main code here, to run repeatedly:
8
9 }

```

**Figure 1.** A view of new Arduino sketch

This structure of Arduino program allows execution of special tasks only on the principle of batch processing. This means that each task is defined as a separate function, which is then called within the main program loop. A specific function (task) will only be executed again when

all the next functions in the loop are executed. The total time of one passage through the program loop depends on the number of functions that are executed and the execution time of each function. The appearance of the corresponding Arduino program is shown in Figure 2.

```

sketch_apr15a | Arduino 1.8.5
File Edit Sketch Tools Help
sketch_apr15a $
1 void setup() {
2 // put your setup code here, to run once:
3
4 }
5
6 void loop() {
7 task_1();
8 task_2();
9 ...
10 task_j();
11 }
12 void task_1() {
13 ...
14 }
15
16 void task_2() {
17 ...
18 }
19 //...
20 void task_j() {
21 ...
22 }
23

```

**Figure 2.** Arduino program with multifunction environment

The problem can arise if the number of tasks that are executed is large. In this case, the time interval between the two consecutive activations of the same task can be long. The inability to realize multitasking, in the basic version of the Arduino program, imposed the need for alternative solutions. The most common solution is based on the inclusion of multitasking support by adding appropriate libraries.

Based on this, it can be concluded that the Arduino software environment does not support concurrency, and that the interval in which a particular task can be performed cannot be defined. One of the solutions is the use of the Scheduler Library, which provides support for multiple concurrency loops. Figure 3 shows a part of the code that illustrates multitasking in the Arduino program using the Scheduler library.

Within the code, a special attention has to be given to the command `Scheduler.startLoop(Task1)` and `Scheduler.startLoop(Task2)`. By default, these commands start tasks Task1 and Task2, whose functions are later defined. A command string, in the basic loop, *loop()* defines tasks that can be tagged with Task0. When this command is

executed, the control is transferred to another task. In the case of using the Scheduler library, the transfer of control to the following tasks can also be accomplished by calling the `yield()` function, as done in the definition of Task2 task.

```

1 // Include Scheduler Library for managing multiple tasks
2 void setup() {
3   ...
4   // Add "Task1" and "Task2" to scheduling.
5   // "Task" is always started by default.
6   Scheduler.startLoop(Task1);
7   Scheduler.startLoop(Task2);
8 }
9 // Task0 ON/OFF LED width 1 second delay
10 void loop() {
11   digitalWrite(LED0, HIGH);
12   // When multiple tasks are running 'delay' passes control to
13   // other tasks while waiting and guarantees they get executed.
14   delay(1000);
15   digitalWrite(LED0, LOW);
16   delay(1000);
17 }
18 // Task1 blink LED with 0.1 second delay.
19 void Task1() {
20   digitalWrite(LED1, HIGH);
21   delay(100);
22   digitalWrite(LED1, LOW);
23   delay(100);
24 }
25
26 // Task2 accept commands from Serial port
27 // '0' turns OFF LED
28 // '1' turns ON LED
29 void loop3() {
30   if (Serial.available()) {
31     char c = Serial.read();
32     if (c == '0') {
33       digitalWrite(LED2, LOW);
34       Serial.println("LED turned OFF!");
35     }
36     if (c == '1') {
37       digitalWrite(LED2, HIGH);
38       Serial.println("LED turned ON!");
39     }
40   }
41
42   // We must call 'yield' at a regular basis to pass
43   // control to other tasks.
44   yield();
45 }

```

**Figure 3.** Example of multitasking using the Scheduler library [5]

In this case, there is no separate task scheduler, but the task management is accomplished by directing the function `yield()` or `delay()`. Also, the considered approach does not provide support for real time operation, periodic activities, and there is no possibility of preemption.

Given the availability and popularity of the Arduino platform and development environment, the designers have also tried to find other solutions for multitasking. As a possible solution, the use of the FreeRTOS operating system was imposed. FreeRTOS [6,7] is an operating system that is designed to support the work of embedded devices in real time. The program was developed with the aim of being small, simple and quick to execute. Therefore, it does not possess some of the advanced features such as device drivers, user accounts and networking, encountered within standard operating systems.

FreeRTOS support for multitasking with Arduino platforms is accomplished by using the appropriate library.

### 3. ARDUINO AND FREERTOS OPERATING SYSTEM

Operating Systems (OS) are computer programs that support basic computer operations, functions, and provide services to all programs running on it. Most OS allow multiple functions to be executed at once, otherwise known as multitasking. This is just an illusion and in reality, one processor core can run only one task at the time. Behind multitasking process there is a part of operating system called *scheduler*, which rapidly switches through each program and runs only one task at the time. There are different types of OS based on the rules by which schedulers execute tasks, for example, scheduler in Unix OS provides equal time of execution for every task [8].

Real Time Operating System (RTOS) is a type of OS with scheduler that provides *deterministic* pattern for executing tasks [9]. This scheduler is mostly used for embedded systems that often have real time requirements such as responding to events in within defined time window. This deterministic pattern is often achieved by allowing user to assign a priority to each task that has to be executed. One version of RTOS that can be run on microcontrollers is FreeRTOS with real-time scheduler [10].

For realization of the multitasking on Arduino platforms, it is necessary to install the appropriate FreeRTOS library. In this case, the FreeRTOS version was optimized for Arduino AVR devices. This library has compatibility with the Arduino environment with simultaneous access to FreeRTOS functions.

FreeRTOS is compatible with many different architectures and compilers, and each version has few demo applications to help new users. To start project with this library it is necessary to download FreeRTOS .zip file, that contains source code with some demo projects, and extract it. List of all supported demos can be found on [www.freertos.org](http://www.freertos.org) along with the official documentation that contains instruction for running and modifying the FreeRTOS library.

#### 3.1 Installing and using FreeRTOS with Arduino systems

FreeRTOS can be installed on Arduino platform using Arduino IDE Library manager greater than version 1.6.8. After installing it, library is included through *Sketch->Include Library* menu. On Arduino Uno device, FreeRTOS takes about 7340 bytes of its flash memory. After passing these steps, the programmer can compile one of three demos provided with the library. In addition to the simple FreeRTOS functions it is possible to include and use many other functions, like *Semaphores* and similar functions.

To enable multitasking within the Arduino program, it is necessary to include the

Arduino\_FreeRTOS library. After that, it is necessary to define tasks that will be competitively carried out. The tasks are created using the xTaskCreate() function [11]. By creating tasks, the scheduler starts automatically. Within the Arduino program, each task is defined by the corresponding function. The principles of multitasking implementation within the Arduino system are shown in Figure 4.

```

1 #include <Arduino_FreeRTOS.h>
2 // Define two tasks Task1 & Task2
3 void TaskBlink( void *pvParameters );
4 void TaskAnalogRead( void *pvParameters );
5 void setup() {
6 // initialize serial communication at 9600 bits per second:
7   Serial.begin(9600);
8 }
9 // Now set up two tasks to run independently.
10 xTaskCreate(
11   Task1
12   , (const portCHAR *)"Task1" // A name just for humans
13   , 128 // Stack size
14   , NULL
15   , 2 // Priority,
16   , NULL );
17 xTaskCreate(
18   Task2
19   , (const portCHAR *) "Task2"
20   , 128 // Stack size
21   , NULL
22   , 1 // Priority
23   , NULL );
24 // Now the task scheduler automatically started
25 }
26 void loop()
27 {
28 // Empty. Things are done in Tasks.
29 }
30 /*----- Tasks -----*/
31 void Task1(void *pvParameters) // This is a task.
32 {
33 (void) pvParameters;
34 for (;;) // A Task shall never return or exit.
35 {
36 // Instructions
37 }
38 }
39 void Task2(void *pvParameters) // This is a task.
40 {
41 (void) pvParameters;
42 for (;;)
43 {
44 // Instructions
45 }
46 }

```

**Figure 4.** The concept of multitasking implementation in the Arduino system using FreeRTOS

In a multitasking environment, the new task is always ready for execution and is placed in the list of ready tasks. The position of the tasks in the list of prepared tasks is in principle defined by its importance in relation to other tasks. According to task priority, the scheduler selects the next task to execute. During the execution of a task, it can be completed or its assigned time can be expired, and therefore its execution must be interrupted. In this case, the task is returned to the list of ready tasks. If during execution, the task cannot obtain the desired resource, its execution is interrupted, and the task is placed in the list of tasks waiting for resources. On the other hand, if during the execution the task releases the resource, the tasks that are waiting for that resource are transferred to the list of ready tasks.

In the case of FreeRTOS a new tasks are put into the ready state. However, if there are no high priority tasks, the new task will immediately go into the running state. It should be noted that

tasks could be created both before and after the scheduler starts. Figure 6 shows the prototype of the xTaskCreate() function.

```

#include "FreeRTOS.h"
#include "task.h"

 BaseType_t xTaskCreate( TaskFunction_t pvTaskCode,
                        const char * const pcName,
                        unsigned short usStackDepth,
                        void *pvParameters,
                        UBaseType_t uxPriority,
                        TaskHandle_t *pxCreatedTask );

```

**Figure 6.** xTaskCreate() function prototype

The pvTaskCode parameter in the xTaskCreate () function is a pointer to the function that realizes the task. The pcName parameter is a symbolic task name. The stack size is defined by the usStackDepth parameter. In addition, when creating tasks, its priority and input and output parameters are defined.

Transferring control to another task in a ready state can be accomplished by calling the functions vTaskDelay() and taskYIELD(). If the task vTaskDelay() task is called in the running task, the task goes into a blocked state and remains in it a certain number of intervals, which are specified as the function parameter. If this parameter is zero, the task goes into a blocked state, and running becomes a ready task with the same priority. Figure 7 shows the prototype of the vTaskDelay() function.

```

#include "FreeRTOS.h"
#include "task.h"

void vTaskDelay( TickType_t xTicksToDelay );

```

**Figure 7.** vTaskDelay() function prototype

Calling vTaskDelay(0) functions is equivalent to calling the taskYIELD() function. This function cannot be called only within the running task, which means it cannot be called before the scheduler starts. If there is no task with the same priority, the control will return to the task within which the taskYIELD() function is called.

The Watchdog Timer at Arduino microcontroller level generates time intervals from 15ms to 500ms, necessary for multitasking. If the task is completed before the expiration of the allocated quantum of time, the control automatically returns to the Scheduler.

By including FreeRTOS library in the Arduino program, the availability of the program memory for the user functions is reduced. An empty Arduino program (sketch) takes 444 bytes, which is 1% of the program memory. When FreeRTOS library is turned on, the occupancy is 14506 bytes or 44% of the program memory.

#### 4. EXAMPLE OF MULTITASKING ON ARDUINO PLATFORM

An example of three tasks can serve as an illustration of using the FreeRTOS operating

system to work with Arduino platforms. Tasks are intended for:

- To turn On/Off LEDs;
- Reading the analogue value;
- Reading the digital value.

Figure 5 shows the introductory part of the Arduino program, which includes declaring libraries to be used or declaring variables.

```

1 #include <Arduino_FreeRTOS.h>
2 int inPin = 7;
3 int val = 1;
4
5 // Define three tasks for Blink & AnalogRead & DigitalRead
6 void TaskBlink( void *pvParameters );
7 void TaskAnalogRead( void *pvParameters );
8 void TaskDigitalRead( void *pvParameters );
9 // The setup function runs once when you
10 // press reset or power the board
11 void setup() {
12 // Initialize serial communication at 9600 bits per second:
13 Serial.begin(9600);
14 pinMode(inPin, INPUT);
15
16 // Now set up three tasks to run independently.
17 xTaskCreate(
18     TaskBlink
19     , (const portCHAR *)"Blink" // A name just for humans
20     , 128 // This stack size can be checked & adjusted
21     // by reading the Stack Highwater
22     , NULL
23     , 3 // Priority, with 3 (configMAX_PRIORITIES - 1)
24     // being the highest, and 0 being the lowest.
25     , NULL );
26
27 xTaskCreate(
28     TaskAnalogRead
29     , (const portCHAR *) "AnalogRead"
30     , 128 // Stack size
31     , NULL
32     , 2 // Priority
33     , NULL );
34
35 xTaskCreate(
36     TaskDigitalRead
37     , (const portCHAR *) "DigitalRead"
38     , 128 // Stack size
39     , NULL
40     , 1 // Priority
41     , NULL );
42 // Now the task scheduler, which takes over control of
43 // scheduling individual tasks, is automatically started.
44 }

```

**Figure 5.** Introductory part of Arduino program

In the declaration part of the program, the inclusion of the library required for enabling multitasking (Arduino\_FreeRTOS) was performed. Also, three tasks have been declared – TaskBlink, TaskAnalogRead, and TaskDigitalRead. Within the setup of the section besides the standard definition of serial communication and digital contact as an input, tasks were created as independent entities. For each of the tasks created, it is defined:

- Symbolic task name (Blink, AnalogRead, DigitalRead);
- The size of the stack assigned to the task;
- Task priority.

By executing a setup part of the program, the task scheduler starts automatically. The main program loop is empty, because all jobs are executed within the tasks. At the end of the program, the

program codes of the functions that implement the tasks are given. In Figure 6, the Blink and DigitalRead Task codes are given.

```

53 void TaskBlink(void *pvParameters) // This is a task.
54 {
55     (void) pvParameters;
56
57     // Initialize digital LED_BUILTIN on pin 13 as an output.
58     pinMode(LED_BUILTIN, OUTPUT);
59
60     for (;;) // A Task shall never return or exit.
61     {
62         Serial.println("-----Task 1-1");
63         digitalWrite(LED_BUILTIN, HIGH);
64         // Turn the LED on (HIGH is the voltage level)
65         vTaskDelay( 1000 / portTICK_PERIOD_MS );
66         // Wait for one second
67         Serial.println("-----Task 1-2");
68         digitalWrite(LED_BUILTIN, LOW);
69         // Turn the LED off by making the voltage LOW
70         vTaskDelay( 1000 / portTICK_PERIOD_MS ); // wait for one second
71     }
72 }
73
74
75
76
77
78
79 void TaskDigitalRead(void *pvParameters) // This is a task.
80 {
81     (void) pvParameters;
82     for (;;)
83     {
84         //Serial.println("-----Task 3");
85         // Read the input on digital pin 7:
86         val = digitalRead(inPin);
87         // Print out the value you read:
88         Serial.print("Digital value: ");
89         Serial.println(val);
90         vTaskDelay(40);
91         // One tick delay (1ms) in between reads for stability
92     }
93 }
94 }

```

**Figure 6.** The program code of the DigitalRead task

Figure 7 shows the appearance of the SerialMonitor, which reflects sequencing of tasks, which are defined within the Arduino program under consideration.

```

-----Task 1-1
Analog value: 572
Digital value: 0
Analog value: 573
Digital value: 0
-----Task 1-2
Analog value: 572
Digital value: 0
Analog value: 572
Digital value: 0
-----Task 1-1

```

**Figure 7.** Display on Serial Monitor

Task 1 is executed from two steps. The first step is to turn on the LED, after which the task is blocked, and the control transmits to Task 2, and then to Task 3. Blocked Task 1 takes a long enough time to repeat the Task 2 and Task 3 execution cycle. Task 1 takes a long time to repeat the execution. Task 2 and Task 3 cycle activate Task 1, i.e. its second step in which the LED turns off and goes back to the blocked state. This creates the conditions to reactivate Task 1 and Task 2, which are executed twice before the control takes over Task 1 again.

## 5. CONCLUSION

The paper presents an approach to overcoming the problem of the lack of adequate multitasking support for the Arduino program environment.

Similar problems are not rarity in the field of computer technology, so they can serve as an example of what everything should be considered when designing new systems. The popularity and the breadth of the application of the Arduino concept further influenced the significance of this problem.

Indication of this and similar problems, as well as the presentation of the ways of their overcoming, creates opportunities for the development of appropriate educational content, especially at the master studies level. This was precisely the motive for students of master studies in the field of computer engineering in the Intelligent Sensors course to deal with the problems of multitasking in the Arduino system. The goal was to get out of the standard framework for acquiring knowledge on the principle of ex cathedra and to move on to learning through practice. The results achieved during the research, familiarization with the problem of multitasking in the Arduino system and ways of solving them, point to the importance and possibilities of this approach to acquiring knowledge.

Experience in implementing multitasking on Arduino systems can serve in the implementation of a similar work environment on embedded systems based on microcontrollers. This has a special significance when implementing devices belonging to IoT (Internet of Things), in which the application of multitasking can be very important [12].

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# Raspberry Pi module clustering and cluster application capabilities

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**Abstracts:** *The development of semiconductor technology and, consequently, the development of microcomputers created the conditions for adequate support for embedded parallelism in procedures for solving various problems in science and technology. With the simultaneous development of computer networks, conditions have been created for microcomputers to connect to clusters, which today are one of the pillars for the realization of parallel calculations. Raspberry Pi computer modules represent a good basis for cluster formation and support for parallel computing. The support of these computing practice in parallel computing is most often carried out with the support of the MPI (Message Passing Interface) concept.*

**Keywords:** *Parallel Computing; computer cluster; Raspberry Pi; message passing interface*

## 1. INTRODUCTION

Although parallel computing is often regarded as an objective in achieving more efficient problem solving, it can also be viewed from a completely opposite angle. This second angle relates to the real possibility that the built-in parallelism in the process of solving various problems is supported by computers. The ability to solve the problem, that is, calculations supported by parallel computer systems, has become real with the intensive development of semiconductor technology and its impact on the development of computing [1].

Particularly significant progress in parallel computing was achieved through computer clusters realized within the TCP/IP network [2]. In such systems, the parallel computation process takes place through the exchange of messages. The best known systems for parallel computing support within the TCP/IP cluster are MPI (Message Passing Interface) [3] and PVM (Parallel Virtual Machine) [4].

A large number of microcomputers, realized on the principle of one board computer, can be found on the market. Such computers, as a rule, have standard communication interfaces, which allow them to connect to the necessary peripheral devices, including connecting to various types of computer networks. One of the most famous modern microcomputer families are Raspberry Pi modules [5]. The latest generation of this module, Raspberry Pi 3 model B has the following features:

- CPU: Quad-core 64-bit ARM Cortex A53, 1.2GHz

- GPU: 400MHz VideoCore IV multimedia
- Memory: 1GB LPDDR2-900 MHz SDRAM
- USB: 4 ports
- Video outputs: HDMI, composite video (PAL and NTSC)
- Network: 10/100Mbps Ethernet and 802.11n Wireless LAN
- Peripherals: 17 GPIO, HAT ID Bus
- Bluetooth: 4.1
- Power source: 5V via MicroUSB or GPIO header.

Figure 1 shows the appearance of the Raspberry Pi module.



**Figure 1.** *Raspberry Pi module*

Due to processor and memory characteristics, as well as the ability to connect to the Ethernet network, Raspberry Pi is a good basis for the formation of the appropriate computer cluster. The aim of this paper is to demonstrate the possibility of realization of the computer cluster based on the Raspberry Pi 3 module connected in the TCP/IP network.

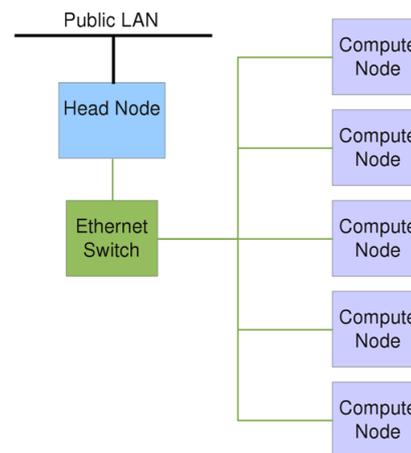
## 2. THE TERM OF COMPUTER CLUSTER

Computer clusters were developed in order to overcome limitation of computers available on the market with most cost efficient method. The term computer cluster can be defined in many ways, but essentially it represents multiple computers connected in a way that, from the "outside", they form a single unit. Inside computer cluster each computer is called a node, and one cluster can contain from two to few hundred nodes. Usually, nodes are commonly connected through fast local area networks (LANs) and they can form tight or loose connections depending on the way they are connected.

There are three main types of computer clusters: high performance (HP), load balancing, and high availability (HA) clusters. HP clusters are used for solving high and advanced computation problems, when result of one node effects future result of another node. Load balancing clusters are used when there is a need for more servers/nodes to host one website. In this case nodes serve multiple users with same resources at the same time. High availability clusters are used in cases when security of data stored on them needs to be active with minimum of down-time.

Some of major advantages of using computer clusters include better processing speed, flexibility, and high availability of resources. Multi-core processors have enabled the execution of the code to be parallelized by using the MPI concept. The question arises whether it is possible to achieve the same effect by using multiple computers connected to the LAN. Practice has shown that this can be achieved very successfully, as evidenced by numerous systems based on MPI network clusters [6]. One of the most famous systems is the Beowulf cluster [7, 8].

Figure 2 shows the basic scheme of a computer cluster in which computers are connected to a local computer network. Compute Node represents computers running parallel computing branches. Head Node represents the computer through which the cluster connects with the environment. In principle, this computer needs to have more powerful hardware than Compute Node computers. As a rule, the network that needs to provide the information exchange within the cluster should be based on Gigabit Ethernet. The cluster configuration in Figure 2 is sufficient to support lower-cost calculations. At the same time, this cluster can be a good basis for getting acquainted with the principles of parallel computing using the MPI concept. Accordingly, the appropriate cluster structure can be realized using the Raspberry Pi module.



**Figure 2.** Typical structure of MPI cluster [9]

This paper deals with the possibilities of using clusters realized using four Raspberry Pi modules. In a given cluster, one Raspberry Pi module has the Head Node function, and the other three are the Compute Nodes.

## 3. POSSIBILITIES OF NETWORKING THE RASPBERRY PI MODULE

Raspberry Pi is very powerful but small computer module, created by developer team in England for educational purposes. Latest version of this module is Raspberry Pi 3 Model B+ with 1.4GHz 64-bit quad-core processor and dual-band wireless LAN, Bluetooth 4.2, faster Ethernet and Power-over-Ethernet support.

Possibilities of using Raspberry Pi module are many. It can be used as a computer, media server, gaming console, IoT device, and much more. It is possible to install many OS on the Raspberry Pi module, so configuration is mostly easily done through terminal and additional libraries. For those that do not want to use external hardware like monitor, keyboard or mouse, can just insert SD cards with pre-installed OS and use Bluetooth to operate Raspberry Pi module. Most recent version of Raspbian OS has all software needed for setting up and running Bluetooth connection.

Using Bluetooth connection, Raspberry Pi can control external hardware, like Bluetooth speakers, actuators, or even make connection with mobile phones. As for Wi-Fi module, it is usually used for connecting Raspberry Pi to other devices and actuators over Wi-Fi network. With this modules it is possible to build Wi-Fi router, 3D printer, make smart home devices or send collected data to online server. Another type of connection is through Ethernet. Raspberry Pi modules inside clusters are usually connected with Ethernet cables to secure data and get fastest exchange of data [10].

#### 4. RASPBERRY PI CLUSTER BASED ON MPI CONCEPT

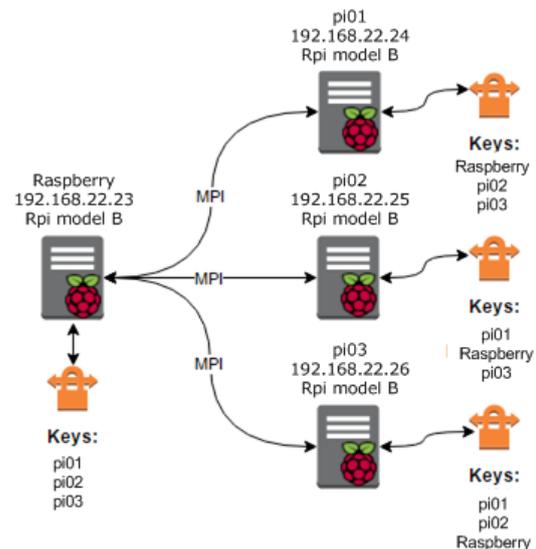
MPI or Message Passing Interface is communication protocol for programming parallel computers. Originally, MPI was designed for distributed memory architectures, but now it can run on almost any hardware platform, distributed memory, shared memory, hybrid, and so on. Some advantages of using MPI are: support for full asynchronous communication, processes can be grouped based on context, it is flexible and portable.

Hardware requirements for building one Raspberry Pi cluster are: four Raspberry Pi 3 modules, four 16GB micro SD cards, four USB to Micro USB cables, port switch, router, and Ethernet cable. For building cluster there has to be at least two or three nodes (Raspberry Pi) and if it is not enough it is possible to add more later on. To start on configuring the cluster, first the Raspbian Jessie image is downloaded to each micro SD card. Raspbian Jessie is operating system based on Debian Jessie, specifically designed for Raspberry Pi modules. After booting Raspbian on each module, take note of their IP addresses to be able to generate SSH keys. SSH stand for secure shell and it is used as encrypted remote login protocol and a way to communicate with other nodes on the same network. SSH can be configured over Wi-Fi and once configured you can use SCP (Secure Copy) and SFTP (Secure File Transfer Protocol) for transferring files and directives directly from one node to another. Via SSH it is also possible to directly run commands on selected node, change host name of nodes or even shutdown a node. At this point it is good to have another SD card with more memory to service as a disk for cluster. Depending on the type of cluster you are making, this additional memory can be available to all nodes or just the Head Node.

After configuring the operating system, it is necessary to install MPI software on the SD card of each of the nodes in the cluster. In this case, the MPICH3 version is installed. Also, you need to install the MPI4PY library, which allows programming nodes in the Python programming language.

In order to use identical system software on all nodes, it is necessary to perform cloning of the formed SD card. Finally, each node needs to be configured by assigning a unique name (HostName) and enabling it to work with the SSH protocol. Also, it is important that each node has its own IP address, which has to be stored in the so-called machine file. This file contains the IP addresses of all the nodes on which processes are started. This file must be located at each node and uses MPICH3 for communication and sending/receiving messages between the nodes.

Finally, it is necessary to generate SSH keys to allow management of each Raspberry Pi module without using the username and password. Figure 3 shows a schematic representation of the MPI cluster structure with hostname, IP addresses, and SSH keys used.



**Figure 3.** Example of hostname and SSH keys in the MPI cluster based on the Raspberry Pi 3 module [11]

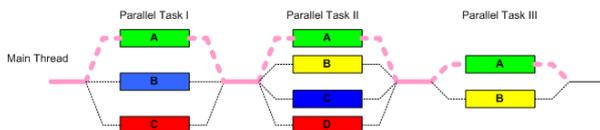
#### 5. POSSIBILITIES OF USING RASPBERRY PI MPI CLUSTER

When one program requires running multiple tasks that can be run separately it is good idea to run it on cluster. This shortens execution time of programs, because each node inside cluster can run one task, creating parallel computing. Not only this, but using clusters can improve redundancy and fault tolerance. When one node or server crashes inside cluster, process is distributed on rest of available nodes. Knowing this, there are many possibilities using Raspberry Pi cluster. Some possible uses are: machine learning, 3D processing, some types of simulations, automated software testing, media encoding, network load distribution, and much more.

In practice, there are examples of the use of Raspberry Pi-based clusters for the development of parallel applications. At the Cornell University, a project was realized to develop Symmetric Multi-Processing Platform (SMP) and Asymmetric Multi-Processing (ASMP) parallel applications [15]. The goal of realization of this project is to obtain support for Lab projects, within the course "Design with Embedded Operating Systems". The project was realized using the Raspberry Pi 2 Model B computer. With four cores that share physical memory this computer represents a good platform for Symmetric Multi-Processing. For

Asymmetric Multi-Processing, a cluster was developed in which four Raspberry Pi modules are connected via an Ethernet router. As an application for analyzing the performance of the realized cluster, Sobel Filter Edge Detection was selected. The Sobel filter is based on calculations over two-dimensional series, which is an excellent basis for the development of a parallel program. The results of the analysis showed that using Symmetric Multi - processing and Asymmetric Multi - Processing software achieve four to ten times better performance than with sequential programming.

OpenMP (Open Multi Processing) technology was used to develop parallel applications within the Symmetric Multi-Processing approach. This technology is adapted to multiprocessing based on shared memory. The OpenMP concept is based on compiler directives and libraries that define the framework for parallel programming [16]. Through OpenMP, the user receives a simple interface for the development of parallel applications. The platforms on which these applications can be used range from standard personal computers to supercomputers. This technology realizes multithreading, i.e. a parallelization method to which the main thread, which is a series of instructions, executes consecutively in a certain number of threads, thus achieving the parallelization of tasks, as shown in Figure 4.



**Figure 4.** Multithreading using openMP

In the case of Asymmetric Multi-Processing, MPI technology is used. It is a standardized messaging system that defines the syntax and semantics of library routines that use a wide range of users to write programs in C, C++, and FORTRAN programming languages. Accordingly, MPI can be considered as a communication protocol for parallel programming. In the concrete project, the MPICH option was used, because it is widely accepted in relation to other realizations of the MPI concept. It should be noted that the MPI4PY achieves the MPI concept for programmers in the PYTHON programming language. Otherwise, within this project, C programming language was used for realization of both types of multiprocessing (SMP and ASMP).

At the Midwest Instruction and Computing Symposium 2017 (MICS 2017), researchers from the University of Wisconsin - La Crosse presented a cluster based on eight Raspberry Pi 3 Model B modules [17]. As in the previous case, the Raspbian Jessie based on Debian Linux was used as an operating system. Multiprocessing is

realized using MPI standards and applications written in the Python programming language. The realized cluster was tested using the Monte Carlo method for calculating the value of Pi. Calculation was performed on eight nodes with one to four processes per node.

During the testing of the MPI application on the Raspberry Pi cluster, it was determined that only 25% of the computational power on each Raspberry Pi module was used. This is due to the use of only one core within the Raspberry Pi module. Consequently, the idea was to include, in addition to the MPI approach, the local multiprocessing at the level of each Raspberry Pi module within the cluster in the calculation. Since the MPI variant used the Python programming language, local multiprocessing was implemented through standard multiprocessing libraries of this programming language. Thanks to this, Raspberry Pi node computing resources are fully used, i.e. each of its four cores. Table 1 shows the mean times of calculating Pi using Monte Carlo approximation in 500 points.

**Table 1.** Mean computing time within clusters with MPI and multiprocessing.

Cluster MPI		Cluster Multiprocess	
Processes	Time [s]	Processes	Time [s]
1	78,61	1	98,41
2	47,35	2	49,56
3	32,01	3	33,07
4	24,39	4	24,85

This research applied the multiprocessing concept instead of multithreading to avoid the limitation due to the Global Interpreter Lock (GIL). Because of the GIL Python interpreter, it does not allow two instructions in the Python program to run at the same time, causing the threading concept to not increase the performance. As can be seen from Table 1, the mean calculation times are approximately the same. Improvements of approximately 35% are achieved by increasing the level of multiprocessing. Researchers assume that similar times are calculated for the consequences of a small number of messages that are exchanged between nodes.

Cluster building experiences, based on the Raspberry Pi module, have initiated the implementation of similar clusters with a large number of nodes. Examples of such clusters are "Beast v1", with 120 and "Beast v2" with 144 Raspberry Pi modules. These clusters are primarily designed to test software produced by reisin.io, designed to support IoT and embedded devices.

A group of professors and students from the University of Southampton created "Iridis - Pi" Cluster [18]. The cluster consists of 64 Raspberry Pi nodes that are interconnected over 100 Mbit Ethernet network. The cluster was created as a result of an attempt to provide a low - cost

starting platform that would enable students to get to know them and can apply high-performance computing and data processing in a range of engineering and scientific problems.

Maybe biggest Raspberry Pi cluster made so far is 256 node "SeeMore" cluster. This project is developed by Kirk Cameron, professor of computer science and Sam Blanchard, an assistant professor of sculpture at Virginia Tech University. Idea was to create something to which will bring art and engineering together, while showcasing significance of parallel computing to viewers. Blanchard's idea was to create a kinetic sculpture that will show what's going on inside the computer.



**Figure 5.** CSLab Raspberry Pi cluster

Having in mind the aforementioned experiences in creating a cluster based on the Raspberry Pi module, in the Laboratory for Computer Science, the Faculty of Technical Sciences in Čačak has started to create its own computer cluster. Primarily, the goal was for students of master studies to be familiar with the problems of parallel computing, computer clustering and the Message Passing Interface concept. Also, they also wanted to gain experience in working with Raspberry Pi modules, installing the appropriate operating system and programming them, primarily using Python programming language.

The cluster was created using four Raspberry Pi 3 B modules, which are connected to a local

computer network using a 5-port Ethernet router (Figure 5). The power supply of the Raspberry Pi 3 B module was achieved using the 5-port Power USB Hub. Raspberry OS has been installed on each Raspberry Pi module and the desired network parameters (IP addresses) have been set. Also, MPICH3 is installed on each module, allowing clustering based on the MPI concept.

Checking the correctness of the work of the created Raspberry Pi cluster was performed by executing a simple test program written in the Python programming language. This test program shows that some processes are performed on different computers within a cluster. This demonstrated that the created system is available for performing an arbitrary parallel application.

In the continuation of the research it is planned to develop various parallel applications and compare their performance with respect to the sequential execution of programs on one computer, or in the multithreading environment on computers with multi-core processors. It is also planned to expand the existing cluster by adding new Raspberry Pi 3 B modules.

## 6. CONCLUSION

The formation of MPI clusters has become particularly interesting with the emergence of computer modules such as Raspberry Pi or BeagleBone [14]. Good process and network characteristics of these modules allow clusters with a number of nodes to be formed based on them. This paper presents the realization of the MPI cluster from four nodes based on the Raspberry Pi 3 module.

Through the conducted research, within which the cluster shown was formed, the aspects of using the Raspberry Pi 3 module for this purpose, the installations of the required software, and the method and requirements for configuring nodes within the cluster were examined. Also, experience has been gained in terms of basic knowledge in programming such a computing complexity using the MPI concept. The realized research has shown that the construction of this cluster helped students of master studies in acquiring additional knowledge in the field of parallel processing. Consequently, the developed cluster, as well as future research on this plan, will provide a good basis for the education of students in the field of parallel processing.

It is planned that as part of further research, a cluster with a large number of Raspberry Pi nodes to be formed. It is also planned to use the programming of a more complex algorithm to use such a cluster and MPI concept and to conduct an appropriate comparative analysis in relation to the use of the sequential program.

Also, it will be interesting for further research to compare performance times and other performance factors for different platforms in which software applications for the same algorithms would be executed. Further research implies the use of different programming languages for the development of parallel applications and the implementation of an appropriate comparative analysis of the results obtained.

### ACKNOWLEDGEMENTS

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# Multifunctional Solar Park with “+five in one”

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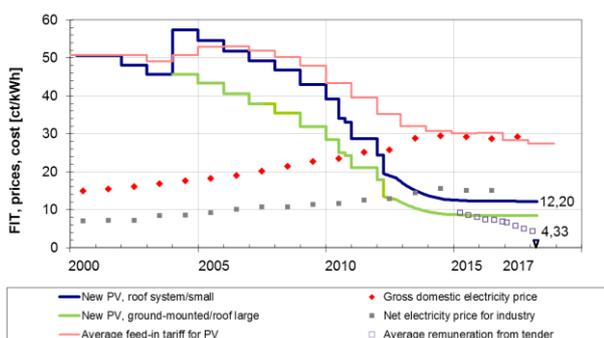
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**Abstract:** This work describes photovoltaic solar park for family houses and residential objects with multifunction “+five in one” in range 10-100kWp. Key element of this system is Photovoltaic Converter unit which is realized as non-isolated photovoltaic string inverter with energy storage and uninterruptable power supply function. The control electronic of the inverter is described more detail in the paper. At this point, hardware of Electronic Control Module and base software were realized. The next steps of development are an energetic part of the inverters in IGBT and SiC technology, embedded software and web server.

**Keywords:** solar park; photovoltaic converter;

## 1. INTRODUCTION

The situation on the solar energy market has changed sharply in the direction of a significant reduction in prices and initiative for electricity generated from solar sources. New regulations have been introduced where solar energy is increasingly gaining market and competitive forms. You could see attached graph from Fraunhofer institute (New PV roof electricity price << Domestic electricity price) Germany Feed-in tariff for small roof systems put into operation by April 2018 can be up to 12.20 €-cts/kWh and is guaranteed to the operator over the next twenty years. Serbian Feed-in tariff (Službeni glasnik RS br. 8/2013) is 20.66 €-cts/kWh.



**Figure 1.** Picture 3. Feed-in tariff for PV power in Germany (source Fraunhofer institute Freiburg, February 21, 2018)

It should also be noted that the Energy Community calls on Serbia to adopt amendments to the law and support measures for renewable energy sources and the procedure of public bidding. There should be referent price, and that is a market price defined “day in advance” on hour period, on the organized electricity market [2, from 06/13/2017]). The facts about the actual and expected changes in the solar

energy market led us to think about the addition and change of the solar energy paradigm in the case of a photovoltaic power plant, i.e. a garden for family houses and residential buildings. We think that future PV power plants for roof systems should be multifunctional and informatically connected to “smart grid” system. In that direction we propose the introduction of a dynamic tariff system, which implies a continuous change in the unit price of energy by the operator, that is, the public buyer and the seller of electricity (most often that is country). The expression “+ five in one” is a symbolic sign that the proposed PV system compared to the classic has additional 5-five new functions. Classic PV system works parallel with the network and any excess of electricity produced is immediately handed over to the network and, that way, they become balance irresponsible producers and consumers. New system introduces high level of balance responsibility and it has been supplemented with some other attractive functions such as PV-roof, Energy Storage, UPS and REACTIVE energy production.

## 2. PHOTOVOLTAIC ROOF PANELS

Tesla and SolarCity developed a solar roof system that integrates the solar cells and modules inside the structure of the roof rather than just panels on a roof. They are using a high-efficiency solar cell manufactured by Panasonic and covered with a “color louver film”, which allows cells to blend into the roof while exposing them to the sun above, and finally a tempered glass on top for durability. It comes with a lifetime of the house warranty and 30-year power generation guaranteed. After the electricity production, Tesla estimates that its solar roof will be cheaper than regular tile roofs or

virtually pay for itself through electricity savings. The new product was unveiled on October 28, 2016, at a joint event with Tesla and Solar City in Los Angeles. In May 2017, Tesla started taking orders with a \$1,000 deposit for the first versions of its solar roof tiles and the product was sold out "well into 2018" within the first few weeks.

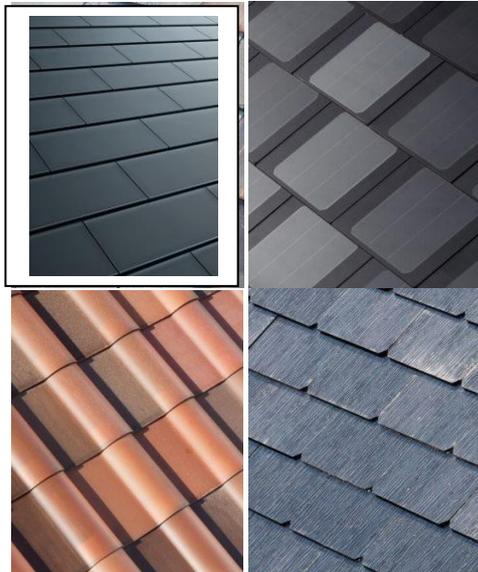


Figure 2. Solar roof panel designs

### 3. PHOTOVOLTAIC CONVERTER UNIT - STRING INVERTER "THREE IN ONE" UNIT

Designed by ElektroDRIVE d.o.o. [3] non-isolated photovoltaic string inverter with energy storage and uninterruptable power supply function.

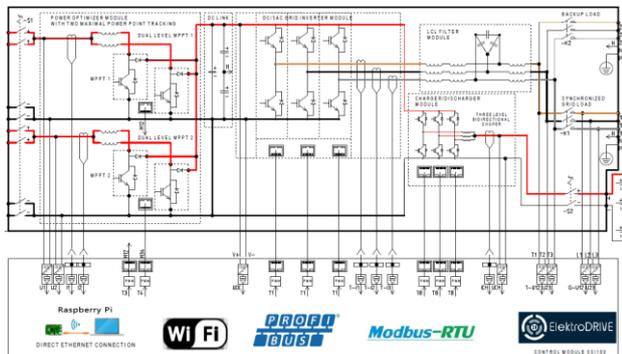


Figure 3. Electronic Control Module (ECM) Designed by ElektroDRIVE

- power module components
  - o two power optimizer modules with dual level boost choper realized in igt or sic technology;
  - o dc link module;
  - o dc/3ac grid inverter modulerealized in igt or sic technology;
  - o lcl filter module;
  - o charger/dicharger module realized in IGBT or SiC technology;
- interface components and mechanical components
  - o S1 input switch with optional with breaker;

- o S2 switch for connection with external battery, optional with circuit breakers;
- o K1 Contactor for grid connection, optional with circuit breakers;
- o K2 Contactor for connection with BACKUP load, optional with circuit breakers;
- o X Connection terminal and connectors.

Control module hardware realized with two electronic cards:

- Power supply and measuring electronic card
- CPU, gate-driver and input-output module, electronic card
  - o 8 voltage measuring +/-1000Vpp convert in DSP volt gain range 0 ... 3.3 VDC
  - o 6 current measuring
  - o 2x3 PWM driver T1 – Three phase 6PWM driver for grid inverter
  - o 2x3 PWM driver T8 – PWM driver for charger / discharger chopper
  - o 2 PWM driver T3 and T4 for two level boost choppers - power optimizer MPPT1
  - o 4DI, 2RO 4 digital input (galvanic isolation), 2 relay outputs
  - o 2AI, 1AO2 analog input and one analog output
  - o Safe power off circuit for hardware shutdown – block off all PWM drivers
  - o RS485 or PROFIBUS serial communication channel
  - o WIFI based web server optional module node MCU ESP12E
  - o Raspberry PI3 mini PC based extension optional module

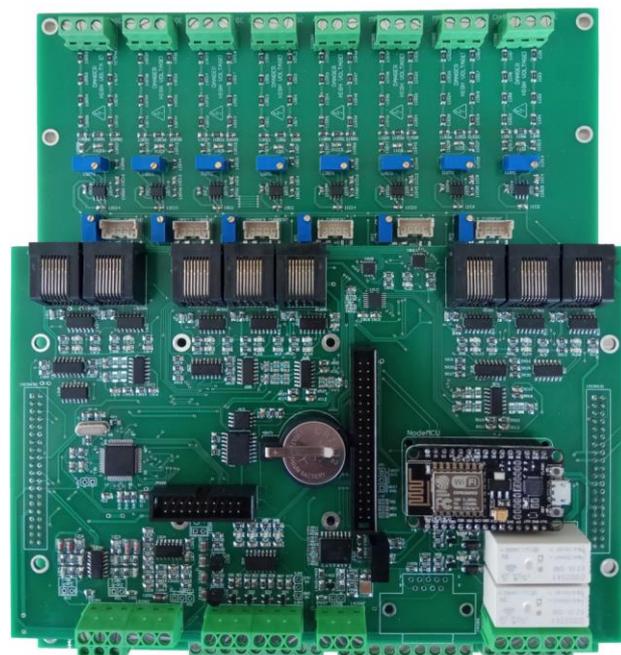


Figure 4. Electronic Control Module (ECM) Designed by ElektroDRIVE [3]

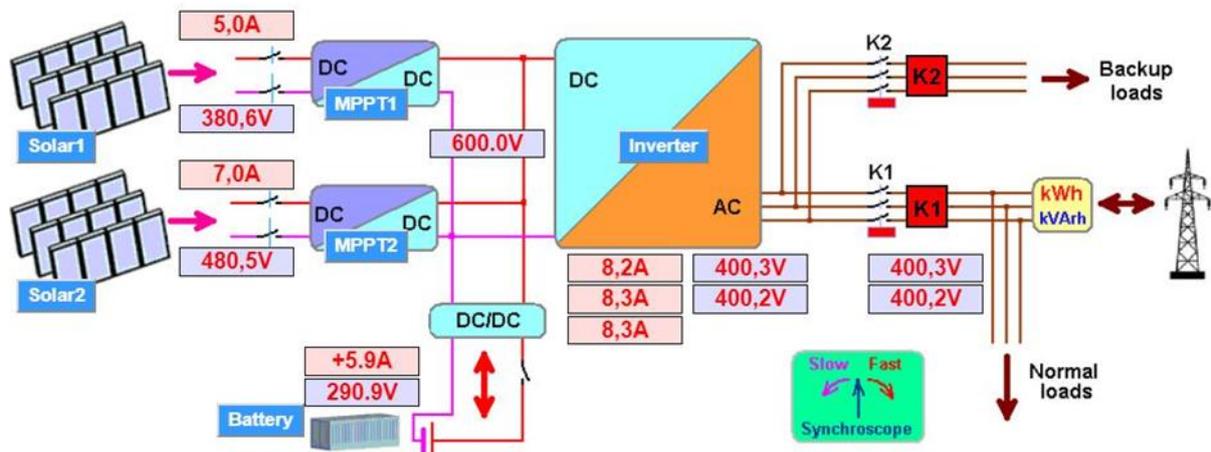


Figure 5. HMI function with WEB server of solar inverter in development phase

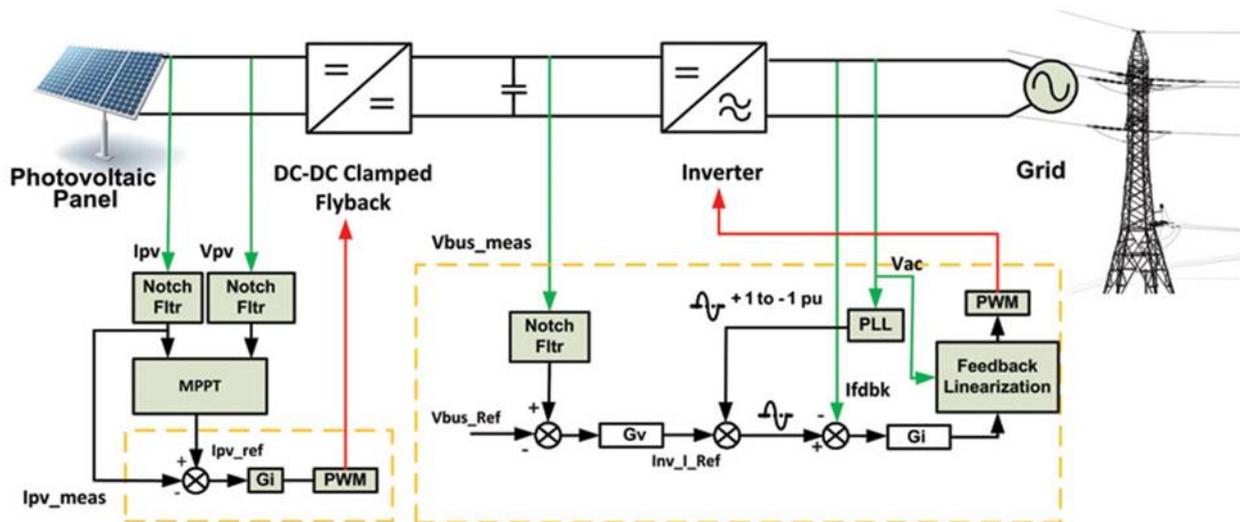


Figure 6. Illustration of one-part embedded software-firmware which refers to MPPT and PLL

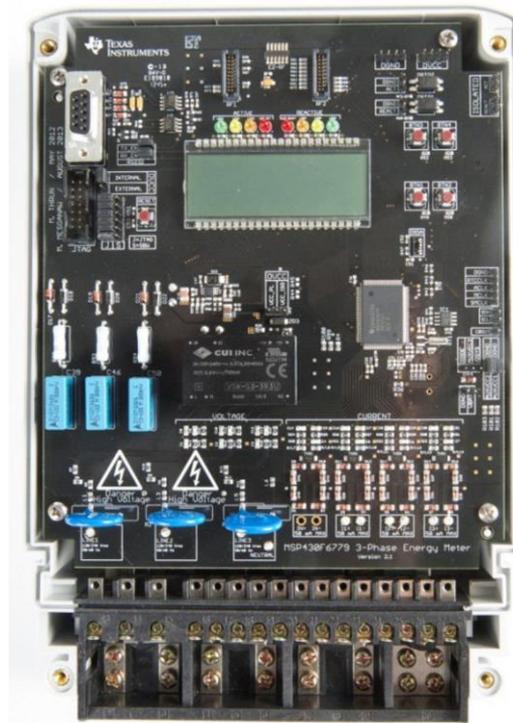
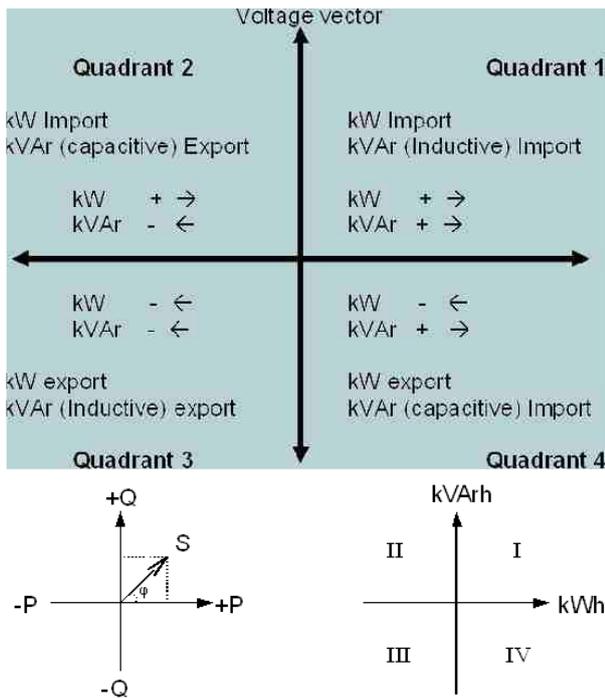
Control module firmware:

- PPT Maximal Power Point Tracking control task;
- AFE Active Front End and PLL Phase Locked Loop task;
- Synchroscope, inverter - master grid synchronization;
- Charge/dicharge control task;
- UPS uninterruptible Power Supply interface algorithm;
- Real time communication firmware and web server program.

#### 4. FOUR-QUADRANT ENERGY MEASURING AND PRICE COMPUTING UNIT

Advanced bidirectional utility measure process of measuring reactive and real energy accounting both forward and reverse flows.

Four-quadrant energy measurement is supported for net metering systems with bidirectional energy flow. Voltage Sag and Swell Events Logged with Programmable Threshold Levels. Power quality monitoring and analysis in a three-phase energy



**Figure 7.** Illustration of Four-quadrant energy measurement

measurement. THD Calculated for Voltage and Current. Complete Energy Library with Fundamental Voltage and Current, Fundamental Active and Reactive Power, Active and Reactive Energy, Root Mean Square (RMS) Current and Voltage, Power Factor, Line Frequency and Dynamic Prices:

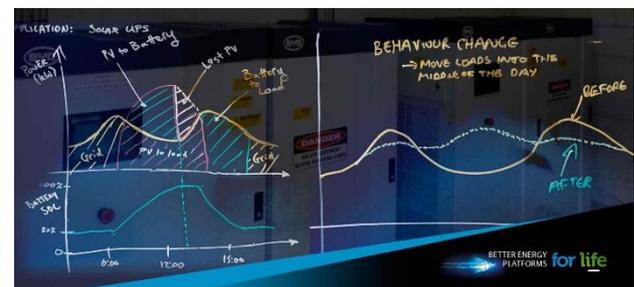
Dynamic Price for Active energyImport	DPAeIm	[€-cts/kWh]
Dynamic Price for Reactive energyImport	DPreIm	[€-cts/kVArh]
Dynamic Price for Active energyExport	DPAeEx	[€-cts/kWh]
Dynamic Price for Reactive energyExport	DPreEx	[€-cts/kVArh]

The calculation is done in such a way that integrals of import and export of Active and Reactive power is multiplied by dynamic prices. Bill in euro cents is calculated by subtraction of export sum from import. Dynamic prices of the public buyer-state change, for example, every five minutes or every hour based on the classic techno economic parameters (of course, within the framework of the contract defined rules) and immediately communicates via the Internet to buyers-sellers with whom it has a contract. Buyers and sellers, or their IT systems monitor the price (in our case it is a task of Advanced Photovoltaic Converter unit) and it decides how to work to get the maximum profit out of their power plant.

**5. GRID BALANCING**

In order for electrical grid to function reliably, it needs to be balanced. In practice, the Transmission System Operator achieves this by perfectly matching the consumption of electricity with the production. In traditional, fossil-fueled energy systems, production of base-load assets is scheduled to match the expected energy demand.

Short-term deviations in the expected demand are then accounted for by more flexible assets that can be quickly ramped up and down, with gas fired power plants as the most popular example.



**Figure 8.** Illustration of energy grid balancing

Grid balancing has become an important aspect for the power grid in matching the supply of energy to demand. In more recent years this has become less predictable with more renewable energy being installed into the grid.

This has resulted in wind farms being turned off at night time, when it is windy, but there is no demand. In Scotland this has resulted in payouts, most recently over £6m in 33 days has been paid by the grid to wind farms to not generate electricity.

Possible solution for this problem are batteries. To provide flexibility, the battery should (on average) be loaded at 50%, giving it equal potential for on or off loading depending on the needs of the grid operator at that very moment. The capacity of the battery can be used optimally by setting its load factor based on forecasted renewable output and electricity demand.

## 6. CONCLUSION

Five key features of proposed photovoltaic system “+five in one”

- Usage of the roof solar panels as a roof for family houses and residential objects;
- Energy storage;
- Extra reactive energy production (Maximum kW and maximum kVA tracking);
- Taking over balancing responsibilities from the power distribution (Dynamic Price Market);
- UPS function, uninterrupted power supply for backup load;

Future paradigm of management and subvention of small roof PV power systems (PV power plants on objects, roofs):

- Public buyer - state dynamically manages prices (each hour changes the import and export prices of active and reactive energy). This way, if the seller or solar park real-time monitors the price trends, it automatically begins to behave not only as a selfish producer but also as responsible BALANSER of energy.
- It is definitely necessary to accept the fact that the current price of energy sold to the public buyer - state is always cheaper than purchasing because that normal economy requires.
- For green solar energy, state should favor in that way that small roof PV power system gets free of

charge two key devices with standardized software:

- o Four-quadrant energy metering and price computing unit;
- o Advanced Photovoltaic Converter unit “+five in one”.

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# Photovoltaic Laboratory Trainer in Student Educations for Renewable Energy Sources

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**Abstract:** *This paper describes a lab setting for a photovoltaic system which was delivered at the Faculty of Technical Science (FTS) in Kosovska Mitrovica and is now at the stage of preparation for teaching. The Photovoltaic Laboratory Trainer enables project work to be carried out with industrial components. The solar trainer permits realistic simulation of the progression of the sun. Emulators make it possible to carry out the experiments in the laboratory without the sun. The Interactive Lab Assist and Advanced Photovoltaic multimedia course is designed to convey the theoretical information and practical know-how, and performs the PC-supported evaluation of measurement data.*

**Keywords:** *Photovoltaic; Renewable; Educations*

## 1. INTRODUCTION

In developed countries, renewable energy sources have a significant percentage of the installed power of the power electricity system. For their connection to the classic power distribution network or supply local consumers in place of electricity production have been developed special devices of the power electronics, as well as intelligent components for their control and supervision, [1]. All these power electronics, control, measurement and communication components of decentralized power electrical sources make up an intelligent system called a Smart Grid. Based on smart sensors, digital measuring devices, IT technologies such as the Internet, communication protocols (LAN, WLAN, RS485) and software, Smart Grid systems improve the coordination between power consumption and production via intelligent switching of load depending on the available energy, [2].

As part of the plans and projects of FTS KM for the development of teaching process and modernization of curricula, as well as their harmonization with the needs of the European power electricity market, it is envisaged to form a complex laboratory setting for the analysis and work on the training of the Smart Grid system in laboratory conditions, [3]. The structure of this lab set consists of three subsystems of the Smart Grid system. These are production subsystem, management and control subsystem, and consumption subsystem.

The first subsystem represents all lab settings that represent controlled distributed sources of power electricity from renewable sources in lab conditions. This subsystem includes photovoltaic systems,

wind generators of various configurations, fuel cells, etc. which can be hardware and software integrated into a unique Smart Grid system.

The second subsystem is the control part of the Smart Grid system with SCADA software and the accompanying equipment for hardware simulation of the switching states of the dual bus terminals and power switches in the distribution switchgear (cells) which are standard configuration in the power distribution stations.

The third subsystem includes hardware simulation of variable loads in distribution networks with the possibility of changing load impedance, i.e. with independent change R, L and C. This subsystem will also contain a part for compensation of reactive power and protective devices against electrical faults. Dynamic variable load is an induction cage motor that drives a variable mechanical load that is simulated by a hardware-controlled servo drive.

## 2. LAB EQUIPMENT

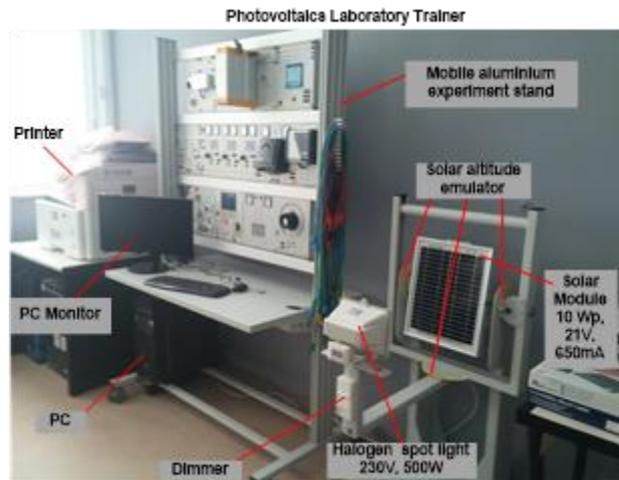
As shown in Figure 1 Lab setting for Photovoltaics Laboratory Trainer consists of: a mobile aluminum experiment stand, solar altitude emulator, PC, monitor and printer, [4].

The experiment instructions come in the form of an Interactive Lab Assistant course. This multimedia course is a step-by-step guide through the topic of modern photovoltaic energy systems, [4]. The physical fundamentals are conveyed using easy to understand animations. The Interactive Lab Assistant in conjunction with the virtual instruments constitutes a comfortable experimenting environment, [5].

An interactive multimedia user guide is installed on the PC. As well as software (VI Starter) for virtual

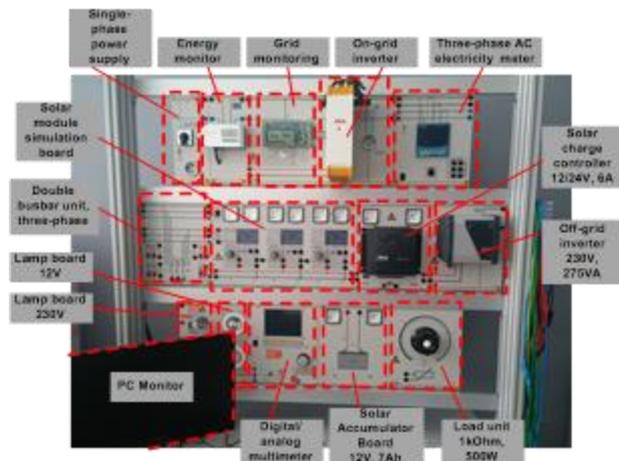
instruments supported by for Digital/analog multimeter, [6]. For the functioning of this software, a USB connection between the PC and the Digital/analog multimeter is required, as well as the installation of the appropriate drivers.

It is also installed on the PC as an additional option for the Photovoltaics Laboratory Trainer and powerconfig software that supports the power monitoring device PAC4200, [7].



**Figure 1.** Photovoltaics Laboratory Trainer – Laboratory for Renewable Energy Sources, FTC-KM

Experiment stand is divided into three levels, or three lines of equipment, as shown in Figure 2.

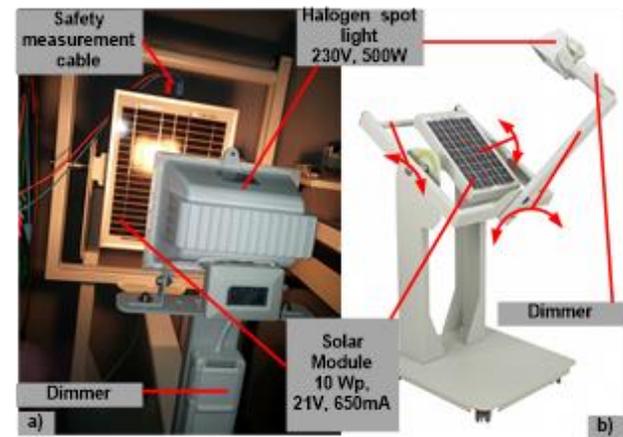


**Figure 2.** Photovoltaics Laboratory Trainer – Disposition and designation of the main part of equipment

**2.1. Solar module with solar altitude emulator**

The solar module rack consists of a polycrystalline solar module and a halogen spot light as solar simulator [8]. The brightness of the halogen spot light can be adjusted using a dimmer, Figure 3. Various roof top angles can be emulated using the tilt adjustment of the solar module allowing these effects on the solar module to be investigated. The halogen spot light is swivel mounted permitting it to simulate the progression of the sun over a whole day. To be able to emulate the various progressions

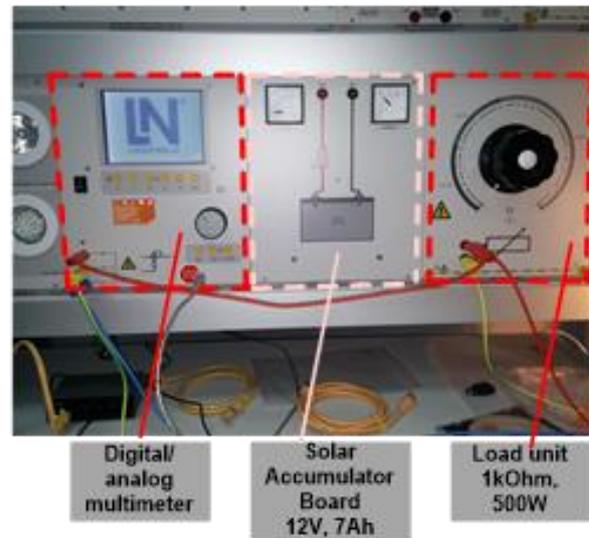
of the sun over the entire year, the tilt angle of the sun’s progression can be adjusted.



**Figure 3.** Solar altitude emulator – a) Work without sun light, b) Construction

**2.2. First line of the experiment stand**

The first line (Figure 4) of the experiment stand consists of: variable resistor as a load unit (1kΩ, 500W), Solar accumulator board (12V, 7Ah), Digital/analog multimeter, Lamp board 12V and Lamp board 230V.



**Figure 4.** Photovoltaics Laboratory Trainer – Equipment on the first row of the experiment stand

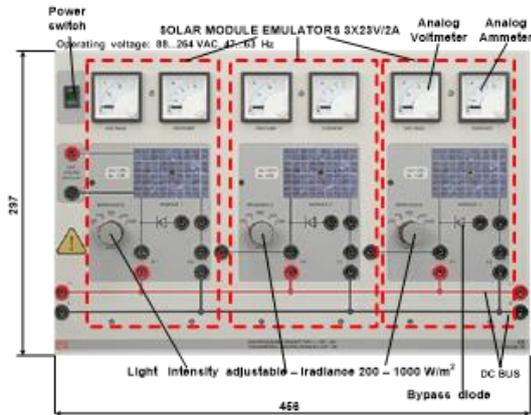
Load resistor is the load unit for solar module and solar power units. The resistor (0...1 kOhm/500W) are continuously adjustable, with stepped winding can be used as load resistance for Solar module, Solar charge regulator and Solar Inverters, [8].

**2.3. Second line of the experiment stand**

Figure 5 and Figure 6 show the magnified details of second line of the experiment stand that includes the following components: Solar module simulation model (3x, 23V/2A), Solar charge controller (12/24V,6A) and Off-grid inverter (230V, 275VA), [8].

The solar module simulation board offers three independent simulations of a solar module that

enable the realistic emulation of the solar module. Higher voltages and stronger currents can be realized by means of series and parallel circuit configurations. For each simulation a separate solar light intensity can be set and a bypass diode added.



**Figure 5.** Solar model hardware simulation board -3x23V/2A with adjustable level of irradiation

The solar charge controller (12/24V,6A) monitors the charge level of the accumulator (12V,7Ah) and protects this against excessive and deep depletion. To charge up the lead accumulator, the charge controller uses the IU charging processes. LEDs provide information regarding the operating and charge status. The charge regulator is equipped with the following features: Automatic 12/24V switching, Maximum Power Point (MPP) – Tracker, Terminal connection for Solar generator, Solar accumulator and DC load, [9].



**Figure 6.** Solar charge controller and Off-grid inverter

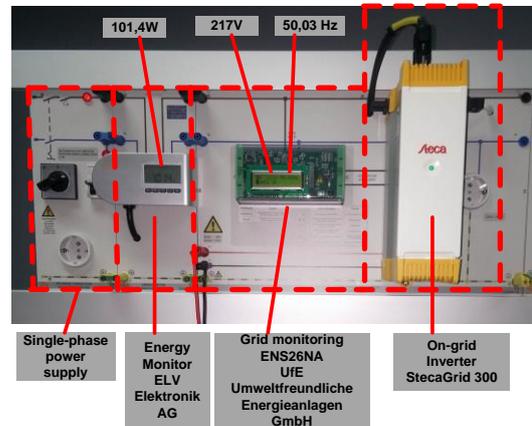
To operate standard commercially available electrical devices used in standalone solar power systems, the generated DC voltage must be converted into AC voltage. In the second line of the experiment stand the board consists of a commercially available off-grid inverter which generates an output voltage of 230 V AC from an input voltage of 12VDC. The off-grid inverter is equipped with a deep depletion protection facility with which it can be connected directly to a lead accumulator. The off-grid inverter is equipped with the following features: On/ off switch, LED display of operating status, Output voltage: sinusoidal

230V +/- 5%, Efficiency: 93%, Cut out for excess battery voltage, Over temperature and overload protection, Short –circuit protection and Pole reversal protection, [10].

**2.4. Third line of the experiment stand**

Modern solar power systems use grid-connected inverters to feed electric power into the mains. Experimental setup of a Photovoltaics Laboratory Trainer for grid parallel operation consists of a grid-connected inverter (StecaGrid 300) with a separable external monitoring unit (ENS26NA), [11].

The ENS unit monitors the mains voltage, frequency and impedance and switches the system off in the event of deviations. The ENS26NA automatic isolation units continually monitor the following parameters of the public electricity supply: overvoltage and undervoltage, frequency deviation and Impedance jumps, [11].



**Figure 7.** Solar power generation system connected to the low-voltage distribution network

The ENS26NA (designed for StecaGrid 300 and StecaGrid 500) is a single-phase power generation systems protection with integrated 25 A relays according to VDE-AR-N 4105 with the respective declaration of conformity and tested functional safety. The device has a test key and an LCD display showing trigger values, current measurements, status and the last 9 grid errors and can either be employed as power generation systems protection pursuant to VDE-AR-N 4105. Due to its islanding detection function, any supplier can be used even if they have no islanding detection properties of their own. Thanks to the built-in 25 A relays, no further contactors are required. The ENS26NA is the grid monitoring device for single-phase systems up to 5.7 kW, [11]. In the event of faults in the mains supply, the ENS26NA interrupts the feeding of electricity in the mains to prevent island effects. The safety functions are executed in a dual channel system, whereby each channel monitors the proper function of the other channel. In case of a failure the channels disconnect independently from each

other. The channels monitor each other mutually to increase error protection, [11].

### 3. MEASURING INSTRUMENTATIONS

In a laboratory setup of a Photovoltaics Laboratory Trainer two measuring devices, digital/analog multimeter and three-phase power monitoring meter are installed.

#### 3.1. Digital/analog multimeter

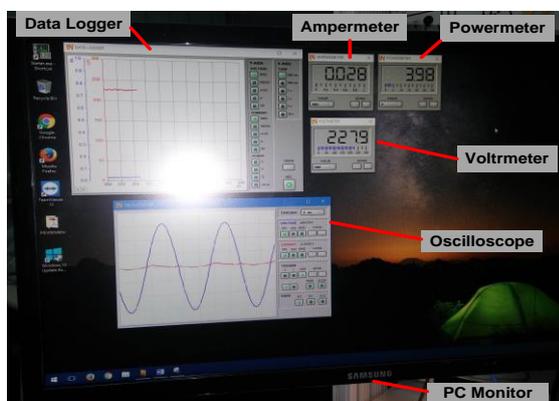
Digital/analog multimeter is the universal measuring device has been designed particularly to satisfy following requirements: high-performance overload protection, acquisition of measurement values must be performed accurately and independently of the curve's shape. It can simultaneously replace as many as four different measuring instruments – constituting a current/voltmeter, power and phase angle meter all in one. The graphic display allows for both student as well demonstration experiments, [6].



**Figure 8.** Digital/analog multimeter with USB interface and internal display

The VI Starter software allows all the measurements to be displayed on the PC, [6]. Up to 17 different displays can be opened:

- Oscilloscope display of voltage, current and power
- Consumption meter to display power consumed and output
- Data logger for 14 different variables
- Data export for data logger
- Characteristic recorder

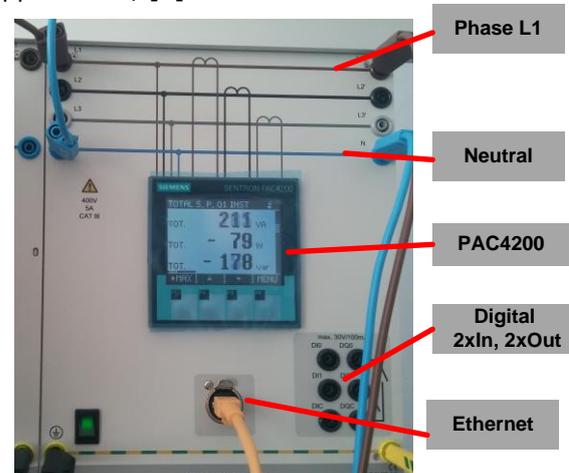


**Figure 9.** The VI Starter software allows all the measurements to be displayed on the PC

#### 3.2. Power monitoring device

The digital energy monitor SENTRON PAC4200 is a three-phase AC electricity meter which makes it possible to simply measure the energy output by a solar electricity generator or energy consumed by an electrical appliance [12].

The SENTRON PAC4200 is a feature packed power monitoring device that is suitable for use in industrial, government and commercial applications, [7].

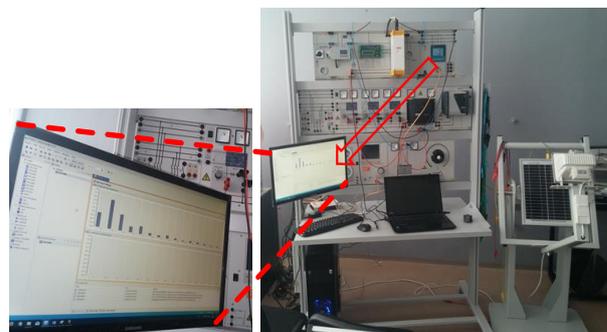


**Figure 10.** Three-phase AC electricity meter with power monitoring device SENRON PAC4200

The energy monitor *SENRON PAC4200* includes the following features:

- Three-phase measurement of current and voltage, 3x 400 V/5A
- Measurement of phase voltages, line-to-line voltages, currents
- Determination of apparent, active and reactive power
- Determination of active and reactive energy
- Determination of frequency and power factor
- Large, high-contrast background-lit graphic display

Powerconfig software is not delivered as part of the package in a laboratory setting for photovoltaic systems, but is taken as a free application from the website the manufacturer and installed on the PC and used as additional powerful tool for analysis of the measurements during the lab experiments.

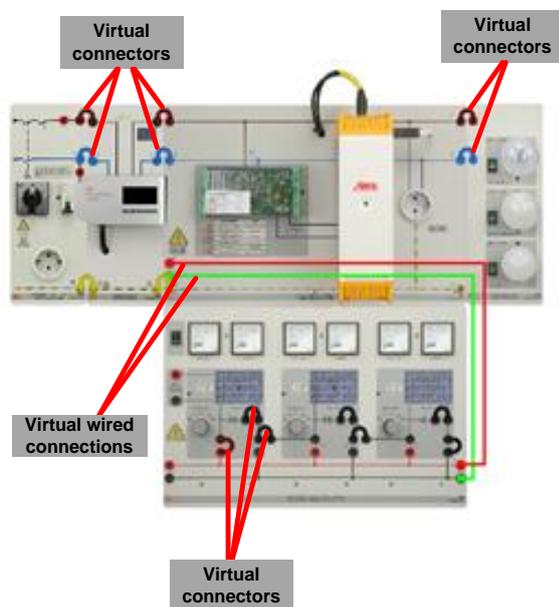


**Figure 11.** One screen of the Powerconfig software on PC. An overview harmonic content of the phase voltage and phase current.

The Powerconfig software is commissioning and service tool for communication-capable SENTRON measuring devices with PC. The power monitoring devices (PAC4200) with Powerconfig software tool for PC can be parameterized, documented, operated and monitored using various communication interfaces, [7].

#### 4. EXAMPLE -ON-GRID OPERATIONS

The multimedia animation is used as guide to prepare the experiment by setting animated virtual connectors and virtual wired connections. The user can clearly see how to connect the corresponding points on the modules. Figure 12 shows the final animation scene from the Interactive Lab Assistant with highlighted animated graphic elements that place on the fixed image of the equipment in the background, [12].



**Figure 12.** Experiment: Photovoltaic system with On-grid inverter. Animated virtual connectors and virtual wired connections in Interactive Lab Assistant as multimedia support tools.

Three solar modules (23V, 2A) are connected in serial and supply the On-grid inverter input. Value of irradiance on the hardware solar module simulator are set to 800W/m<sup>2</sup>.

Figure 13 shows the connected pieces of the modular type equipment using Safety connecting plugs and Safety measurement cables with built-in safety plugs at both ends.

Figure 13 shows the lab setting for the production of electricity from the solar system and delivery to the power supply network via an on-grid inverter. Instead of a bulb module, the power monitoring device SENTRON PAC4200 is connected to measure voltage and current at one phase.



**Figure 13.** Lab setting for the Experiment: Photovoltaic system with On-grid inverter.

Measured values for apparent, active and reactive power during this experiment are listed on the display of the power monitoring device PAC4200, as shown in Figure 10.

The harmonic content of the phase voltage and phase current of up to 31 harmonics at the output from the inverters obtained by measuring the PAC4200 are shown on the PC screen using the Powerconfig software, Figure 14.

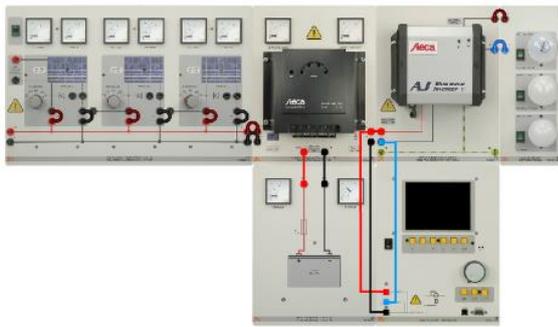


**Figure 14.** Experiment: Photovoltaic system with On-grid inverter. An overview harmonic content of the phase voltage and phase current

#### 5. EXAMPLE OFF-GRID OPERATIONS

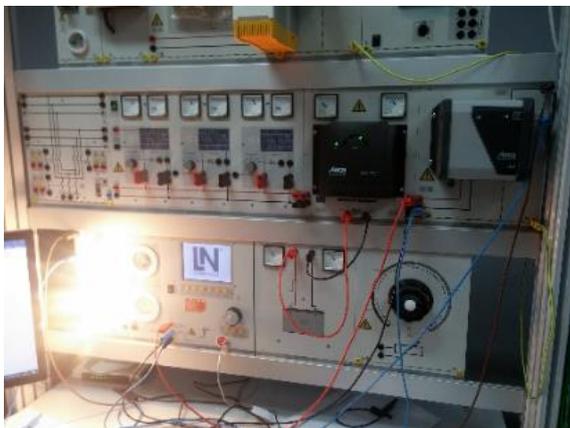
Three solar modules (23V, 2A) are connected in parallel and supply the Solar charge controller input. Value of irradiance on the hardware solar module simulator are set to 200 W/m<sup>2</sup>.

In Figure 15 shows the lab setting to produce electricity from the solar system, and delivery to the consumer who makes bulb module with three lights (230V AC) through of-grid inverter, [13].

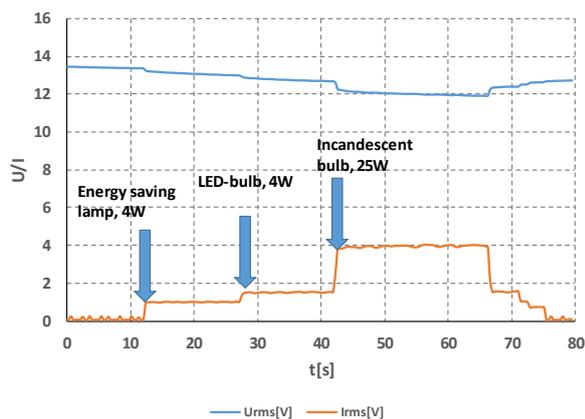


**Figure 15.** Experiment: Of grid inverter. Animated virtual connectors and virtual wired connections in Interactive Lab Assistant as multimedia support tools.

On Figure 16 shows the connected pieces of the modular type equipment using Safety connecting plugs and Safety measurement cables in the Experiment: Photovoltaic system with Of-grid inverter.



**Figure 16.** Lab setting for the Experiment: Photovoltaic system with Of-grid inverter

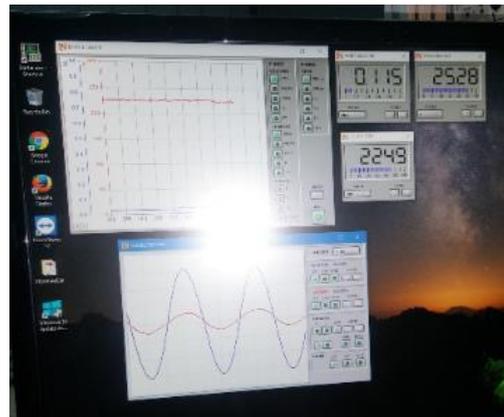


**Figure 17.** Supply lamp board (230V AC) from dc battery (12V, 7Ah) an Off-grid inverter. Measured voltage and current of the battery on the dc input of the inverter

The results are shown in Figure 17 obtained the recording numerical data in the data file by using option the "Export data" in the VI Starter software of the Digital/analog multimeter. The data from the

data file are then imported and graphically presented in Excel.

Figure 17 shows three moments when the lamps of different type are manually switched on but which have the same lighting effect. First, the 4W Energy saving lamp is, with a sudden leak of 1.2A current. After that, 4W LED bulb is included. The amount of current increase is about 0.6A, so the total current has increased to 1.8A. In the third transient process Incandescent lamp 25W is included, with a 2.1A jump current. The total current is 3.9A. The battery voltage is 12V.



**Figure 18.** Supply Incandescent lamp (230V AC) from dc battery (12V, 7Ah) through Off-grid inverter. Measured wave shapes of the voltage and current on the ac output of the inverter

On the virtual oscilloscope, waveforms of ac voltage and current on resistor load which is the incandescent bulb are shown (voltage and current sinusoids are in phase), Figure 18.

## 6. CONCLUSION

With this Photovoltaic Laboratory Trainer, students can acquire new knowledge and skills about all parts of a photovoltaic system under lab conditions that fully correspond to actual photovoltaic systems whose solar panels are installed outside.

The multimedia interactive approach, then the virtual instrumentation software as well as the power monitoring software with all functions are powerful tools that enable the efficient transfer of theoretical knowledges and their understanding by looking at practical results as well as saving the output reports using standard software tools for word processing and data processing.

Within this lab setting, there are over 10 different lab combinations for experimental testing with full multimedia and theoretical support. It provides an excellent basis for the formation of a new teaching courses within the Power engineering module for academic studies on the Faculty of Technical Sciences in Kosovska Mitrovica.

The complete lab Photovoltaic Laboratory Trainer also has a dual bus module that allows this setting to be integrated into a complex Smart Grid system.

## ACKNOWLEDGEMENTS

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# The Magnetoimpedance Effect and Principles of Measuring

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**Abstract:** This paper presents magnetoimpedance (MI) effects and the principles of measuring in order to exhibit the MI dependence on frequency and external magnetic field intensity. This phenomenon is not enough represented in Educational programs so this paper will be used as a learning material of basic concepts, influencing factors and the principles of measuring of MI effect. The obtained MI diagrams are shown for amorphous/nanocrystalline FINEMET type ferromagnetic  $\text{Fe}_{72}\text{Cu}_1\text{V}_4\text{Si}_{15}\text{B}_8$  ribbons and  $\text{Fe}_{73}\text{Cu}_1\text{Nb}_3\text{Si}_{13.5}\text{B}_{9.5}$  microwires.

**Keywords:** MI effect, skin effect, amorphous/nanocrystalline ferromagnetic ribbons and microwires

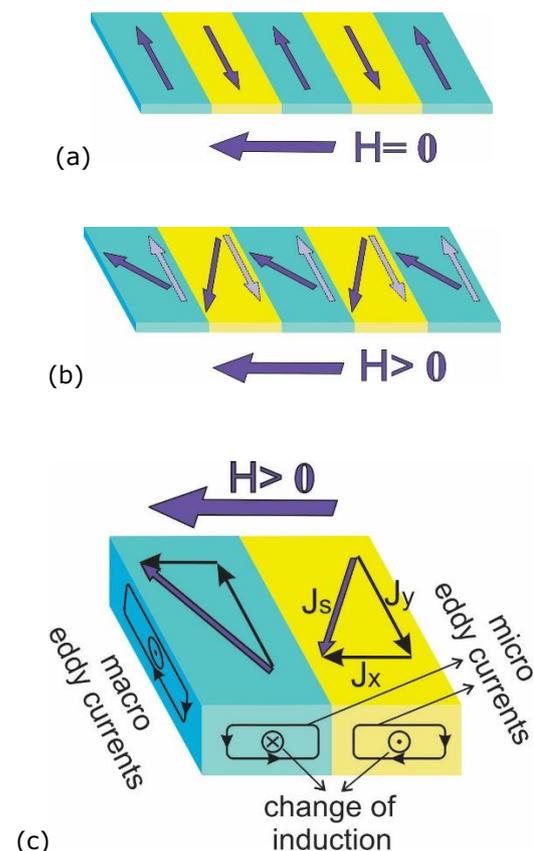
## 1. INTRODUCTION

Changing magnetic impedance under the influence of an external DC magnetic field is named magnetoimpedance (MI) effect. If the MI ratio is higher than 100 % than it is named the giant magnetoimpedance (GMI) effect. MI effect was discovered in the early nineties of the twentieth century [1] and today is used for making a very sensitive magnetic field sensor whose sensitivity reaches up to about 7% /kA/m [1-7]. Different impedance measurements methods are implemented through the educational system as well as the phenomenon and explanations of the skin effect on the conductor through which flows the alternating current. This paper describes principles in measuring MI effects unifying classical impedance measuring principles which changes under the influence of frequency and external magnetic field. The influence of frequency at the impedance is studied by the skin effect and the influence of the external magnetic field by the domain structure of the material.

### 1.1. The domain structure of the material under the MI effect

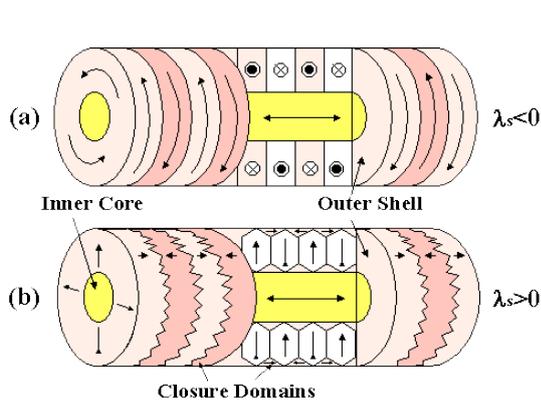
In order to explain the MI effect, it is necessary to analyze the domain structure of the elements in which the effect is studied (e.g., ribbons, wires, films).

For samples in the form of striped parallelepiped, the magnetic domains are arranged along of axis, i.e. at an angle of 90° in relation to the length of the ribbons, as it shown in Fig. 1. Adjacent domains have the opposite orientation, which is caused by achieving the best energy configuration.



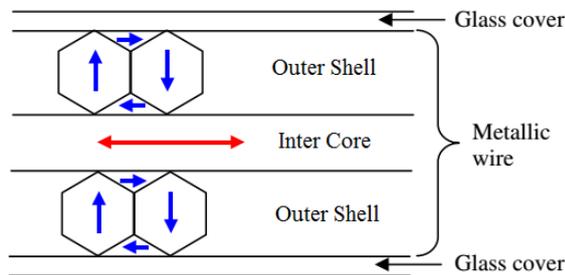
**Figure 1.** The magnetic domains in amorphous ribbon.

The orientation of magnetic domains in amorphous melt-spun microwires depends on magnetostriction, where it can be positive (for iron-based alloys) or negative (for cobalt based alloys) as it shown in Fig. 2.



**Figure 2.** The magnetic domains in amorphous melt-spun wires.

There are also amorphous metal-like glass-covered magnetic wires with a specific magnetic domain arrangement Fig. 3 [8].



**Figure 3.** The magnetic domains in amorphous glass-covered magnetic microwires.

**1.2. Calculating the MI ratio**

Exposing the ferromagnetic material to external dc magnetic field leads to the rotation of the magnetic domains in the direction of the magnetic field what leads to a decrease in the impedance of the sample. Relative change in impedance ( $Z$ ) of the sample with the change of dc magnetic field ( $H$ ) is called magnetic-impedance (MI) ratio and is defined as:

$$\frac{\Delta Z}{Z} = 100\% \cdot \frac{Z(H) - Z(H_{max})}{Z(H_{max})}, \quad (1)$$

where  $Z(H)$  is impedance at a certain value of the magnetic field, and  $Z(H_{max})$  is the impedance at the maximum magnetic field that depends on measuring equipment.

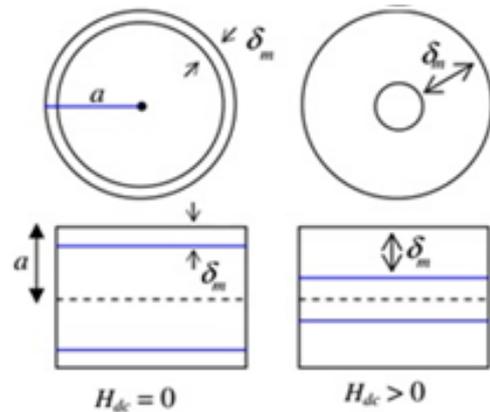
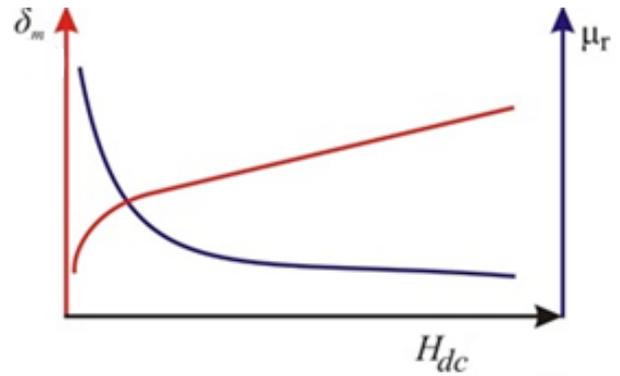
**1.2. Influence of frequency on MI effect**

Changing the frequency leads to the change of the impedance according to skin effect (see Fig. 4), given by the following equation [9]:

$$\delta_m = \sqrt{\frac{\rho}{\pi \cdot \mu \cdot f}}, \quad (2)$$

where are

- $\delta_m$  – penetration depth (skin effect)
- $\rho$  – electrical resistivity,
- $\mu$  – magnetic permeability, and
- $f$  – frequency.



**Figure 4.** Penetration depth changes in microwires depending on external dc magnetic field [10].

In the soft magnetic material with high permeability values and lower values of the electrical resistivity, at a relatively high frequency, penetration depth becomes less than half the thickness of the ribbon, i.e. the radius of the microwire. The cutoff frequency at which this is happening and MI-effect begins is named the critical frequency.

Regarding this, it is important to note that at a certain value of the frequency and magnetic field strength, the maximum value of the MI ratio is reached, so that experimental measurements establish these values that are further used for designing the MI-based sensors.

**2. MI measuring principles**

Two common instruments used to perform MI measurements are the RLC meter and the Vector Network Analyzer - VNA.

Depending on the principle of impedance measurement there can be defined two methods: using the RLC meter (usually for lower frequencies, up to few MHz) and using the microwave technique by VNA (at higher frequencies up to few GHz).

In the first case the impedance is measured at four points method and it is based on the measurement of the voltage drop at the ends of the sample with the current passing through the same. In the second case it is used the microwave

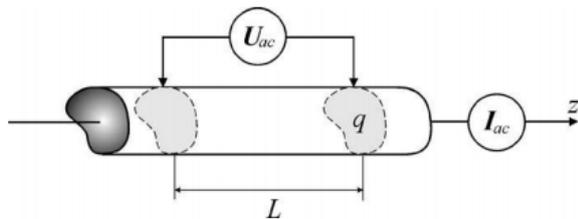
technique of high-frequency passage of the current through the sample.

**2.1. Measuring principle of MI effect by measuring voltage and current**

This principle is based on measuring impedance by the four-point method by LCR HiTester, where the voltage and the current are measured on the same sample.

The instrument automatically calculates and displays the results of the impedance. Depending on the type of the instrument, it is possible to get the real and imaginary part of the impedance as well as the results for the different values of the current intensity used in the measurement.

The impedance can be expressed in the complex form by the equation  $Z(\omega) = R + jX$ , where  $R$  and  $X$  are a real and complex component of impedance. Its value is obtained by the ratio  $V_{ac}/I_{ac}$ . The value of  $I_{ac}$  is the amplitude of the current of the sinusoidal form  $i = I_{ac} \sin(\omega t)$ , and  $V_{ac}$  is the voltage amplitude measured at the ends of the sample through which the current flows as it is shown on Fig. 5 [2, 4].



**Figure 5.** Schematic illustration of impedance measuring using RLC meter.

This impedance definition applies only to the linear segment of ferromagnetic materials and is limited in application. Since the ferromagnetic materials are non-linear, the linear approximation is used to calculate the GMI ratio of ferromagnetic materials of length  $L$  and cross-section  $q$  [7]:

$$Z = \frac{V_{ac}}{I_{ac}} = \frac{LE_z(S)}{q\langle j_z \rangle_q} = R_{dc} \frac{j_z(S)}{\langle j_z \rangle_q}, \quad (3)$$

where  $E_z$  and  $j_z(S)$  are longitudinal component of the electrical field and current density, respectively,  $R_{dc}$  is a dc resistance of the sample, and  $\langle j_z \rangle_q$  is the mean value of the current component through the cross-section  $q$ .

The MI ratio can be calculated, for a cylindrical conductor (amorphous or nanocrystalline microwires) by the equation [7]:

$$\frac{Z}{R_{DC}} = ka \frac{J_0(ka)}{2J_1(ka)} \quad (4)$$

where  $J_0$  and  $J_1$  are the Bessel function of the first kind, and for samples in the form of a thin film, or strip [2]:

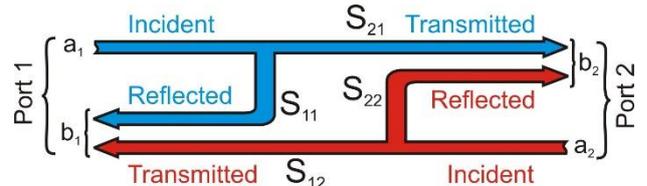
$$\frac{Z}{R_{DC}} = k \frac{t}{2} \cot(k \frac{t}{2}), \quad (5)$$

where  $a$  is the diameter of the wire,  $t$  is the thickness of the strip or film. The propagation constant  $k$  is defined as  $k=(1-i)/\delta_m$ , where  $\delta_m$  is the penetration depth in the classical skin effect defined by the equation (2).

**2.2. The principle of MI effect measurements in the microwave technique**

It is convenient to realize impedance measuring at higher frequencies using Vector Network Analyzer by the principle of microwave technique [11].

In order to clarify the principle of measurements using the VNA instrument, it is necessary to define the scattering parameters, known as  $S$ -parameters which can describe and design the electrical components in microwave devices, as well as adjust the consumers connected to microwave lines. Fig. 6 shows the  $S$ -parameters defined in wave propagation between the two ports of the VNA instrument.



**Figure 6** Schematic illustration of the scattering parameters.

According to Fig. 6,  $S$ -parameters are defined with two basic relations

$$b_1 = S_{11} \cdot a_1 + S_{12} \cdot a_2 \quad (6)$$

$$b_2 = S_{21} \cdot a_1 + S_{22} \cdot a_2, \quad (7)$$

where  $S_{11}$  and  $S_{22}$  represent the parameters of reflection and  $S_{21}$  and  $S_{12}$  represent the parameters of transmission of the signal:

$S_{11}$  - Forward Reflection (input match - impedance)

$S_{22}$  - Reverse Reflection (output match - impedance)

$S_{21}$  - Forward Transmission (gain or loss)

$S_{12}$  - Reverse Transmission (leakage or isolation).

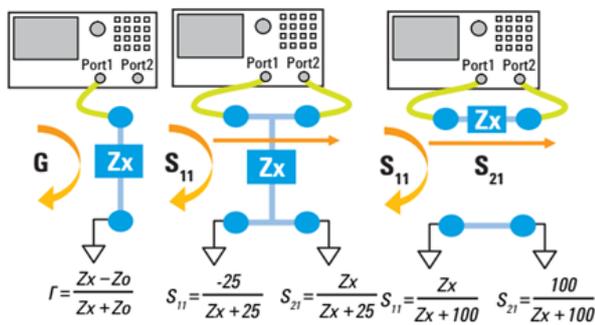
The impedance measurement is performed by connecting a sample ("DUT" - "device under test") with unknown impedance ( $Z_x$ ) to one or two instrument ports. The results are available on the display using the calculation of the  $S$  parameter, depending on sample connection.

The unknown impedance refers to the required calibration of the instrument before measurement, with a special calibration kit that is part of the instrument set. In order to connect the sample to the instrument, it is necessary to design a special

sample holder which dimensions must be in accordance with the frequency range used in the measurement. It is necessary to harmonize the wavelength of the electromagnetic wave  $\lambda$  and the length of the medium through which it extends. Wavelength is calculated according to the form  $\lambda=c/f$ , ( $c=3 \cdot 10^8$  m/s).

Transmission lines play an important role at medium and higher frequencies, and the measured current and voltage are not equal at every point in a line (wires); this cause the appearance of the envelope wave on the measured sample. Therefore, it is more important to pay attention to the characteristic impedance  $Z_0$  of the cables on the VNA instrument.

The characteristic impedance is defined as the ratio of voltage and current at any point of the infinitely long homogeneous conductor, and this value is constant. It can be defined as impedance at the end of the conductor so that the input impedance of conductor is equal to itself. The characteristic impedance is the secondary conductor parameter and is also defined as the geometric mean of the impedance at closed ( $Z_{sc}$ ) - short connection and open ( $Z_{\infty}$ ) - open connection:  $Z_0 = (Z_{sc} \cdot Z_{\infty})^{1/2}$ , where it is used  $Z_{sc} = R + j\omega L$ ;  $Z_{\infty} = 1/(G + j\omega C)$ , so:  $Z_0 = [(R + j\omega L)/(G + j\omega C)]^{1/2}$ .



**Figure 7.** Impedance measurement with VNA instrument with: one port and two ports to different DUT configurations.

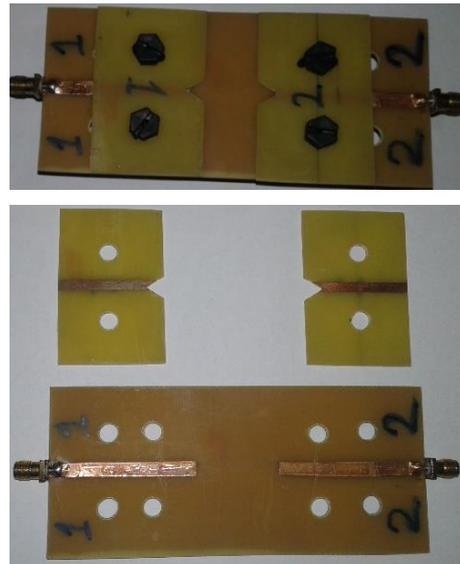
In order to realize measurement with VNA, the manufacturer (HP Agilent) defined the use of coaxial cables with  $Z_0 = 50 \Omega$ , as well as principles for measuring unknown impedance ( $Z_x$ ), of depending on one, or two or more approaches were used, and depending on principles different S-parameters were used. It is necessary, during the experiment, to make a sample holder that enables the sample connection to one or two ports (see Fig. 7).

The recommended principles are used depending on the value of the unknown impedance. The measurement principle with one instrument port is used for an unknown impedance with close value of  $Z_0$ , where the unknown impedance is determined using the ratio between the unknown and the characteristic impedance.

The principle of shaft (serial connection) is used in the case when the difference between the unknown and characteristic impedance cause the increase of measurement noise. The sample is connected in two ways, by shorting the access (and the middle part of the cable and armor) between which the unknown impedance is connected, as well as by shortening the middle part of the cable through an unknown impedance, and armor directly, without an unknown impedance (see Fig. 7).

One of the designed holder in the shape of microstrip transfer media is realized in such a way that the measured sample with the contacts builds the transmission line, and the under part of the plate is a jumper (entire surface made of copper). There are "SNA 7" connectors at the ends of the sample holder that allow the coaxial cables of the characteristic impedance  $Z_0 = 50 \Omega$  to be connected to the VNA instrument (see Fig. 8).

Connection terminals, BNC and NC connectors are also used in practice in order to provide correct connections to the connection cables, but the selection of connectors depends on the frequency of the signal used during the measurement.



**Figure 8.** Sample holder in the form of microstrip transfer media for measuring the MI effect.

**3. MI EFFECT DIAGRAM APPERANCE**

Depending on the measurement equipment and the acquisition of the results, it is possible to obtain MI diagrams that are described with a lot of points, which enables a more precise and quality monitoring of the results. For example, VNA instrument can measure 1601 different values of the impedance in a single sweep, depending on the frequency range (with a linear or logarithmic distribution).

The results are visible on the instrument display (see Fig. 9), but the instrument also record the

results in a separate file format on the external memory. The instrument has the option to save the first measurement as a state and to display it as a baseline diagram on the monitor at the same time as currently measured values. This enables control of the correctness of the measurement and orientation monitoring of the MI effect during the measuring.

During the experiment, after recording a single measurement cycle that impedance is reduced when the sample is exposed to a magnetic field that gradually increases to a maximum value.



Figure 9. Display of the results of impedance measurement using VNA.

The first measurement cycle is completed after reaching the maximum field value (in the case of  $H_{max} = +21.8$  kA/m). When the next measurement cycle starts the sample is not subjected to field effect ( $H = 0$ ). The value of the impedance in this case is lower than in the initial measurement when the field is also  $H = 0$ . The cause is retained magnetization that has remained after previously occurred magnetization of the sample.

When the sample is exposed to the opposite field that gradually increases, for example to  $H_{max} = -21.8$  kA/m and the impedance is remeasured at  $H = 0$  (after the second measurement cycle), almost identical results of the measured impedance are obtained, as in the first cycle, where:  $0 < \Delta Z < 0.03 \Omega$  (see Fig. 10).

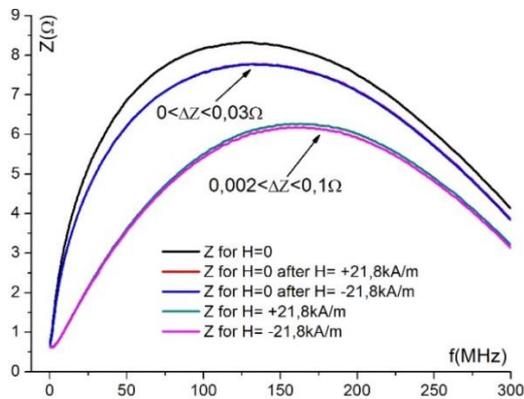


Figure 10. Impedance of  $Fe_{72}Cu_1V_4Si_{15}B_8$  ribbons annealed at  $500^\circ C$  of depending on the  $H=0$ , or  $H_{max} = \pm 21.8$  kA/m before and after two measurement cycles.

Approximately the same impedance values are obtained at identical values of the magnetic field, but in the opposite direction. In Fig. 10 are displayed values of the measured impedance for the  $Fe_{72}Cu_1V_4Si_{15}B_8$  alloy sample annealed at  $500^\circ C$  at  $H_{max} = +21.8$  kA/m and  $H_{max} = -21.8$  kA/m where  $0.002 \Omega < \Delta Z < 0.1 \Omega$ .

Fig. 11 shows frequency dependence of MI ratio of  $Fe_{73}Cu_1Nb_3Si_{13.5}B_{9.5}$  microwires for sinusoidal current amplitude of 3 mA performed by the four-point method by Hioki LCR/HiTester [12]. Critical frequency of about 30 kHz (when  $\delta_m \approx d/2$ ) was observed as the point with initial increase of MI.

It is important to note that the maximum value of MI ratio is attained at frequency of about 1 MHz, what is crucial to design optimum MI-based sensors [12].

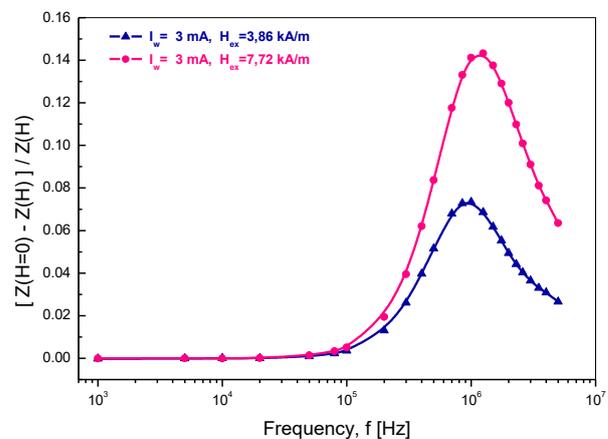


Figure 11. Dependence of the MI ratio on frequency in as-quenched  $Fe_{73}Cu_1Nb_3Si_{13.5}B_{9.5}$  microwires for  $H'_{ex} = 3.86$  kA/m and  $H''_{ex} = 7.72$  kA/m sinusoidal current amplitude 3 mA [11].

Diagrams for the MI ratio dependence on frequency as well as external magnetic field intensity in as-quenched  $Fe_{72}Cu_1V_4Si_{15}B_8$  ribbons are shown on Fig. 12 and Fig. 13 respectively, representing the 2-D and 3-D views of the result. Those 3-D diagrams enable complete observation of the MI-ratio interdependence on both parameters.

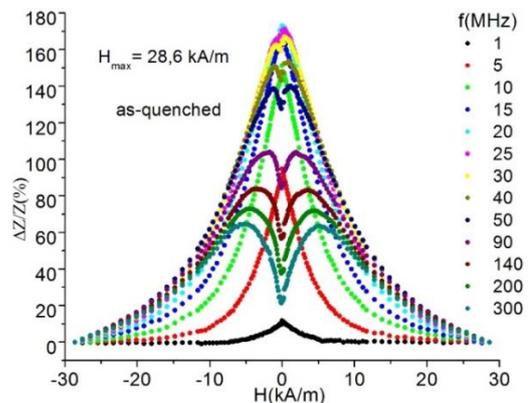
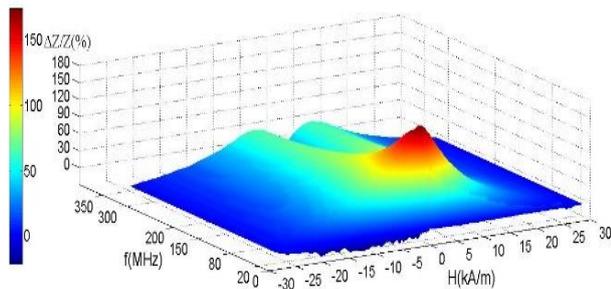


Figure 12. Dependence of the MI ratio on external magnetic field  $H$  in as-quenched  $Fe_{72}Cu_1V_4Si_{15}B_8$  ribbons [6].



**Figure 13.** MI ratio in as-quenched  $Fe_{72}Cu_1V_4Si_{15}B_8$  ribbons depending on external magnetic field  $H$  and frequency  $f$  (3-D display) [6].

#### 4. CONCLUSION

Discovery of the MI effect initiated research of the materials in which this effect is the most expressive. It is possible to create a very sensitive magnetic field sensor that can be applied in various industrial, medical and biological spheres where the requirements for the acquisition of changes in the magnetic field are very strict, just by producing iron and cobalt based alloys. Modern scientific trends are focused on material research in order to produce miniature devices with the same or improved characteristics. The study of MI effect gives a positive contribution to education in the field of physical sciences, because this effect brings together several scientific disciplines, which makes it multidisciplinary. Educations that include the study of MI effects are materials science, electrical engineering as well as informatics.

The idea is to educate scientific staff for the design, structural and physical analysis of the materials in which the MI effect exhibits and to give a contribution to the choice of principle of measuring depending on the frequency at which the effect occurs.

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# A tomographic method for determining the distance between standing wave anti-nodes and the frequency of electromagnetic radiation inside a microwave oven

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**Abstract:** *The paper identifies the challenges of the tomographic method for determining the position and shape of the modes of the electromagnetic standing wave in a microwave oven. The experiment described here shows the inhomogeneity of heating and unpredictability of the occurrence of anti-nodes, or hot-spots, inside the microwave oven chamber, as well as a procedure for their better localization. The proposed tomographic method has been used for characterizing and visualizing standing wave modes. As part of the described experiment, an algorithm is presented to determine the optimal dimensions of the 3D chamber, which represent a resonator where the standing wave is formed. Also, a mathematical procedure for calculating the radius of the circle through the circle chord is described in detail, which was used to determine the distance between two neighboring anti-nodes of the standing wave.*

**Keywords:** *standing wave; microwave oven; anti-nodes; hot-spots; circle chord*

## 1. INTRODUCTION

Microwave ovens are among the most common electrical appliances in households. However, their journey from discovery to acceptance by a wider audience lasted for quite a long time. Today, apart from food preparation, microwave ovens are also used in various branches of industry, science and medicine [1].

They can also be suitable teaching tools for demonstrating physico-chemical processes in various fields of applied physics [2], [3].

## 2. THEORY

The harmonic wave that moves in the positive direction of the  $x$  axis can be represented by the equation

$$y_1(x,t) = A \sin\left(\frac{2\pi x}{\lambda} - \omega t\right) \quad (1)$$

In the case of a reflection by a boundary placed on a side in the direction of wave propagation, it will be reflected and its direction and oscillation phase will change, so the equation of motion will then be

$$y_2(x,t) = A \sin\left(\frac{2\pi x}{\lambda} + \omega t\right) \quad (2)$$

As a result, a standing wave is created that represents the superposition of two waves  $y_1(x,t)$

and  $y_2(x,t)$ , and the equation of the resulting wave will therefore read

$$y(x,t) = A \sin\left(\frac{2\pi x}{\lambda} - \omega t\right) + A \sin\left(\frac{2\pi x}{\lambda} + \omega t\right) \quad (3)$$

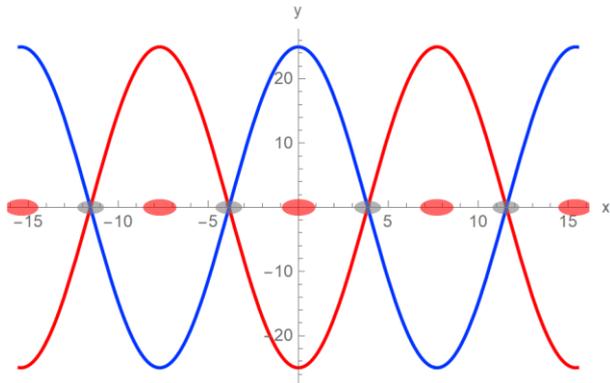
or otherwise written

$$y(x,t) = 2A \sin\left(\frac{2\pi x}{\lambda}\right) \cos(\omega t) \quad (4)$$

The last term describes a wave that oscillates in time and has a space dependence that is stationary [4]. At any point  $x$  the oscillation amplitude is constant and has a value  $2A \sin\left(\frac{2\pi x}{\lambda}\right)$ . The "nodes" of the standing wave are obtained for  $x$  values that correspond to even multiples of  $\lambda/4$ , and "anti-nodes" for odd multiples. In the nodes of the standing wave the sum of the amplitudes of the wave is zero, whereas in the anti-nodes it is maximal. Based on the above, it turns out that the distance between two nearby nodes (anti-nodes) of the standing wave is equal to  $\lambda/2$  (Figure 1).

Constrained 3D space, such as the interior of a rectangular microwave oven, potentially represents a space where it is possible to form a standing wave [5]–[7]. Radiation inside the oven originates from a microwave radiation source named magnetron. The radiation reaches the food that needs to be heated by a special metal channel. Given the shape of the interior, which is as a rule square, and bearing in mind the fact that the walls are made of metal from which microwave radiation is reflected,

the interior of the oven can be considered as a resonant cavity.

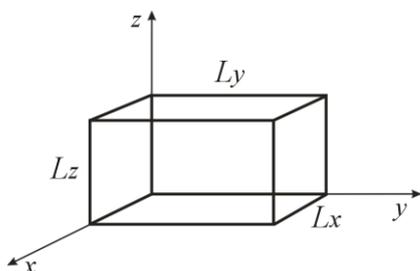


**Figure 1.** Nodes and anti-nodes of the standing wave

The resonant frequency, that is, the wavelength at which the formation of the standing wave will occur, depends on the internal dimensions of the resonator itself. The wavelength of the resonant frequency of the square-shaped resonators whose dimensions are  $L_x, L_y, L_z$  (Fig. 2), can be determined by the expression

$$\left(\frac{2}{\lambda}\right)^2 = \left(\frac{l}{L_x}\right)^2 + \left(\frac{m}{L_y}\right)^2 + \left(\frac{n}{L_z}\right)^2 \quad (5)$$

where  $l, m, n$  are positive integers (or zero) and represent the modes of the standing wave, and  $\lambda$  is the wavelength of the emitted electromagnetic radiation inside the oven [8].



**Figure 2.** Square-shaped resonator model

If the dimensions of the oven chamber are such that they can be obtained as the product of an integer and the wavelength corresponding to the resonant frequency, then a 3D standing wave will be formed. The dimensions  $L_x, L_y, L_z$  of the chamber are proportional to the wavelength in each of the corresponding directions ( $x, y, z$ ), that is

$$L_x = l \frac{\lambda_x}{2}, L_y = m \frac{\lambda_y}{2}, L_z = n \frac{\lambda_z}{2} \quad (6)$$

This means that  $\lambda_x, \lambda_y, \lambda_z$  are determined by the dimensions of the oven chamber, and expression (7) is obtained by replacing (6) in (5), [9]. Characteristic of equation (7) is that there are several solutions that correspond to resonant frequencies (wavelengths), which are in close proximity to the frequency (wavelength) of the radiation emitted by the magnetron

$$\frac{1}{\lambda^2} = \frac{1}{\lambda_x^2} + \frac{1}{\lambda_y^2} + \frac{1}{\lambda_z^2} \quad (7)$$

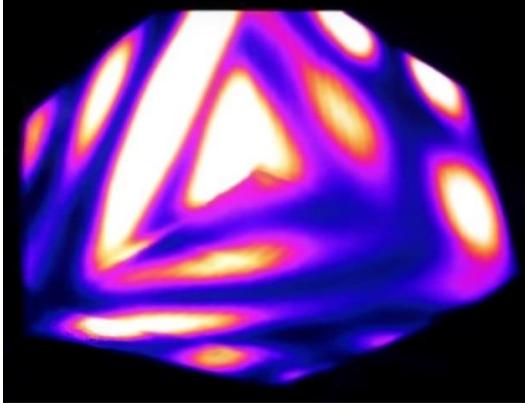
Various optimization algorithms can be used to find a solution to expression (7), which is overdetermined [10]. The approach we used to solve this problem was an algorithm written in Mathematica software, with certain limitations related to the range of values  $\lambda$  in which we sought the solutions. Given the fact that the emitted radiation frequency was  $\nu_0 = 2.45 \cdot 10^9$  Hz, the exact wavelength ( $\lambda_0 = 12.236$  cm) was obtained from  $c = \lambda \cdot \nu_0$  ( $c = 2.997925 \cdot 10^8$  m/s). Therefore, the limit that we included in the calculation of modes ( $l, m, n$ ) of the standing wave refers to the deviation of the wavelength in the interval from the exact value (i.e.  $12 \text{ cm} \leq \lambda_0 \leq 12.5 \text{ cm}$ ). The dimensions of the microwave oven at our disposal were: depth  $L_x = 25.5$  cm, width  $L_y = 29.5$  cm and height  $L_z = 18.1$  cm. Consequently, the values of the oscillation modes ( $l, m, n$ ) included in equation (1) were such that the wavelength  $\lambda_d$  in terms of value needed to be close to the wavelength of magnetron radiation  $\lambda_0$  (Table 1).

**Table 1.** Wavelengths  $\lambda_d$  whose values were close to the radiation wavelength of the magnetron  $\lambda_0$ , with relative errors and obtained oscillation modes for the microwave oven of dimensions  $L_x = 25.5$  cm,  $L_y = 29.5$  cm,  $L_z = 18.1$  cm

$\lambda_d$ (cm)	$\delta_\lambda$ (%)	$l$	$m$	$n$
12.067	1.39	0	0	3
12.041	1.60	2	4	1
12.391	1.27	3	0	2
12.127	0.89	3	1	2
12.119	0.96	3	3	1
12.026	1.72	4	0	1
12.462	1.85	4	1	0

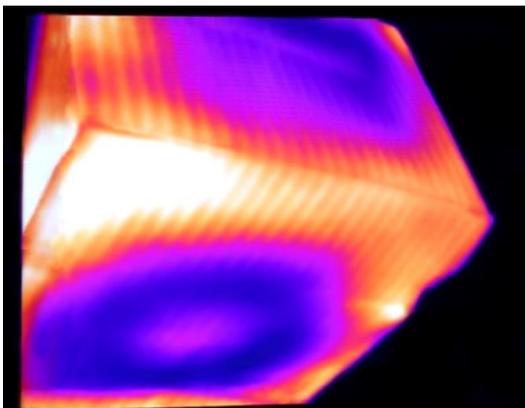
At first glance, the results obtained for the relative error of the wavelength of the emitted radiation ( $\delta_\lambda$ ) may appear quite small ( $<2\%$ ). Namely, from Table 1 shows that the smallest error for  $\lambda$  was obtained for mode  $TE_{3,1,2}$  (TE - transverse electric fields) and it was 0.89%. However, since the standing wave is formed on the basis of multiple reflections from the interior walls of the oven, it is obvious that the entered values of dimensions  $L_x, L_y, L_z$  did not entirely support its formation. The values of  $L_x, L_y, L_z$  were carefully selected to allow the radiation entering the oven interior to be as dispersed as possible, in order to make the food more efficiently and uniformly heated. Uneven heating in microwave ovens, since the time of its invention during the course the military research (in the Second World War) to the present day, when it represents a commercialized product, has never been completely eliminated. This phenomenon occurs even in modern devices, which is why an additional option has been implemented

to eliminate this deficiency, which is based on the fact that during the heating process the body placed on the base (the bottom of the oven) is continuously rotated. Figure 3 shows thermal emission of electromagnetic radiation from the oven interior, on a square-shaped body. The image was taken using a thermal camera [11].



**Figure 3.** Thermal distribution of electromagnetic radiation on a stationary square-shaped body inside the oven [11].

In the case where the body does not rotate (as in Fig. 3), the anti-nodes of the standing wave (hot - bright areas) and the nodes (cold - dark areas) can be clearly seen with the thermal camera. They will be formed regardless of the fact that the very interior design attempted to minimize this phenomenon. Contrarily, better distribution of thermal energy can be achieved with rotation of the object inside the oven (Fig. 4) [11].



**Figure 4.** Thermal distribution of electromagnetic radiation on square-shaped body rotating inside the oven [11].

### 3. EXPERIMENT

In order to reduce the relative error  $\delta_\lambda$  of the obtained wavelength values for individual modes of standing wave oscillation, we made some changes

to the algorithm we implemented in Mathematica. In an algorithm that required minimal deviation of the obtained wavelength from its exact value for different standing wave modes, we changed the length of the side of the  $L_y$  to be variable. In effect, the program searched the values of standing wave modes and found the width at which the deviation was minimal. The width of the oven interior was chosen to be of variable size, because it was easiest to change it in a real experiment by reducing the width. This was achieved by placing a reflector (stainless steel sheet, 1mm thick) on the opposite side of the magnetron - parallel to its opposite side. Figure 6 shows a flowchart of the algorithm for finding the optimum width of square-shaped resonators (microwave oven interior), for transverse electromagnetic waves.

Table 2 shows the modes that exhibited the smallest relative wavelength error, for the interval of the interior width of the microwave from  $L_y/2$  to  $L_y = 29.5$  cm.

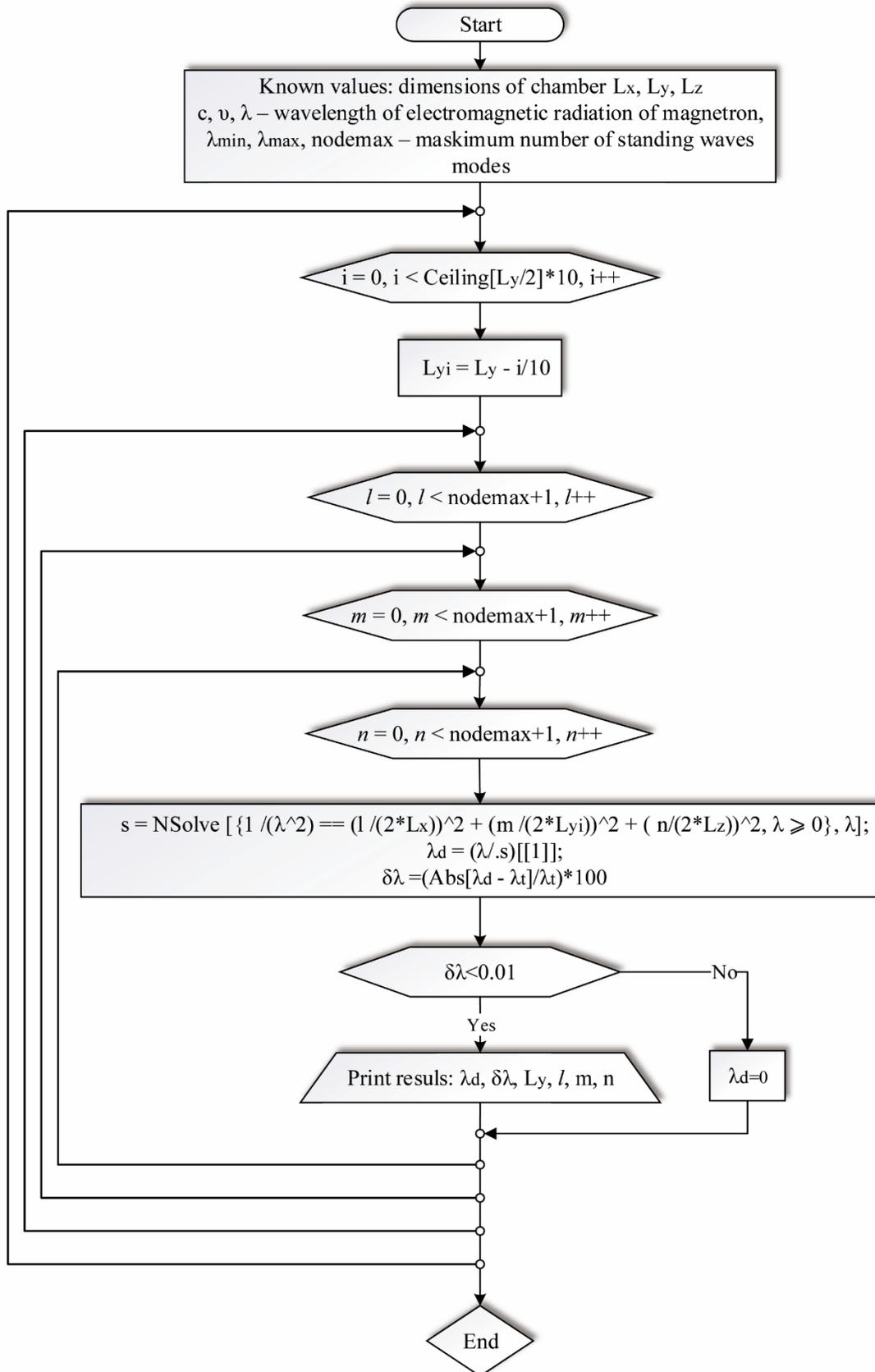
**Table 2.** Wavelengths  $\lambda_d$  whose values were closest to the wavelength of magnetron radiation, their relative errors and obtained oscillation modes, for the microwave oven dimensions  $L_x = 25.5$  cm,  $L_z = 18.1$  cm and variable width  $L_y$

$\lambda_d$ (cm)	$\delta_\lambda$ (%)	$L_y$ (cm)	$l$	$m$	$n$
12.238	0.016	27.9	2	4	0
12.240	0.029	26.5	1	3	2
12.239	0.021	22.7	2	3	1
12.237	0.009	21.8	4	1	0
12.233	0.028	21.7	4	1	0
12.233	0.029	20.2	3	2	1

Based on Table 2, by reducing the internal width of the  $L_y$  oven by 3 cm, the resulting relative error for  $\delta_\lambda$  (mod TE<sub>1,3,2</sub>) can be significantly reduced, thereby significantly contributing to the proper formation of standing wave modes.

After this correction, shortening of  $L_y$  to 26.5 cm, an experiment was carried out in which an organic mixture (wax and chocolate bar) was placed in the xy-plane at a height of  $z_0 = 2.5$  cm and subjected to electromagnetic radiation for 2 min at medium intensity, where  $z_0$  was the distance from the bottom of the oven to the upper surface of the body that was placed inside.

After the experiment, the distance between the anti-nodes of the standing wave were measured (Figure 7).



**Figure 6.** Flowchart of algorithm for finding the optimal width of the 3D resonator

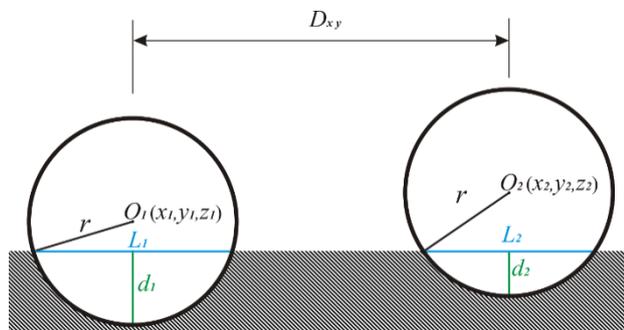
### 4. RESULTS AND DISCUSSION

When the distance between the centers of the anti-nodes of the standing wave was measured, it was noticed that they did not lie in a plane parallel to the horizontal plane, but were at a certain angle  $\alpha$  relative to it. We came to this conclusion by observing the width and depth of the anti-nodes whose diameters were not the same, although this could be expected from the proper formation of modes. Therefore, it was necessary to make additional calculations to determine the positions of the centers of the anti-nodes  $O_1(x_1, y_1, z_1)$  and  $O_2(x_2, y_2, z_2)$  in the 3D space and the distance between them  $\overline{O_1O_2}$  (Fig. 8).



**Figure 7.** "Imprint" of the anti-nodes of the standing wave on a chocolate bar at a height of  $z_0 = 2.5$  cm

The measurements were made of the widths ( $L_1, L_2$  - circle chords), and the depth ( $d_2$ ) of the melted part of the body (hot-spots) exposed to radiation, as well as their center distances ( $D_{xy}$ ). The depth  $d_1$ , which is slightly larger than  $d_2$ , was obtained by calculations.



**Figure 8.** Schematic representation of the anti-nodes of the standing waves (spheres with centers in  $O_1$  and  $O_2$ ), in relation to the body exposed to electromagnetic radiation

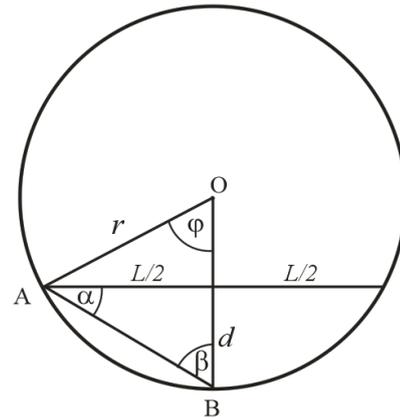
The reason for this was that in a certain number of measurements, depth  $d_1$  was greater than the thickness of the body exposed to electromagnetic radiation (wax or other substance). The radius,  $r$ , of the sphere was calculated based on the obtained data. Then  $d_1$  was calculated assuming that  $r$  of both spheres was the same. Table 3 shows measured values.

Figure 9 shows a hot-spot (anti-node) of standing waves with radius  $r$ , presented through a projection in 2D space.

**Table 3.** Measured parameters of standing wave anti-nodes

First anti-node		Second anti-node		Distance of centers
$d_1$ (mm)	$L_1$ (mm)	$d_2$ (mm)	$L_2$ (mm)	$D_{xy}$ (mm)
16.74	38.3	2,5	19	59.7

The size of the radius spheres (i.e. the circle)  $r$ , depends on the duration and intensity of electromagnetic radiation.



**Figure 9.** Sketch of the hot-spot of the standing wave - circle with center at point O

It is apparent in Figure 9 that the line  $\frac{L}{2}$ , which originates at point A and is normal to line  $BO$ , can be written as  $\frac{L}{2} = r \sin \varphi$ . It follows that

$$r = \frac{L}{2 \sin \varphi} \tag{8}$$

Also, Figure 9 shows that angles  $\alpha$  and  $\beta$  are  $\alpha = \frac{\varphi}{2}$ ,  $\beta = \frac{\pi}{2} - \frac{\varphi}{2}$ , so

$$\tan \frac{\varphi}{2} = \frac{d}{\frac{L}{2}} = \frac{2d}{L} \tag{9}$$

, and it follows that

$$\varphi = 2 \tan^{-1} \frac{2d}{L} \tag{10}$$

It is obvious that for  $x > 0$

$$\tan^{-1} \frac{1}{x} = \frac{\pi}{2} - \tan^{-1} x \tag{11}$$

and the change  $x = \frac{L}{2d}$  results in

$$\tan^{-1} \frac{2d}{L} = \frac{\pi}{2} - \tan^{-1} \frac{L}{2d} \tag{12}$$

, or

$$2 \tan^{-1} \frac{2d}{L} = \pi - 2 \tan^{-1} \frac{L}{2d} \tag{13}$$

By substituting equation (13) in equation (10), we have that angle  $\varphi$

$$\varphi = \pi - 2 \tan^{-1} \frac{L}{2d} \quad (14)$$

Replacing the last expression in equation (8) yields

$$r = \frac{L}{2 \sin\left(\pi - 2 \tan^{-1} \frac{L}{2d}\right)} = \frac{L}{2 \sin\left(2 \tan^{-1} \frac{L}{2d}\right)} \quad (15)$$

The last equation is crucial for the tomographic reconstruction of the mutual positions of the hot-spots of the standing wave. It correlates the radius of the circle (or sphere), that is, the anti-node of the standing wave  $r$ , its circle chord  $L$  and the distance of the center of the circle chord from the circle  $d$ .

Since  $D_{xy}$  is given by

$$D_{xy} = \sqrt{(\Delta x^2) - (\Delta y^2)} = \sqrt{(x_2 - x_1)^2 - (y_2 - y_1)^2} \quad (16)$$

, and the distance between the centers  $O_1$  and  $O_2$  by

$$\overline{O_1 O_2} = \sqrt{(\Delta x^2) + (\Delta y^2) + (\Delta z^2)} \quad (17)$$

we have

$$\overline{O_1 O_2} = \sqrt{D_{xy}^2 + (\Delta z)^2} = \sqrt{D_{xy}^2 - (z_2 - z_1)^2} \quad (18)$$

where  $z_1 = z_0 - d_1 + r_1$ ,  $z_2 = z_0 - d_2 + r_2$  and  $r_1 = r_2$ . From there  $\Delta z$  becomes

$$\Delta z = z_2 - z_1 = z_0 - d_2 + r - z_0 + d_1 + r = d_1 - d_2 \quad (19)$$

, so the distance between the centers  $O_1$  and  $O_2$  is

$$\overline{O_1 O_2} = \sqrt{D_{xy}^2 + (\Delta d)^2} \quad (20)$$

Angle  $\alpha$  between the level of the hot-spots of the standing wave and the horizontal plane is given as

$$\alpha = \cos^{-1} \left( \frac{D_{xy}}{\overline{O_1 O_2}} \right) \quad (21)$$

Using the data from Table 3, we obtained  $\overline{O_1 O_2} = 61.37$  mm and  $\alpha = 13.4^\circ$  which represents  $\lambda/2$  of electromagnetic waves within the oven. Based on these data, our calculation gives the value of the frequency of the electromagnetic wave of the emitted radiation  $\nu = 2.443 \cdot 10^9$  Hz. This represents a deviation of 0.3% for frequency  $\nu_0$  and the same deviation is obtained for the wavelength of magneton radiation  $\lambda_0$ .

## 5. CONCLUSION

From the experiment described in the paper we learned that small changes in the dimensions of the resonators can result in the formation of certain

modes of standing wave. An algorithm was proposed to help find the optimal dimensions of 3D space, as well as the standing wave modes that would arise in such a space.

The anti-nodes of the standing wave are in a plane aligned with some angle  $\alpha$  to the plane of the bottom of the microwave oven. With a tomographic projection of the distance of the hot-spots, it is possible to reconstruct their positions in the oven interior.

With this type of experiment it is possible to draw conclusions in a way that could be interesting to students, about various physical phenomena and the relationships between individual physical quantities that describe the given phenomena.

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# Educational Laboratory Setup for Electric Current Measurement using Hall Effect Current Sensors

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**Abstract:** *The aim of this paper is to present an educational laboratory setup for current measurement using current sensor Ametes-Senis CS10A-02, data acquisition card NI USB 6009 and personal computer with LabVIEW software. This current sensor module contains a single Hall effect sensor CSA-1V and accompanied electronic parts. The paper contains a brief description of the working principles of Hall effect sensors and the current sensor, presents its structure and technical details of interest. It also gives a description of a laboratory setup for measurements with current sensor, as well as a description of the used LabVIEW application. The paper presents the results of measurements and a proper discussion.*

**Keywords:** *Hall sensor; Current sensor; Open loop sensor; Closed loop sensor; CS10A-02*

## 1. INTRODUCTION

Nowadays, measurement, control and monitoring of electric current is needed in various applications. For that purpose, different types of sensors are used, such as: sense resistors (shunts), current transformers, Rogowski coils, magnetoresistive and Hall effect current sensors. Recently, noninvasive methods like Hall effect current sensing has become more interesting subject for research in the field of electrotechnics. Hall effect current sensor became more profitable after development of integrated circuit technology and smaller, more reliable and cheaper amplifiers needed for its operation. Advantages of Hall effect current sensors are high isolation and small insertion loss of energy. Also, some of Hall effect current sensors offer current measurement without any insertion in the electric circuit which current is being measured.

Hall effect current sensors come in a variety of configurations and offer a wide range of applications. Because of their advantages, such as small size and small insertion losses, Hall effect current sensor finds their use in systems like Battery Management Systems (BMS) and power supplies [1]. In solar and wind power plants they are used in feedback loop both for MPPT and synchronization with electrical grid [2]. Because of their ability to measure currents without galvanic connection and ability to measure both DC and AC currents, principle of Hall effect current sensors are used in electrical tools like clamp meters [3]. Because of their wide bandwidth and accuracy,

they are used in electric drives (in a closed loop feedback) for control and protection [4, 5].

Hall effect sensors have a simple construction and therefore are relatively cheap. Also, other sensors based on Hall sensor are simple and cheap, which makes it suitable for student work in the laboratory.

This paper presents a student project done within two subjects "Virtual instrumentation" and "Electrical measurements of non-electrical quantities". It will be used as new laboratory exercise for future generations of students.

The paper presents a theoretical approach to the subject of Hall effect current sensors (Sections 2 and 3). A description of laboratory setup for current measurement using a Hall effect current sensor, as well as a realised control panel of PC based virtual instrument and measurement results are given in Section 4. LabVIEW software has been used for development of the virtual instrument. Alongside current measurement with Hall effect current sensor, current has been measured with one commonly used method for measuring current – shunt resistor. Also, current has been measured using a digital multimeter. A comparison of the results of these three measurements is presented in the paper.

## 2. Hall effect current sensors

Hall effect sensors are special electromagnetic sensors named after scientist Edwin Herbert Hall who discovered Hall effect in the year 1879 [6]. Hall effect is phenomenon of occurrence of voltage  $U_H$  (Hall voltage) on the opposite sides of strip

(Hall element) with constant current  $I$  and in the presence of external magnetic field  $H$  normal to its surface. Generated Hall voltage is linearly proportional to the magnetic flux density:

$$U_H = R_H \frac{I}{d} B + U_{off} = kI + U_{off} \quad (1)$$

where  $R_H$  is Hall coefficient,  $d$  is thickness of Hall element,  $B$  is magnetic flux density of external magnetic field,  $U_{off}$  is offset voltage and  $k$  is sensitivity of Hall element. Fig. 1 illustrates phenomenon of Hall effect.

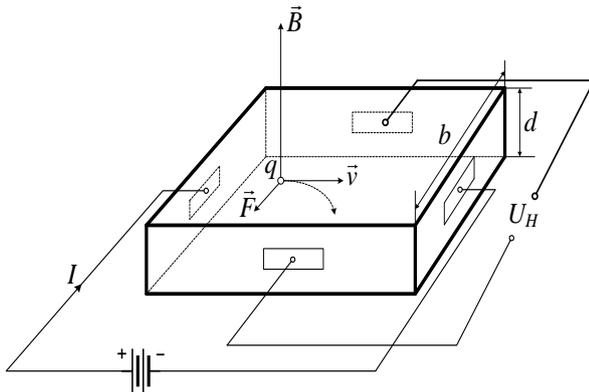


Figure 1. Hall element

Semiconductor material like indium arsenide (InAs), indium arsenide phosphate (InAsP), gallium arsenide (GaAs) and indium antimonide (InSb) have high value of the Hall coefficient [7]. A typical value of Hall voltage is in order of mV. Therefore, amplifiers are used to increase this voltage up to order of V [8].

Hall element is the basic part of modern Hall sensor with integrated circuit (IC), which is widely used for measurement of magnetic field, electric current, position, speed sensing, detection of presence and other [8, 9]. It can be manufactured as analog or as digital device.

There are two basic types of Hall effect current sensors – Open loop and Closed loop sensors.

**2.1. Open loop Hall effect current sensor**

Current measurement using device with only Hall sensor and amplifier is possible in case of PCB (Printed Circuit Board) where the distance between a conductor and Hall element is small and where conductor is rigidly fixed in space [10]. The magnetic field decreases fast with distance. Thus, accuracy of current measurement is highly dependent on position of conductor.

For accurate current measurements in other applications, it is necessary to amplify magnetic flux from conductor using high permeability toroid magnetic core [8, 11]. This type of Hall device is called the Open loop Hall effect current sensor, Fig. 2. Hall element is placed in the air gap of such

magnetic core. Magnetic core is also called Flux Concentrator because it concentrates and amplifies magnetic flux in the air gap where the Hall element is placed.

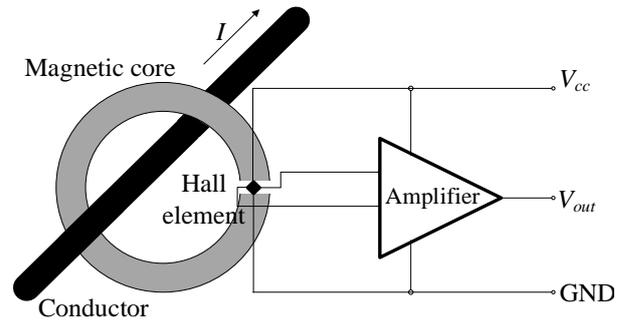


Figure 2. Open loop Hall effect current sensor

Magnetic flux density  $B$  in the air gap created by the conductor is given in (2) [8]:

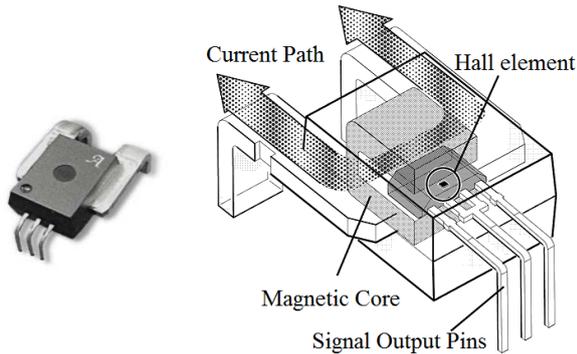
$$B = \frac{\mu_0 \mu_r}{l + \mu_r l_0} I, \quad (2)$$

where  $I$  is the electric current,  $\mu_0$  is the permeability of vacuum,  $\mu_r$  is the relative permeability of magnetic core,  $l$  is the length of magnetic core,  $l_0$  is the length of air gap. It can be seen from (2) that the magnetic flux density depends on conductor current, lengths of air gap and magnetic core and the permeability of magnetic core.

For a wide linear range of current measurement, the magnetic core must have high value of saturation magnetic flux density. For smaller offset of measured current core material should have a small coercive magnetic field. Materials that fulfil these requirements are ferrites [11], which are also cheap and widely applicable.

Advantage of Open loop Hall effect current sensor is its small package (small size and weight) [12]. Also, it is cheap. It provides current measurement with high isolation and low insertion losses. There are some disadvantages of open loop current sensor [12]. Open loop Hall effect current sensor has a lower frequency bandwidth (DC-25 kHz) caused by the appearance of eddy currents in magnetic core at measurement of high frequency currents. Because the magnetic core can go out of its linear range (saturation), linear range of Hall effect sensor in open loop is reduced. Also, accuracy is reduced because the magnetic core cannot eliminate temperature drift, presence of noise and current offset that originates from Hall element and additional electronics. With appropriate electronics many of these disadvantages can be reduced, which increases its accuracy over a wide range of measured currents and frequencies.

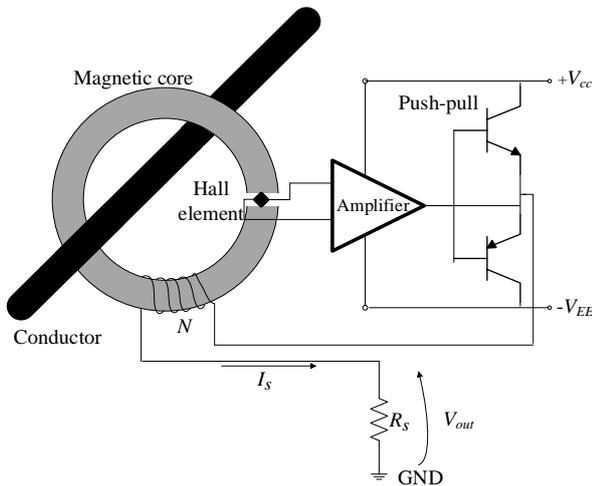
Practical example of Open loop Hall effect current sensor is an Allegro ACS750 sensor presented in Fig. 3 [13].



**Figure 3.** Allegro ACS750 sensor (left) and its components (right)

**2.2. Closed loop Hall effect current sensor**

Most problems of Open loop Hall effect current sensor appear because of saturation of magnetic core. Solution to this problem is to add a secondary coil on the magnetic core which current creates opposite magnetic field to the magnetic field of the conductor and therefore cancel it, Fig. 4 [8, 11]. Thus, the magnetic flux in magnetic core is brought to zero. Current from the Hall element is amplified and passed through a secondary winding (used as negative feedback). This secondary current is used to produce the voltage on sense resistor  $R_s$ . This voltage is used as linear output voltage of the sensor.



**Figure 4.** Closed loop Hall effect current sensor

Closed loop Hall effect current sensor offers high accuracy and linearity (better than 1 %) [12]. Also, it has good response times of 3  $\mu$ s, which allows measurement of impulse currents and currents of high dynamic systems (i.e. electric drives). It has low insertion losses, wide bandwidth (DC-200 kHz), low temperature drift and noise. It has low power loss in measurement of small currents [12, 14]. But, in measurement of

higher current power dissipation is higher because of power loss on sense resistor. Also, sensor with higher rated current need more powerful amplifiers (more powerful electronics) and a higher number of turns on magnetic core, which causes higher prices and increases size. Also, like Open loop, Closed loop Hall effect current sensors have zero current offset (because of coercivity of magnetic core).

**3. Current Sensor Ametes-Senis CS10A-02**

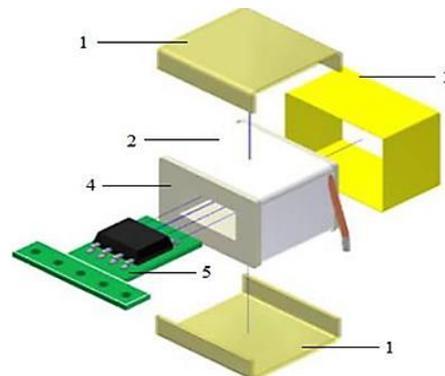
Current sensor Ametes-Senis CS10A-02 is Hall effect-based sensor for measurement of currents up to 10 A with high galvanic isolation (4 kV) [15]. It has a linear analog output. It requires a single DC power supply of 5 V, suitable to be provided by data acquisition card. It has low consumption of power and small insertion losses. It is of a small size and can be easily mounted on the PCB (Printed Circuit Board). It can be used for measurement of DC, AC and impulse currents. The sensor can withstand up to 1 T, so high currents cannot damage the sensor. The sensor is saturated around 8.3 mT, which gives great linearity from 0 mT to 5 mT.

Image of Ametes-Senis CS10A-02 sensor is given in Fig. 5.



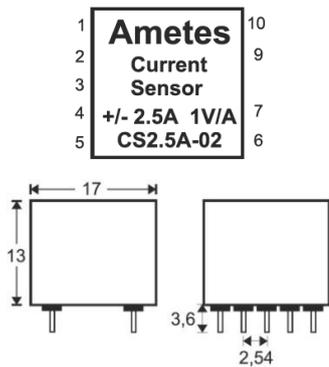
**Figure 5.** Ametes-Senis CS10A-02 sensor module

The main components of current sensor are Hall effect sensor CSA-1V and coil (bobbin) [16]. Fig. 6 shows all parts of the sensor: shield (1), duct tape (2), foil (3), coil (bobbin) (4) and Hall effect sensor CSA-1V (5).



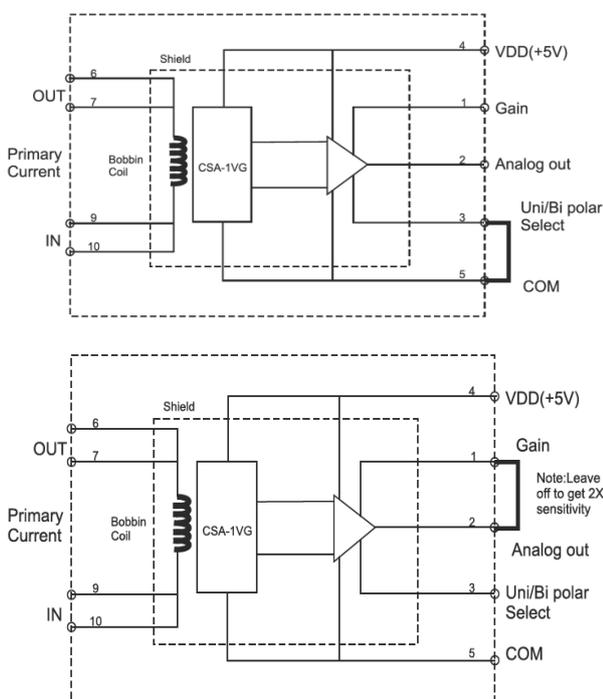
**Figure 6.** Ametes-Senis CS10A-02 sensor module structure

Outline drawings of Ametes-Senis CS10A-02 are shown in Fig. 7.



**Figure 7.** Outline drawing of Ametes-Senis CS10A-02 sensor module

Wiring schemes for Ametes-Senis CS10A-02 are shown in Fig. 8 [14]. The sensor can be used in two ways – unipolar and bipolar.



**Figure 8.** Ametes-Senis CS10A-02 sensor module wiring scheme for unipolar (upper) and bipolar operation (bottom)

For measurement of DC currents unipolar operation should be used, which gives an output from 0 to 5 V. The bipolar operation should be used for measurement of AC currents, which has a quiescent voltage of 2.5 V [14]. For negative measured current output is ranged from 0 to 2.5 V, and for positive measured current output ranges from 2.5 V to 5 V. Bipolar operation has twice smaller sensitivity than unipolar. Sensor module has a sensitivity in unipolar operation of 0.5 V/A. Bipolar operation can have a sensitivity of unipolar operation, if pins 1 and 2 stay unconnected, as shown in Fig. 8. But if mentioned pins stay unconnected measured range will be twice smaller.

Bandwidth of sensor amounts 5 kHz. To lower the insertion losses, sensors should have small primary resistance. The primary resistance of the used sensor amounts 0.006 Ω, and primary inductance about 0.005 mH. Current sensors are built in that way that they have maximum accuracy at the end of their measured range – in this case 10 A.

Sensitivity of the sensor depends on the size of the coil and its number of turns [16]. For used sensor, at rated current of 2.5 A and of 1 V/A, 24 turns of AWG24 wire are used. By using different wire area of cross section and the number of turns other model from same series offer different sensitivity and rated currents, which provides CS series of Ametes-Senis sensor measurement of currents from 250 mA to 10 A. The coil gives sensor high dielectric isolation, which makes this sensor good solution for high voltage power supplies with relatively low currents. Sensitivity and resistance from the foreign magnetic field can be achieved by shielding the coil. The output voltage of the sensor is scaled in such way that it obtains the maximum voltage for highest current to be measured, in order to obtain the best accuracy and resolution.

### 3.1. Hall effect sensor CSA-1V

Main part of previously described current sensor is Hall effect sensor CSA-1V. Its manufacturer is Swiss company Sentron. It is an IC (Integrated Circuit) sensor with analog output proportional to magnetic flux density in proximity of sensor.

The CSA-1V sensor is packaged in a SOIC-8 case and is very suitable for mounting on the PCB and miniaturization of the PCB where it is used for measurement of DC currents (Fig. 9) [17, 18].

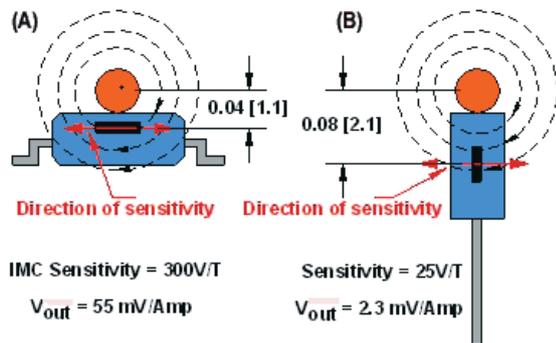


**Figure 9.** CSA-1V sensor

The CSA-1V Hall sensor uses IMC (Integrated Ferromagnetic Concentrator) [18]. Unlike toroid concentrators, IMC has a planar structure which can be laid on the surface of CMOS buffer. It enables integration of the entire sensor on one chip.

Usually, Hall element is sensitive to the magnetic field which lines are normal to its surface [19]. IMC gives sensor sensitivity to magnetic fields which lines are parallel to the surface of the chip, unlike conventional Hall sensors. Actually, IMC converts horizontal lines of magnetic field to vertical ones, normal to a surface of the Hall element placed on sensors IC. IMC enables

conductor to be placed nearer to the chip which increases sensitivity around 10 times and gives 20 times higher output voltage than conventional Hall effect sensors, as shown in Fig. 10 [18].



**Figure 10.** IMC Hall effect sensor and conventional Hal effect sensor

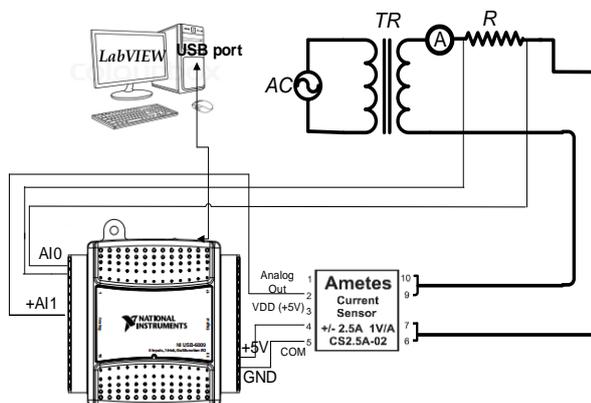
**4. Realised measurements and results**

This section presents a measurement of electric current, both effective value and its waveform, using Hall effect current sensor and comparison of results obtained with results obtained with shunt resistor and digital multimeter (DMM).

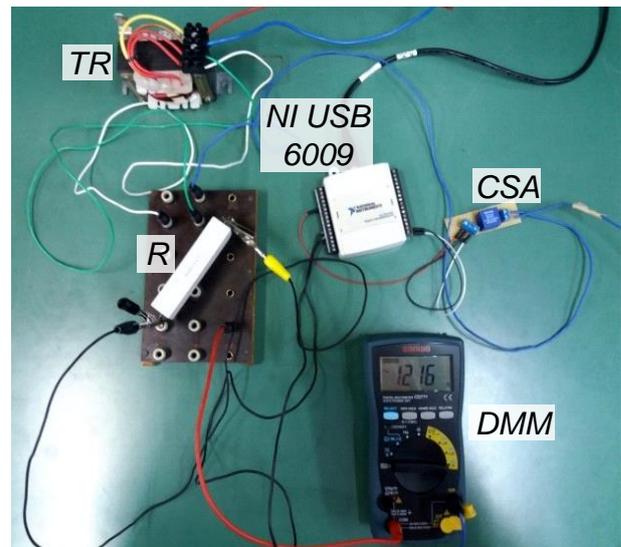
Measurement is realised using a virtual instrument created in LabVIEW program.

**4.1. Laboratory setup**

Realised laboratory setup is presented by the block diagram in Fig. 11 and by photo in Fig. 12. Analog output from the current sensor (CSA) and shunt resistor (R) is connected to the analog input of data acquisition card. Analog pins +5V and ground (GND) from data acquisition card (NI USB 6009) were used as the power supply of current sensor. AC current will be measured and sensor is configured for bipolar operation. Pins 1 and 2 (Gain and Analog Out) were left unconnected, which means that the sensitivity is increased twice (sensitivity is equal to that in unipolar operation) and measurement range is two times smaller (amounts ±5 A). Thus, a sensor is configured to a sensitivity of 0.5 V/A. Measured current is obtained from the electric network (AC) over an isolating transformer (TR).



**Figure 11.** Block diagram of laboratory setup



**Figure 12.** Photo of realised laboratory setup

**4.2. Control Panel**

Realised control panel of virtual instrument is comprised of two tabs, Fig. 13. First tab contains two graphs for representation of time-waveform of voltage from CSA (left) and for comparison of time-waveforms of currents obtained by CSA and shunt resistor. Next to the graphs there are numeric indicators that give RMS values of measured currents. Also, one numeric control exists on the left side for manual inputs of measured currents from DMM. The value of current from DMM is used as the exact value of measured current to calculate relative deviations of other two methods. By choosing the command button "SNIMI" measured values and input value from DMM are written to the table. Also, relative deviations are automatically calculated and written to the table and waveforms of one period of signal are saved to excel file. Also, in case of mistake, data from the table could be deleted by pressing button "RESET".

On the second tab there is a graph that shows all saved waveforms. The choosing of button "ISCRTAJ SIGNALE" draws saved waveforms on the graph. Command "STAMPAJ IZVESTAJ" enables printing of report in PDF format that includes a table of measured data and graph with waveforms.

The program could be stopped at any moment by pressing button "STOP" available in both tabs.

**4.3. Results**

The numerical results of measurement from the exercise are shown in Table 1.

Measurements of current were performed in the range from 0 A to 3.5 A (RMS values), with step of measurement of 0.35 A. Waveforms of measured signals are given in Fig. 14 where blue lined signals are waveforms from CSA and red ones are from shunt resistor.

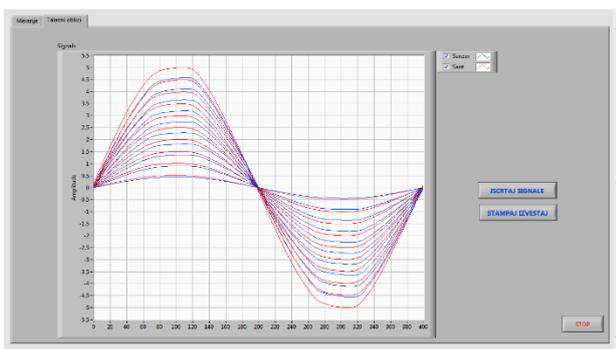
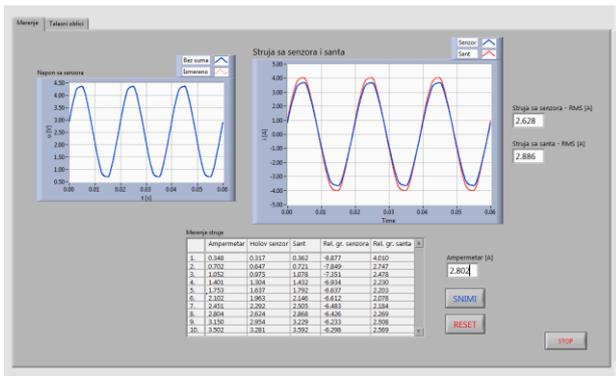


Figure 13. Screenshots of realised Control Panel

Table 1. Measurement results

No.	CSA [A]	Shunt [A]	DMM [A]	Rel. dev. CSA [%]	Rel. dev. shunt [%]
1	0.354	0.371	0.325	-8.224	4.700
2	0.703	0.726	0.647	-7.901	3.310
3	1.052	1.083	0.975	-7.284	2.906
4	1.400	1.438	1.303	-6.904	2.714
5	1.750	1.798	1.635	-6.575	2.729
6	2.100	2.161	1.969	-6.240	2.924
7	2.453	2.519	2.295	-6.443	2.673
8	2.802	2.881	2.625	-6.331	2.819
9	3.153	3.246	2.955	-6.265	2.963
10	3.501	3.609	3.283	-6.230	3.080

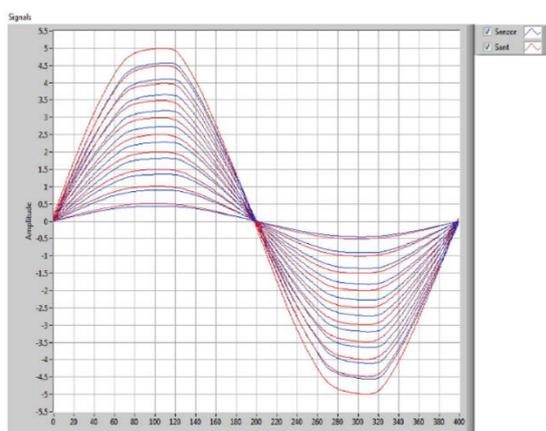


Figure 14. Measured waveforms

From the results presented can be seen that the CSA have a larger relative deviation (around -6%) than shunt resistor (around 3%). It can be noticed that the relative deviation decreases with the increase of measured current. It can be concluded that CSA needs additional calibration. It can be seen in Fig. 14 that time-waveforms of currents measured by CSA have the same shape as time-waveforms of currents measured with shunt resistor, with only different amplitude.

### 5. Conclusions

This paper presents application Hall effect current sensor CS10A-02 for measurement of electric current. It contains a theory on the working principle of Hall effect current sensor, description of necessary laboratory equipment and created virtual instrument. Also, the paper gives the results of measurement of electric current using Hall effect current sensor. The results of such measurement were compared with results obtained using other methods of current measurement – shunt resistor and a digital multimeter. Furthermore, a proper discussion of these results is given in the paper.

Realised laboratory setup opens the possibility to students to get acquainted with knowledge on Hall effect current sensors and virtual instrumentation.

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# Virtual Instrumentation for Load Cell – Calibration and Measurements

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**Abstract:** *The aim of this paper is to present a virtual instrument for load cell. This virtual instrument has been used for calibration of the load cell and for measurements of mass. The paper also presents details on the used load cell. Details on the produced balance that contains this sensor, its mechanical and electrical parts, have been also given in the paper. The paper contains measurement results and a proper discussion.*

**Keywords:** *load cell, balance, calibration, LabVIEW.*

## 1. INTRODUCTION

Mass (load), as the main physical quantity and property of every physical body, is present in everyday life. Because of its exceptional importance there is a permanent need for improvement of technologies for its measurement. Consequently, different measurement methods were developed for that purpose, as well as the different constructions of the measuring devices [1-3]. Development of new technologies has enabled the use of semiconductor components in the construction of electronic devices for load measurement with significant precision and accuracy. However, this type of devices does not have full implementation because in systems where is necessary to measure a great load its performance is not satisfying. For that reason, the most reliable systems for measurement of load are load cells with strain gauges [2-5]. They have a large measuring range, which enables construction of different measurement systems depending on the load. The strain gauges are placed on load cell and their resistance is changing linearly with the deformation of load cell. Therefore, mass (load) can be successfully measured using this solution.

In the study presented in this paper load cell CZL602A was used. It is powered by 9V battery. The load cell output is connected to the analog input of data acquisition card NI-9211, which is connected to a personal computer via USB. Virtual instrument has been made in LABVIEW software [6]. The paper presents the results of calibration of this load cell, as well as measurement of mass according to the determined sensitivity of load cell. Furthermore, it gives the results of absolute and relative deviations of such measurements and a proper discussion.

Measurement setup with load cell and accompanying virtual instrument is suitable for new laboratory exercise and future student work in the laboratory.

## 2. LOAD CELL CZL602A

Load cell CZL602a belongs to group of resistive sensors for measurement of load [1-3]. Basically, this type of sensor is built from an aluminum load cell that has a gap on its middle part. The photo of the CZL602a load cell is presented in Fig. 1.

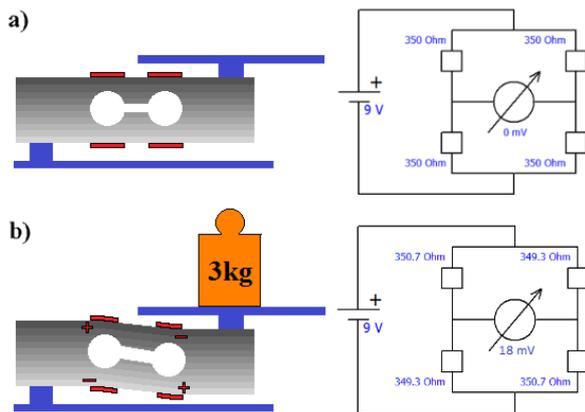


**Figure 1.** Load cell CZL602a

The gap enables elastic bending of the load cell. At both ends of the measuring cell there are two M5 threaded bores that allow easy fixing of the load cell. From the upper and the lower side of the gap there are strain gauges that are fixed with some kind of epoxy resin. Strain gauges are arranged so that the two are positioned from the top of the gap and the other two are at the bottom. This arrangement allows connection of the strain gauges in the electrical circuit of the Wheatstone bridge as it is shown in Fig. 2a [3].

When the object is set on the plate, then the load cell will bend. Bending will cause compression and tension of strain gauges in pairs, which leads to a change of their resistance. The change in resistance causes the disbalance of the Wheatstone bridge, as it is shown in Fig. 2b. As a

result of disbalance at the output of the load cell voltage proportional to can be measured [3].



**Figure 2.** Display of the measuring cell and the Wheatstone bridge: a) when the measuring cell is not loaded, b) when the measuring cell is loaded

Some technical data of load cell CZL602a [7], given by the manufacturer, are:

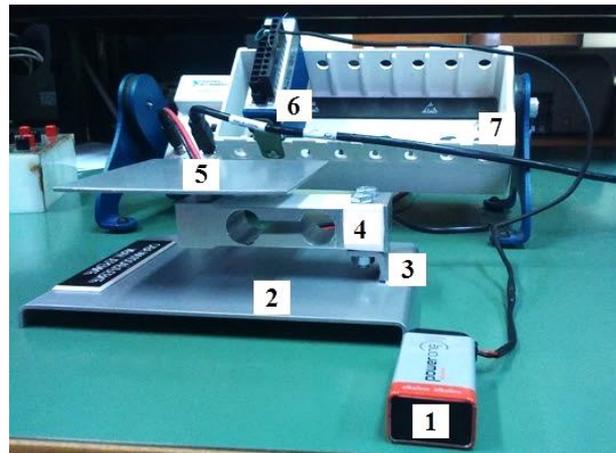
- Rated load (full scale - FS) 3 kg
- Comprehensive error 0.03 % of FS
- Rated output  $2 \pm 0.02$  mV/V
- Nonlinearity 0.03 % of FS
- Repeatability 0.02 % of FS
- Zero Balance 1 % of FS
- Output Resistance  $350 \pm 5 \Omega$
- Excitation Voltage  $9 \sim 12$  V.

According to this data, load cell CZL602a output voltage at rated load of 3 kg and chosen supply voltage of 9 V amounts 18 mV. In other words, its sensitivity  $S$  is  $18 \text{ mV}/3 \text{ kg} = 6 \text{ mV/kg}$ . However, this value needs to be checked because it depends on the voltage (which may vary from taken 9 V) and because sometimes data from the manufacturer may be slightly different from actual data. Therefore, a calibration is needed.

The error of the load cell has been rated at 0.03% of full scale (3 kg), which amounts  $\pm 0.9$  g.

### 3. MEASURING SYSTEM

The measuring system created for mass measurements is shown in Fig. 3. The measuring system consists of load cell CZL602a, 9 V battery and NI-9211 data acquisition card manufactured by National Instruments. The load cell is fixed at the one end to the bracket which is lifted from the stand in order to enable the bending of load cell. At the other end, plate has been designed to make it easier to set up an object which mass is measured. The battery is used as power supply. The load cell output is connected to the analog input of the data acquisition card connected to a personal computer (PC) via USB.

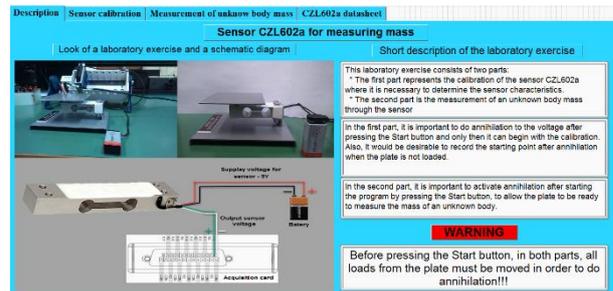


**Figure 3.** System for mass measurement: 1 - 9 V battery, 2 - stand, 3 - bracket, 4 - load cell CZL602a, 5 - plate, 6 - data acquisition card NI-9211 7 - chassis

A virtual instrument has been created in LabVIEW software for measurement of the output voltage of load cell.

### 4. VIRTUAL INSTRUMENT

Created virtual instrument for calibration and mass measurement contains four tabs [6]. The appearance of its first tab is given in Fig. 4.



**Figure 4.** Display of the first tab of the virtual instrument

This first tab contains a brief description of measurement setup and electrical scheme of the measurement system. The second tab is designed to perform a calibration of load cell CZL602a. Calibration is performed by measurement of the output voltage  $U$  of load cell for different values of known mass  $m$ . In this way is obtained characteristic of the load cell as set of points  $(m, U)$ . The third tab is designed for measurement of an unknown mass according to the predetermined characteristic  $m=f(U)$ . By applying linear interpolation, for measured voltage  $U'$  it is possible to determine unknown mass  $m'$  of an object using the existing  $m=f(U)$  characteristic. Also, within this tab it is possible to print a report of measurement in PDF format. In the last tab, the datasheet of the CZL602a sensor is given as an additional information to the user.

#### 4.1. CALIBRATION AND MEASUREMENTS

As in most systems, before the start of the measurement, it is necessary to know its

characteristic (dependence of output quantity on input quantity). This characteristic of load cell with strain gauges represents dependence of the output voltage of load cell on the load itself. As it has been explained in Section 2, it is important to perform a calibration in order to determine this characteristic. Tab entitled "Sensor calibration", which is shown in Fig. 5, is made for this purpose.

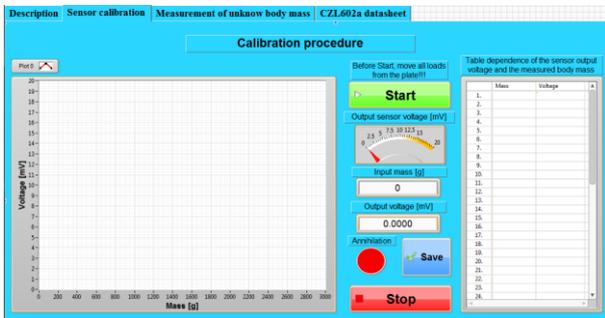


Figure 5. Display of tab for calibration

The calibration procedure is implemented as follows. The calibration starts with no load by clicking on the "Start" button. A certain output voltage different from zero will be measured. This is the result of the imperfection of the system, as well as the existence of a certain mass of the plate, which initially bends the load cell. In order to eliminate this problem, it is possible to annul this voltage in the software. After the annulment, it is necessary to record initial values in the table. At the same time the starting point in the graph will be plotted. After the starting point is recorded, it is possible to gradually bend the load cell with different mass and save obtained values in the table. Simultaneously, new point of the characteristic will appear in the graph. Every following load putted on the plate need to be greater than the previous, until the rated load is reached. When the calibration is finished, by click on the button "Stop" this part of virtual instrument will be stopped and then it is possible to move on the next tab for measurement of unknown mass.

The appearance of the tab for measurement of unknown mass is given in Fig. 6.

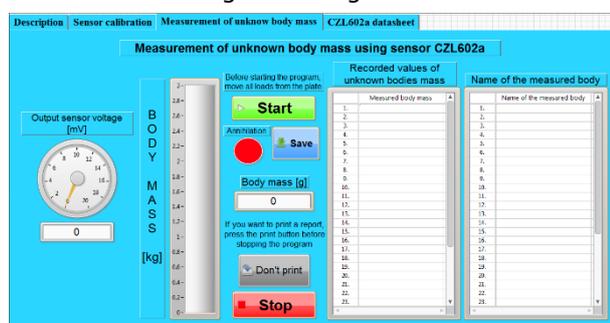


Figure 6. Display of tab for measurement of unknown mass

As in calibration, in this part of the program the output voltage should be annulled immediately after starting the program on the "Start" button

(load cell is unloaded). It is necessary to take care that all loadings from the plate are removed before the start of the program in order to ensure that the annulment is valid.

On this tab it is possible to read the unknown mass placed on the plate, as well as the output voltage of load cell. To save measured mass, it is necessary to click on the button "Save". Then, the mass of the body will be automatically saved in the table of recorded values of the unknown mass. It is possible to insert the name of the measured mass (object). When the mass measurement is finished, it is possible to print a measurement report in PDF format by clicking the button "Don't print". Then the button name will be changed to "Print". This option must be set before stopping the program by clicking "Stop" button. This report contains the following: theoretical basis, results of calibration of load cell with graphs and tables and table of measured masses and their names. This makes calibration and mass measurements with sensor CZL602A complete and program stops.

### 5. MEASUREMENT RESULTS

Numerical data on calibration of load cell are given in Table 1. Also, these data are presented graphically in Fig. 7. It has been performed for different loads up to 1.8 kg.

Table 1. Measurement results of load cell calibration

No.	$m$ [g]	$U$ [mV]
1	0	0
2	100	0.507
3	200	1.016
4	300	1.525
5	400	2.032
6	500	2.543
7	600	3.054
8	700	3.562
9	800	4.072
10	900	4.578
11	1000	5.087
12	1200	6.105
13	1400	7.120
14	1500	7.625
15	1600	8.137
16	1800	9.159

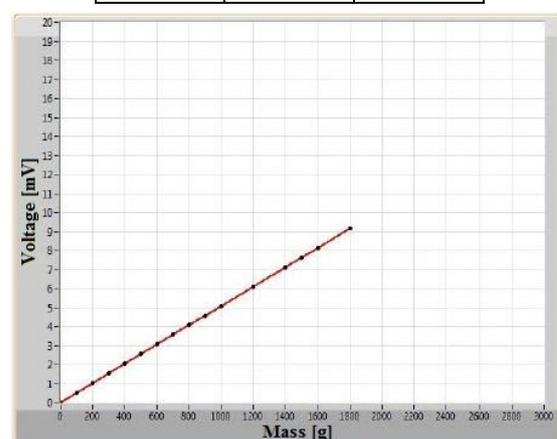


Figure 7. Graphical representation of calibration results

From Fig. 7 is evident that the characteristic of load cell is linear. According to these results, a coefficient  $k$ , which is a ratio of measured voltage  $U$  and set mass  $m$ , can be determined for each measurement:

$$k_i = \frac{U_i}{m_i}; i = 1, 2, \dots, 16. \quad (1)$$

The mean value of this coefficient can be used as a sensitivity  $S$  of load cell and it can be calculated as follows:

$$S = \frac{\sum_{i=1}^{16} k_i}{16} = 5.085 \left[ \frac{\text{mV}}{\text{kg}} \right] \quad (2)$$

This value is significantly different from the one calculated in Section 2 (6 mV/kg), which shows the significance of the performed calibration. Further measurements of mass have been made with known masses in order to check the deviations of the measurement results. The results obtained are given in Table 2.

**Table 2.** Results of measurement of mass and absolute and relative deviations

$m$ [g]	$m'$ [g]	$\Delta m = m' - m$ [g]	$\delta m = 100 \Delta m / m$ [%]
100	100.548	0.548	0.548
250	250.010	0.010	0.004
500	500.120	0.120	0.024
1000	999.746	-0.254	-0.025
1500	1498.126	-1.874	-0.125
1800	1799.318	-0.682	-0.038

From the results given in this table, it can be seen that the obtained absolute deviation  $\Delta m$  is higher than the error of load cell given in Section 2 (0.9 g) only in one measurement. Also, the relative deviations  $\delta m$  are low. These values are acceptable for this type of load cell and performed measurements.

## 6. CONCLUSION

Load cells with strain gauges, in combination with other equipment, are an integral part of almost every device for mass measurement. Their measurement accuracy is increased with the use of new technologies.

The aim of the research presented in this paper is to show one solution for measurement of mass which is based on the load cell. It has been shown how this load cell can be calibrated and how it can be further used for measurements according to the obtained sensitivity. For that purpose, an application has been made in LABVIEW software. It has been used to record all measurement data of

interest during the calibration of load cell and during the measurement of mass.

The paper presents all the results obtained, as well as a proper discussion.

Presented measurement setup opens the possibility to students to get acquainted with knowledge on load cells, mass measurement and virtual instrumentation.

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# Application of Induction Machine U/f Control Through the Educational Laboratory Setup

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**Abstract:** *This paper gives a description of a laboratory setup based on dSPACE1104 DSP board which allows development and testing different control algorithms of AC machines. A detailed description of the laboratory setup components as well as realization of the U/f control algorithm for an induction machine (IM) is presented in the paper. U/f control of IM is enabled by developed Graphical User Interface (GUI) application. The GUI provides observation of characteristic quantities during U/f control and emphasizes didactic character of the laboratory setup. The laboratory setup is intended for students who follow the course of control of electric drives and should enable more quality knowledge gain as well as enhance student's practical skills in the laboratory. At the end, obtained experimental results characterizing the IM operation under U/f control are presented.*

**Keywords:** *U/f control; dSPACE1104; induction machine; Rapid Control Prototyping; electric drive, laboratory setup, MATLAB/Simulink*

## 1. INTRODUCTION

The number of AC motors is much higher than number of DC motors in nowadays electric drive systems. This expansion of AC motors usage was due to their design robustness and the sudden fall in prices and dimensions of drive controllers caused by the rapid development of power electronics in the last few decades [1]. Hand by hand with power electronics expansion as well as the appropriate power converters dynamical growth of various AC machine control algorithms came as well.

Until few years back development of control applications was a huge time consumer and it required a lot of programming experience. Nowadays there is considerable number of digitally-based development systems on the market, which allow rapid development and testing of motor control algorithms [2]-[4] while do not require sophisticated programming skills. The literature [5] provides a detailed comparison of these control platforms and their capabilities based on DSP and FPGA processors. Most of these platforms, nowadays, are usually based on Rapid Control Prototyping (RCP) techniques which allow testing the control system on real-time machine with real I/O interfaces connected to real-world systems. RCP decreases application development time by allowing corrections to be made early in the developing process. By giving engineers an insight to the product early in the design stage, mistakes can be corrected and changes can be made while they are still inexpensive.

Lately, Rapid Control Prototyping becomes quite popular and attractive in electric drive control algorithms development [6]. Quick and easy design of control algorithms allows engineers to test and enhance control methods and develop final prototypes in simple and effective manner.

Modern advanced control algorithms such as vector control (FOC – *Field oriented control*), Direct torque control – DTC in their essence are based on stator rotating magnetic field speed control i.e. changing the frequency of AC machine power supply. These advanced control methods are mostly deployed in systems with high dynamics characteristic. However, in systems where sudden and quick speed reversal is not required, U/f control method also known as scalar control can be an optimal solution having in mind control complexity and overall drive price. The U/f method is one of the simplest control methods and the most represented in modern power converters and drives. This method is considered as “plug-n-play” since very little motor data is needed by the drive. The U/f control method is often used when there is a demand for high frequency operation which could easily exceed 1000 Hz. Most machine tool and spindle applications use the U/f control method for this advantage [7].

In this paper the development of a U/f control algorithm based on dSPACE 11104 DSP board is described. Complete laboratory setup is developed in Laboratory of Electrical Machines, Drives and Regulation at Faculty of Technical Sciences in Čačak, University of Kragujevac, Serbia [8]. The setup (experiment) is intended for students who

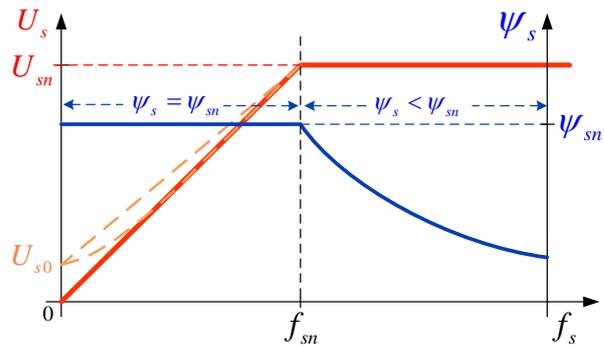
follow the course of Control of Electric Drives at bachelor as well as master studies level. The paper describes each element of the setup as well as development process of control application. Didactical approach of the laboratory setup is particularly accentuated through application's graphical user interface as well as overview of obtained experimental results.

**2. BACKGROUND THEORY OF U/F CONTROL**

Until twenty century late sixties control of induction machine and AC machines in general was very unpractical from reason of lack of the power supply with variable frequency. Speed control of induction machine was done by change of the additional resistance in the machine rotor circuit, switch of the stator pole pairs and similar. Since these AC machine control methods were very limited, DC machines were dominated in the industry applications where precise and continuous torque and speed control were demanded. Unsatisfied with the circumscribed use of the induction machine engineers focused their scientific effort on development of frequency converters which should enable variable speed of AC motors in general. This year completes half a century since Danish company Danfoss was launched first commercial frequency converter [9]. It was legendary VLT5 (VLT - VeLoTtrol abbreviated form velocity control) with rated power of 4 kW weighted slightly more than 50 kg. Technologically, it pushed the limits of what was feasible at the time and held 14 patents. The device attracted significant interest and even won an Industrial Design Award. Thanks to exponential development of power electronics nowadays equivalent with the same rated power weights a little less than 5 kg with many more possibilities and higher efficiency rate as well.

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 rise 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. 1 (red line).

$$u_s = \begin{cases} \frac{U_{sn}}{f_{sn}} f_s & , \text{ for } f_s < f_{sn} \\ U_{sn} & , \text{ for } f_s \geq f_{sn} \end{cases} \quad (1)$$



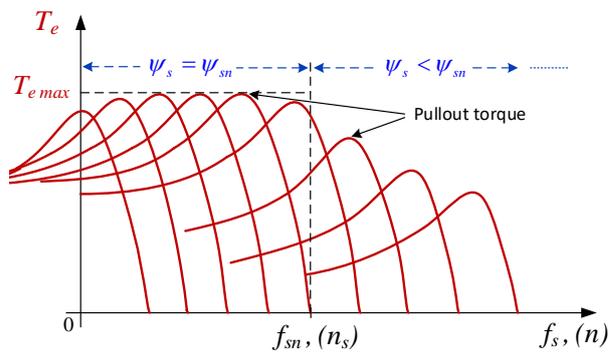
**Figure 1.** U/f characteristic of freq. converter

Machine stator flux is determined by machine voltage, frequency and in smaller sense by voltage drop on stator resistance according to (2):

$$\psi_s = \frac{U_s - R_s i_s}{2\pi f_s} \quad (2)$$

Where:  $\psi_s$ ,  $U_s$ ,  $i_s$ ,  $R_s$  and  $f_s$  are stator flux, voltage, current, resistance and frequency respectively.

By keeping linear dependence between the stator voltage and frequency (U/f=const.) relating mechanical characteristic ( $T_e(n)$ ) of the IM machine in constant field and field weakening zone is shown in Fig.2.



**Figure 2.** Mechanical  $T_e(n)$  characteristic of IM

At frequencies close to zero voltage drop on stator resistance is nearly comparable to back electromotive force (EMF) and it can't be neglected. This results with the stator flux reduction (machine filed reduction) as a consequence of U/f linearity degradation. Reduction of the machine filed further downgrade the pull-out torque (maximal torque) as can be notice in Fig.2. At the medium and high speeds, voltage drop is covered by EMF and doesn't have significant influence on the machine field. In order to minimize or completely remove diminution effect on the machine pull-out torque at low speed it is necessary to compensate the voltage drop on the stator resistance which depends on the machine load (stator current). One of the methods to compensate the voltage drop on stator resistance and ensure constant machine filed at low frequencies is to violate the U/f=const. principle.

This violation of the U/f principle reflects in small voltage value  $U_{s0}$  added at zero frequency (Fig.1 - orange line). Further, stator voltage to its rated value changes linearly with respect to stator frequency or by following some quadrat or exponential shape depending on the load type i.e. voltage drop on stator resistance  $R_{sf_s}$ .

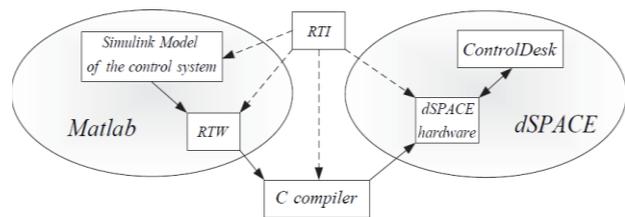
Commercial frequency converters usually dispose of several options for stator resistance voltage drop compensation. Moreover, beside this compensation, frequency converters by default have possibility of slip compensation i.e. compensation of speed reduction originating from rise of the motor load. With these two compensations induction motor speed can be satisfactory regulated by using the U/f control without speed (position) sensor mounted on the motor shaft. This makes U/f method very attractive and widely implemented in modern electric drives across the globe. Very simple algorithm without current regulators and complex mathematical calculations makes the U/f control method quite popular in scientific literature which asks for further improvements of its characteristics and ways which will rise the quality of speed regulation [10]-[12].

Nevertheless, in the electric drive systems where demands for high dynamics are strong the use of power converters drove by control methods with more complex mathematical calculations based on vector control are still mandatory.

### 3. DESCRIPTION OF LABORATORY SETUP BASED ON DSPACE1104 PLATFORM

For implementation of the U/f control algorithm in this paper dSPACE1104 DSP board [13] was used. dSPACE 1104 is a complete real-time control system based on a 603 PowerPC 64-bit floating-point processor running at 250 MHz. For advanced I/O purposes the platform includes slave DSP subsystem based on the TMS320F240 DSP microcontroller (16-bit, 150 MHz). For purposes of rapid control prototyping (RCP), specific interface connectors and connector panels provide easy access to all input and output signals of the board. A/D and D/A inputs and outputs are provided through BNC connectors, I/O and PWM signals through dSUB 37-pin and incremental encoder interface through dSUB 15-pin connectors. dSPACE platform has enabled communication with models created in the MATLAB/Simulink environment. Simulink model can be easily converted to a code suitable for dSPACE processor that further, in real time, controls the application or I/O units. It extends the C code generator Simulink Coder™ (formerly Real-Time Workshop - RTW) for the seamless, automatic implementation of Simulink and Stateflow models on the real-time hardware as it is shown in Fig.3. This significantly simplifies the process of iterations in the development of control

prototypes and applications, without requiring specific programming skills from users.



**Figure 3.** MATLAB – dSPACE communication [14]

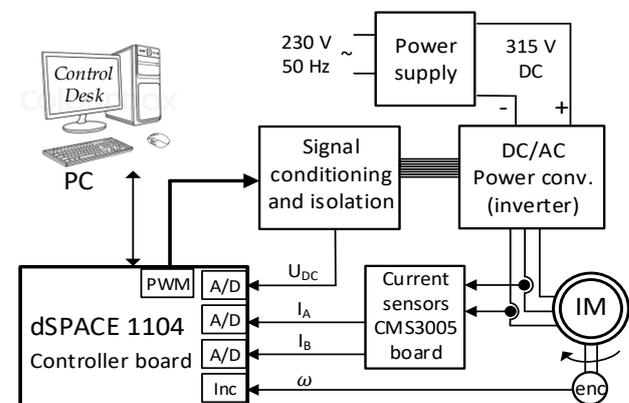
The following resources of dSPACE1104 board are utilized in the setup:

- PWM control unit;
- 2\*A/D converters for current measurement;
- 1\*A/D converter for DC voltage measurement;
- INC unit for measuring the motor speed.

The laboratory setup on which scalar U/f control was implemented besides dSPACE1104 board consists of following parts:

- Isolated power supply;
- 3-ph power converter (inverter) up to 1 kW;
- 2 current sensors CMS3005;
- Signal conditioning and isolation board;
- Isolated DC power supply;
- IM with encoder;
- PC with ControlDesk software installed.

The U/f control algorithm was tested on two pole IM with parameters given in the appendix. Block structure of the overall laboratory setup is presented by Fig. 4.



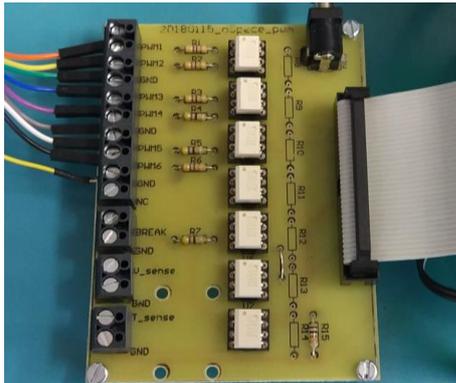
**Figure 4.** Block structure of the laboratory setup

dSPACE 1104 board provides PWM signals which are through signal conditioning and isolation board passed to 3-ph voltage source inverter. Isolation board consist of seven TLP2200 optocouplers which unlike the majority of standard commercial optocouplers provide positive logic i.e. output signal with the same polarity as the input signal. The maximal switching speed depends on the optocoupler bandwidth which is 2.5 MBd. Measured results show that the board transition time for rising edge (turn on) is 250 ns and for falling edge (turn off) is 400 ns. The signal isolating board is shown in Fig. 5a.

Current sensors CMS3005 are used for current measurement in two motor phases. The CMS3000 current sensor family is designed for highly dynamic electronic measurement of DC, AC, pulsed and mixed currents with integrated galvanic isolation. CMS3005 has very high dynamic response (bandwidth up to 2 MHz) without the hysteresis that is present in iron core based designs. This type of sensors is particularly suitable for high dynamics current measurement application such as in AC electric drives. The current sensor board is shown in Fig. 5b. Incremental encoder HEDSS HKT3006 with 500 pulses per rotation in

two phases (2000 pulse/rotation after generation of quadrature-clock and direction signals) and zero phase with reference pulse was used for the speed measurement and positioning. Fig. 5b shows the board with current sensors.

Complete laboratory setup is shown in Fig. 6. Laboratory setup realised in this way (with closed current and speed loops) is suitable for implementation and examination of advanced AC drives control methods as well, such as FOC or DTC methods.

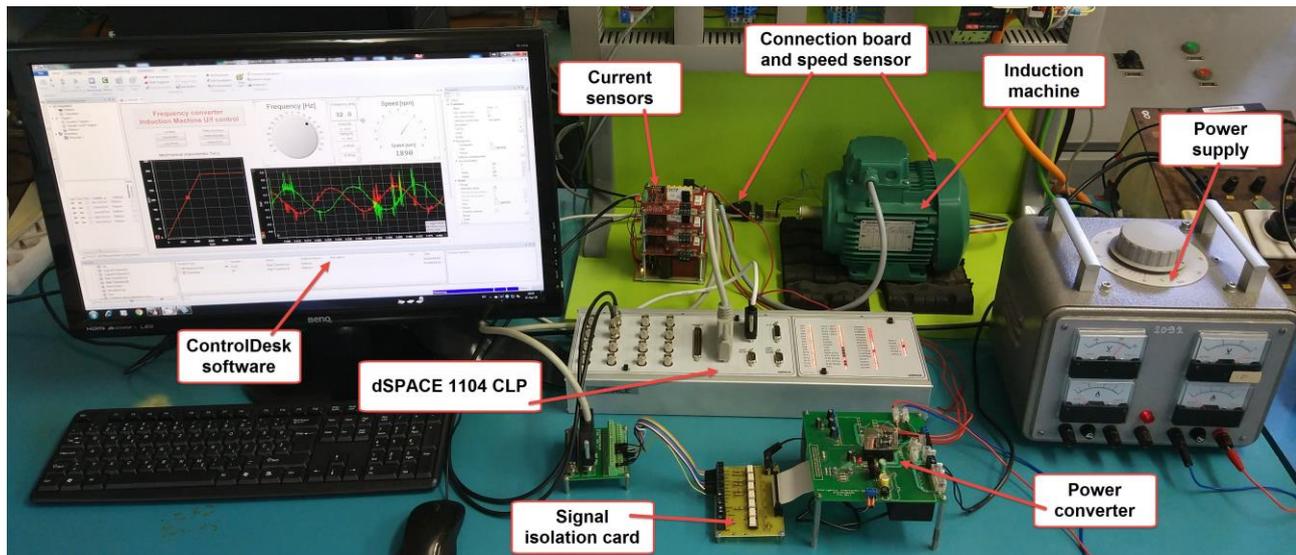


(a)



(b)

**Figure 5.** (a) Signal conditioning and isolation board and (b) currents sensors board



**Figure 6.** Complete experimental laboratory setup for testing different AC machine control algorithms

**4. APPLICATION OF U/F CONTROL OF IM**

Application of U/f control described in section 2 consist of two main parts: Control algorithm (MATLAB/Simulink) and graphical user interface (Control Desk). These two parts of the U/f application communicate through the RTI (Fig.3) allowing read/write control of every quantity in the application (Simulink model). All I/O specifications for RTI can be defined within the Simulink environment. RTI modifies the code generated by RTW according to these I/O specs and processes it to load the DSP system automatically. Supported

by RTI, block-diagram parameters in the real-time program (Control Desk) can be changed through Simulink's external simulation facility without regenerating code.

**4.1 Simulink model of control application**

In order to implement control application in DSP of the dSPACE1104 board, control application should be developed first. Control application is developed in MATLAB/Simulink. Application sample frequency as well as PWM frequency is set to 20 kHz which makes 50 μs available for all algorithm calculations.

Determination of PWM duty cycles (stator voltages) is related to stator frequency reference and defined by equation (1). The calculations have been done in synchronous reference coordinate system. The stator voltage is determined by  $U_d$  and  $U_q$  voltage components in synchronous  $d-q$  coordinates. Then, by using inverse Park transformation, stator voltage references (in all three phases) are obtained in respect to the frequency reference as it is shown in Fig. 7.

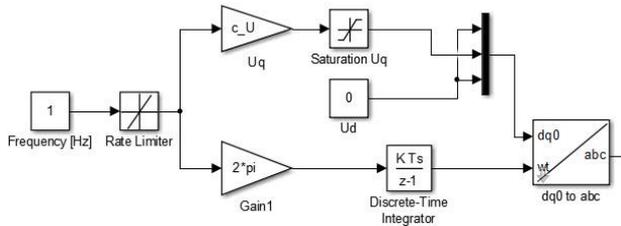


Figure 7. Calculation of stator voltages

Stator current measurement was realized through the interrupt routine which happens at the middle of the PWM cycle. In this way more accurate current measurement in  $a$  and  $b$  motor phases was obtained. Protection from unwanted excessive currents is realized by software. In case the stator current values exceed the maximal allowed value, the generation of the PWM signal stops.

Speed and position measurement is realized by processing obtained encoder signals within the Speed Measurement block. Since mechanical time constant is several times higher than electrical time constant, frequency of the interrupt routine which calls speed measurement is set to 1 kHz. This means that speed values are updated every 1 ms which is 20 times slower than PWM update (50  $\mu$ s).

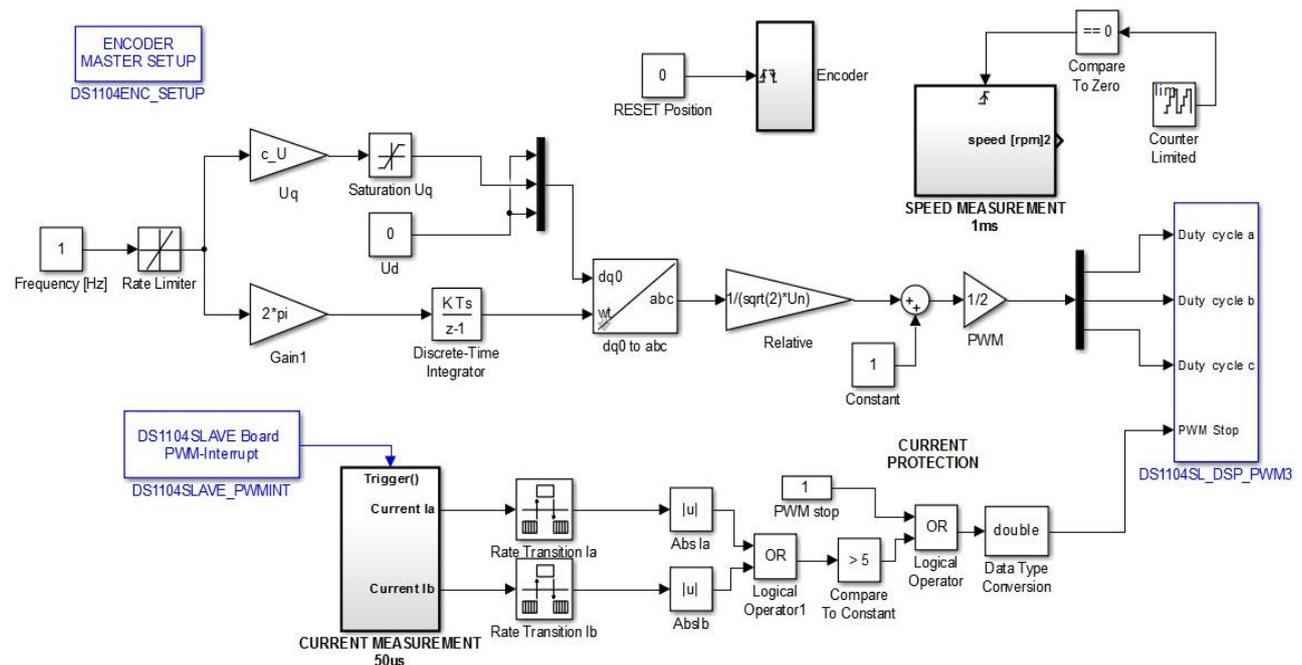


Figure 8. Complete Simulink model of the U/f control algorithm

Fig. 8 shows complete Simulink model of the U/f control algorithm ready to be implemented on the dSPACE board. At the end, the application is automatically built to C code using MATLAB RTW and downloaded to dSPACE1104 control board ready for use. In such applications it is a must to prevent uncontrolled application start after the download on DSP was performed as well as set initial conditions of the application. In order to prevent unstrained application run the *Initial simulation state* option (*Code generation/RTI Simulation option*) in *Model configuration parameters* of the Simulink model should be set to STOP. This variable should be controlled through the GUI as *simState* variable.

4.2. Control environment and results

Graphical User Interface (GUI) has been developed in Control Desk software. The Control Desk enables making objects for control and measurement (plot) characteristic quantities in the control application. The objects are linked to the quantities of interest and their values can be changed/observed in real time. The developed GUI allows setting up the reference frequency as well as observation of electrical and mechanical parameters of the motor such as motor speed, stator currents, U/f and  $\psi/f$  characteristics etc.

Before application start, current offset fields should be adjusted in order to remove DC component in the motor current measurement. After this, application can be started (*simState* variable) and PWM outputs can be resumed (*PWM stop* variable) by selection appropriate buttons. Complete GUI is shown in Fig. 9.

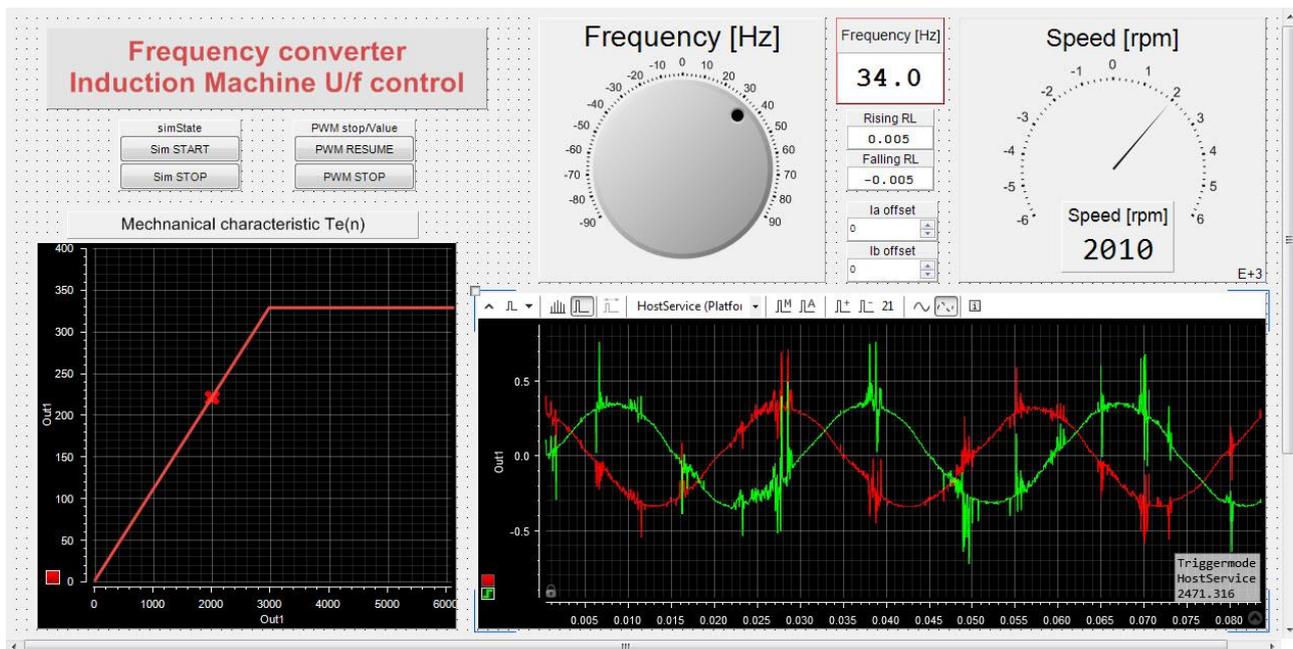


Figure 9. GUI for U/f control of IM

Beside the possibility to set up the appropriate current offsets user can define rising and falling edge limiter of the reference frequency (frequency soft start). The frequency can be set by "Frequency [Hz]" radio button or numerically edited in the corresponding field. The resulting speed is provided graphically as well as numerically at the top right part of the GUI. Dependence of the stator voltage and speed (frequency) is provided graphically in the bottom left corner. The user can observe current value of speed and stator voltage in two zone operation (constant field and field weakening zone) by changing the stator reference frequency. Stator currents in stationary  $d$ - $q$  coordinate system are shown in bottom left corner of the GUI. The currents in Fig. 9 are plotted in time domain. Currents are plotted in raw format measured with the highest sensor bandwidth without any using any filtering option.

This GUI can help students to better comprehend working principle of the U/f control application and relation between characteristic quantities of IM during the operation. The GUI is quite easy to edit so new measurement and graphs of interests can be added very simply.

## 5. CONCLUSION

The paper presented a laboratory setup for testing various control methods of AC machines. Every part of the setup was described in detail as well as developed application of U/f control. Firstly, the basic theoretical overview of U/f control was given after which complete system based on dSPACE 1104 board is described. Control application made in Simulink was properly described and discussed. In the end, GUI interface for U/f control method is

presented together with its control functions and graphs.

The laboratory setup is dedicated to students who follow the course of Control of Electric Drives and should aim for them to gain knowledge and practical skills in the laboratory. This laboratory setup allows its users to perceive all aspects of an AC machine control method in modern electric drive applications such as:

- Current and speed measurement and regulation;
- Implementation of necessary matrix (Clarke and Park) transformations;
- Determination of the necessary voltage and current references and PWM generation;
- Flux estimation techniques;
- Protection implementation;
- 2Q or 4Q machine operation, etc.

Moreover, the setup consists of all necessary parts which enable implementation and testing of different advanced control methods such as FOC or DTC control.

## ACKNOWLEDGEMENTS

This paper is a result of the project TR33016 which is supported by Ministry of Education, Science and Technological Development of Republic of Serbia.

## APPENDIX

Table 1. Induction motor SIEBER L71 parameters

$U_n$ [V]	400	$R_s$ [ $\Omega$ ]	24.6	$L_s$ [H]	1.48
$I_n$ [A]	0.95	$R_r$ [ $\Omega$ ]	16.1	$L_r$ [H]	1.48
$P_n$ [W]	370	$n_n$ [ $\text{min}^{-1}$ ]	2860	$L_m$ [H]	1.46

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# Realization of Model of Robotic Arm S-430iF for Education Purposes

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**Abstract:** In this paper is presented development and realization of model of industrial robot S-430iF for educational purposes. Model of robotic arm is realized by using Matlab, SolidWorks, Arduino IDE software and rapid prototyping technology - 3D printing. Robotic arm described in this paper is cheap and user-friendly solution for students to adopt basic knowledge about mechanics of multibody systems, from simulation to implementation in real model.

**Keywords:** industrial robot, robotic arm model; MATLAB; Rapid Prototyping;

## 1. INTRODUCTION

Industrial robots are mechanically wary complex mechanism, with a lot of degrees of freedom. In general, industrial robots are modeled as open kinematic chain which is made of solid segments, connected each other with joints. Those joints are controlled with actuators (servo motors). Design and production of control system for industrial robots, require solving kinematics and dynamics of complex movement (relative movement) of multibody system. [1]

Calculations of kinematics and dynamics of robots are mathematically very demanding processes that require the use of matrix algebra. By using the computer software problem of demanding mathematical calculation is easily solved. [2] Development of computer technology and software trigger off solution for making models and simulations of robot movement in a very reliable way, before physical realization of expensive technology. These software simulations save a lot of time for development of industrial robot and saves a lot of money for expensive prototypes. Process of calculation and simulation of movement of a robot is described in detail in resent paper [3]

In this paper is described proceeding of realization of model of industrial robot S-430iF. It is cheap and user-friendly solution for students to adopt basic knowledge about mechanics of multibody systems, from simulation to implementation in real model. The hardware components are described and modification of 3D model which are necessary for realization of robotic arm using rapid prototyping technology. Software implemented in microcontroller is described as well. A proper discussion has been given.

## 2. BASIC ELEMENTS OF ROBOTIC ARM

Figure 1 presents an 3D model of robotic arm S-430iF and realized model. Most of the elements

shown on the model are realized by PLA plastics using rapid prototyping technology. Time required for making robotic arm is about seven days, five days for 3D printing (100 hours, 1kg of PLA plastic), one day for assembling and one day for programming and testing.

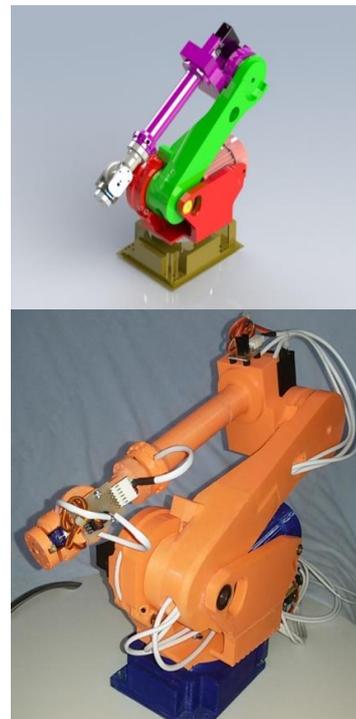


Figure 1. 3D model and realized model

In order to create an educational model of industrial robot, it was necessary to make modifications on the 3D model of robot S-430iF. These modifications to the 3D model are made in order to make mounts for motors and sensors. The models are simplified so that they can be made on a 3D printer.

Block diagram of model of industrial robot S-430iF is presented in figure 2.

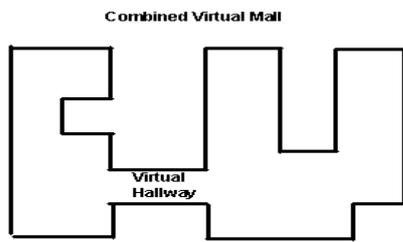


Figure 2. Block diagram of model

2.1. Arduino UNO controller

Arduino UNO is development board based on ATmega328 microcontroller. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power connector, ICSP connector. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable. [4] This board supports a lot of extensional boards called "shields". Arduino UNO can be programmed form in development environment for microcontrollers, or in LabVIEW and MATLAB software.

2.2. RC servo motors

For this model of industrial robot RC servo motors are used. This type of motors is used because they are the cheapest, easy to buy. They are reliable and easy to control using PWM (Pulse Width Modulation) signal form microcontroller. Motors are very small, and inside, they have position feedback control with potentiometer and comparator. Construction of motor contains motor and gearbox. In this model of industrial robot, two types of RC servos were used. First one is AnalogServo - HD-10501MG (figure 3) with high output torque. The second one is Tower Pro Micro Servo 9g SG90 (figure 4) with small output torque and small dimensions.

Basic characteristics of motor AnalogServo - HD-10501MG:

- Power supply 4.8-6.0 VDC
- Speed 0.14sec/60°
- Working current 500mA
- Maximal torque 17 kg-cm
- Maximal current 2500mA
- Mass 63±1g [5]

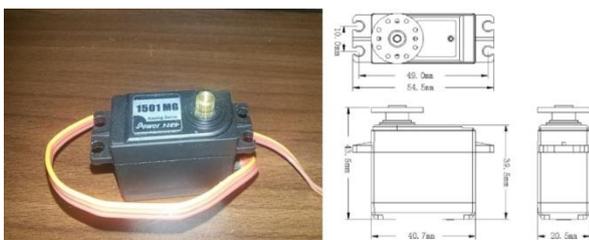


Figure 3. AnalogServo - HD-10501MG [4]

Basic characteristics of motor Tower Pro Micro Servo 9g SG90:

- Power supply 4.8-5.0 VDC

- Speed 0.1sec/60°
- Maximal torque 1.8 kg-cm
- Mass 9g [5]

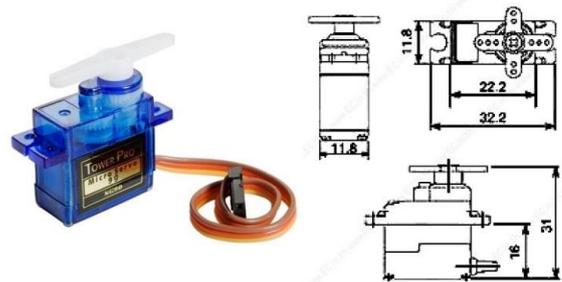


Figure 4. Tower Pro Micro Servo 9g SG90 [6]

3. PROGRAM

Programming of model of industrial robot has been done in Arduino IDE software. In this software the *VarSpeedServo.h* library was used. This library enables control up to eight RC servo motors with different speeds. Library is modification of standard *Servo.h*, which is modified by Korman who has added speed control. Later Philip van Allen has added possibility of waiting to finish motor movement. [7]

The most important method from this library is:

**write(value, speed, wait)**

which define angle that motor has to achieve, his speed and are the motors work synchronically. This notation enables to import matrix which contains rows with angles and rows with motor speed. Matrix like this can be formed in MATLAB simulation [3] with some additional code:

```

ugao=q*57.2957795;
brzina=qd*57.2957795*5;
matrica_zarduino=cat(2,ugao,brzina);
matrica=int64(matrica_zarduino);
    
```

where is:

```

ugao=q*57.2957795; code that converts angle form radian to degrees,
brzina=qd*57.2957795*5; code that converts angular speed form rad/s to °/s,
matrica_zarduino=cat(2,ugao,brzina); code that forms matrix with angle and angular speed,
matrica=int64(matrica_zarduino); code that convert matrix form real to integer type.
    
```

Conversion matrix to integer is necessary because method: **write(value, speed, wait)** can contain only integer data in it.

Matrix was copied from MATLAB and defined as matrix in Arduino IDE software with code:

```

int ub[41][14] = {
    {45, -90, -30, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
    {45, -90, -30, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1},
    ...
    {135, -108, 30, 60, 30, 180, 0, 0, 0, 0, 0, 0, 0, 0},
    0};
    
```

Then for every motor variable was created with code: **VarSpeedServo m1;**

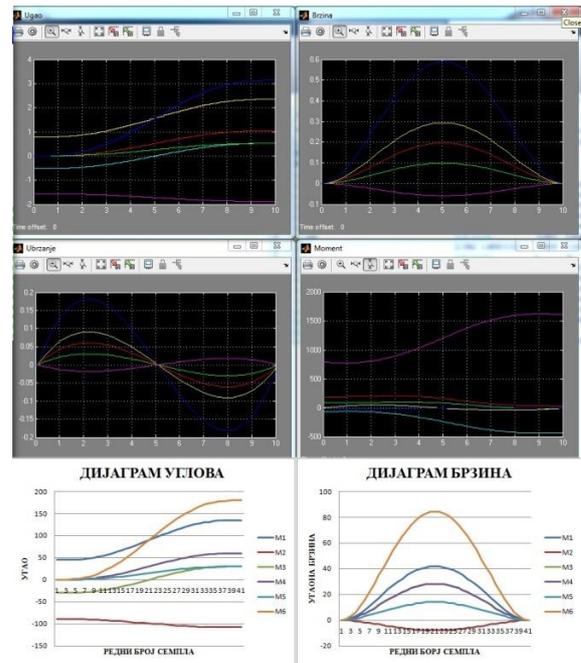
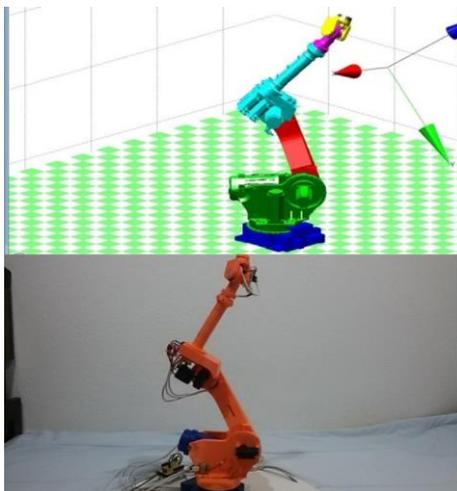
In *setup* function output pins are declared. Those pins are related with variable for each motor. Main loop implements function **matlabProgram()**. In this function the start position is defined as well as sequential movement through the matrix. By executing this function, the model of industrial robot moves as it has been defined in simulation.

This function is defined in such a way:

```
void matlabProgram()
{
  m1.write(45, 5, false);
  m2.write(90, 5, false);
  m3.write(60, 5, false);
  m4.write(180, 5, false);
  m5.write(0, 5, false);
  m6.write(180, 5, true);
  delay(2000);
  for (i = 0; i < 41; i++)
  {
    m1.write(ub[i][0], 1 + abs(ub[i][6]),
    false);
    m2.write(180 + ub[i][1], 1 +
    abs(ub[i][9]), false);
    m3.write(90 + ub[i][2], 1 +
    abs(ub[i][10]), false);
    m4.write(180 - ub[i][3], 1 +
    abs(ub[i][11]), false);
    m5.write(ub[i][4], 1 + abs(ub[i][12]),
    false);
    m6.write(180 - ub[i][7], 1 +
    abs(ub[i][13]), true);
    delay(45);
  }
}
```

Part of code **1 + abs(ub[i][12])** is integrated because method from *VarSpeedServo.h* library doesn't support negative speed, and speed cannot be zero.

Figure 5 shows movement simulation of industrial robot and movement of model made from MATLAB calculation with associated diagrams.



**Figure 5.** Simulation of movement of industrial robotic arm and movement of real model with angle, speed, acceleration diagram

#### 4. CONCLUSION

The paper presents the realization of educational model of industrial robot S-430iF. For realization of this model a lot of different oriented programs were used. MATLAB for simulation a kinematics calculation, SolidWorks for modification of 3D models. Those 3D models are made using Rapid Prototyping -3D printing. Arduino IDE software was used for microcontroller programming. All these programs and technologies are learning in the department of mechatronics. The realized robot model of industrial robot is used in the realization of laboratory exercises. The main idea is to make simulations in MATLAB with different parameters, every student should have his set of parameters, and when they make simulation they can implement it on real model. This can help them to understand kinematics and programming of industrial robots. Further step is to make proper teaching material which should contain examples based on this platform.

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# Application of Computer Simulation in Engineering Education

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**Abstract:** *Today it has become a widespread practice to use computer-based tools to enhance learning. Use of computer simulation in higher education is growing rapidly and has become a major trend in technical education because teaching of technical subjects is a very complicate and complex process and it is demand on logical thinking and imagination. This paper presents the application of interactive computer simulation tools Energy2D and Energy3D in the technical education process. Energy2D covers many topics in the science of heat transfer and its engineering applications. Energy-efficient building design challenges are used as the engineering examples to illustrate the learning and teaching opportunities created by the modeling, simulation, and data mining capabilities of the Energy3D software. The proposed application help students to analyze and solve problems with relevant knowledge and enhance their practical abilities.*

**Keywords:** *computer simulation, technical education, 2D/3D simulations of heat energy, flow and solar radiation*

## 1. INTRODUCTION

Learning involves acquiring and retaining new information, concepts, or skills. Students learn in various ways. Simulation is a very general and flexible teaching approach that can be used in most disciplines. The computer simulation has a high potential to influence learning in technical science [1]. The use of simulations in science education can make significant contributions by providing appropriate learning opportunities to diverse learners and motivating students to learn science, both inside and outside of the school environment. Due to an increase in computational power and improvement of software designs, computer systems can imitate situations of great complexity and provide a high level of interactivity.

There are many prerequisites strongly influence learning achievements. The main are that the choice of the simulation software has to closely match the interests and abilities of the students, and that the simulation tools have to be user-friendly. On the one hand, the "fun" factor is not to be underestimated: if students like to play around with the tool, they also learn more. On the other hand, user-friendliness is required in order that students are efficient in their assignment work.

Teaching courses using simulation software have to be supported by suitable didactic concepts, which need to cover classroom activities as well as computer homework [2]. Simulations allow group cooperation, which is effective in generating new ideas, solving problems, and helping students learn

from each other. In contrast to using video material in teaching, the application of simulation tools is very close to real "hands-on" activities.

Simulations can motivate students of different learning abilities by enabling them to interact with a given task and work with problems that bring meaningful results. Simulations can reduce teachers' teaching times, provide opportunities for student discussion and interaction, and thus, increase communication and reduce both social and learning differences. During simulation sessions, the teacher acts in the role of a coach and students are actively pursuing their design projects [3]. Other advantages when using simulation software and modern ICT technology for teaching are:

- Is applicable to students of all levels and ages
- Students are activated. They have to take responsibility, make decisions and organize their work.
- Trainees can pick the topic that is relevant for them.
- Progress in the exercise is visible to the teacher during class and easily measurable after class.
- Helps students see complex relationships that would otherwise involve expensive equipment or dangerous experiments
- Exceptionally high motivation, in particular for in-service and screen sharing training.

Every discipline treats the conceptual structure of the simulation differently. Teaching of technical subjects is a very complicate and complex process. It demands a logical thinking and imagination. Using of illustrative examples of the real process is one of the ways how to make learning process simplify.

## 2. COMPUTER SIMULATION IN EDUCATION PROCESS

The complexity and diversity of problems and concepts make engineering education a challenge for many students. Today, with the advent of computers and various easily accessible software packages, computer aided teaching tools have become an essential part of both classroom lectures and laboratory experiments in any kind of engineering education curriculum. This interactive learning environment, consisting of simulations, demonstrations and exercises, can fulfill the role of a bridge from passive learning to active engagement and thus stimulate deeper thinking, grounding a problem based-learning environment. The applications are also very important for relating theory to practice, so that the students can develop engineering judgment and understand how process behavior 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.

A number of authors have suggested that simulations can have positive effects on student learning. Xueyi Li et.al [4] improved teaching effectiveness and proposed a novel teaching mode by applying simulation technology to a particular mechanical design course. Tajvidi & Fang [5] analyzed literature review focusing on computer simulation application and pedagogical innovations in engineering education. They concluded that interactive features, animation, and problem solving are the main characteristics of effective computer simulation application and in combination with typical face-to-face or online classes presented the most effectively educational tool. Camaj et al. [6] argued that the computer simulation of technical systems enables testing of alternative solutions, proposals and decision-making strategies with essentially lower costs in comparison with experiments on the real system, which are often even not feasible.

A "computer simulation" is supposed to accept inputs, incorporate those inputs into calculations or modeling, and present functional outputs. Compared to "computer animation", "computer simulation" is usually more calculation-oriented to characterize the real phenomenon of interest.

Instructors in most engineering lectures try to represent 2D and 3D motion through static diagrams and explanations. To date, numerous educational tools and methods have been developed by various researchers to improve student performance in education.

Engineering design course covers various contents, and most of them are complex theoretical knowledge. Many engineering disciplines are becoming increasingly digital, which means relying on an increasing number of digital tools. It is essential that students learn to use the same simulation programs during their time at university as they will be expected to use in the professional world, so that they can then bring those skills into their internships.

Computer-aided design (CAD) is one of the most fundamental changes brought by computer technology to engineering. CAD tools empower users to conceptualize products before making prototypes. In this paper application of an educational CAD tool called Energy2D and Energy3D in technical education is analyzed.

## 3. USE OF ENERGY2D AND ENERGY3D IN TECHNICAL EDUCATION

Dr Charles Xie, a physicist working at the Concord Consortium based in Concord, Massachusetts, USA created Energy2D in 2010 and is being actively developed by him and his team. The development of Energy 2D has recently slowed down as dr Xie is currently focused on developing Energy3D. Energy2D software is based on a unique semi-Lagrangian McCormack method, which is invented by dr Xie, that approximately solve the Navier-Stokes equation. Although this solver is not unconditionally stable, it is capable of simulating turbulent flows.

The models generate dynamic visualizations, so by running them the student can see the flow of energy in real time and generate time-series graphs of the temperature detected by any sensor they choose. They also execute quickly, which is key to maintaining student interest and making it possible to undertake many experiments and design modifications in a short time.

These software packages support open-ended, constructivist learning because they are all highly interactive and graphic. For instance, in Energy2D students can easily change the location, thickness, and thermal properties of the walls, add and remove heat sources, move the sun, and place temperature sensors anywhere [7].

Both Energy2D and Energy3D software are free to download and use.

### 3.1. Energy2D visual simulation program

Energy2D is a two-dimensional interactive heat transfer simulation program based on

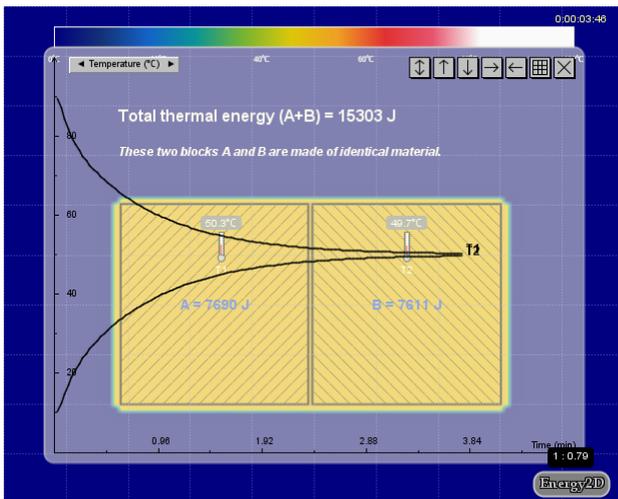
computational fluid dynamics. Students can use Energy2D as an inquiry tool to investigate heat flow and energy usage in 2D model systems [7].

Students can simplify and approximate 3D problems, that they encounter through technical teaching courses, by a 2D model that can be easily and quickly simulated in Energy2D.

Some of the models that comes with the software are presented further in this paper, but it should be noted that all models are changeable (initial temperatures and other parameters, resize or move objects) and students can also easily create new models from scratch on their own or interfere anytime while a simulation is already running. There are also graph options which can print temperature and anemometer sensor values. All sensor data can be exported in a table which is convenient for further use if needed.

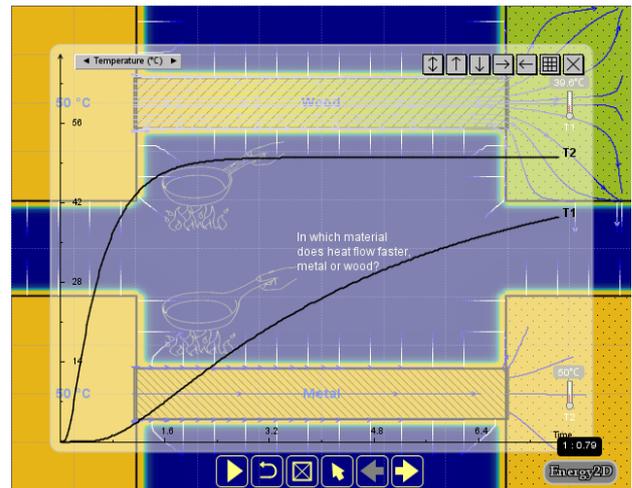
Overall, Energy2D is a great software which could supplement classroom instructions with visual learning experiences for students through visualizations of heat and temperature.

In this section, it is shown a set of examples for teaching courses of conduction and convection. There are also a radiation examples which will not be covered with this paper.



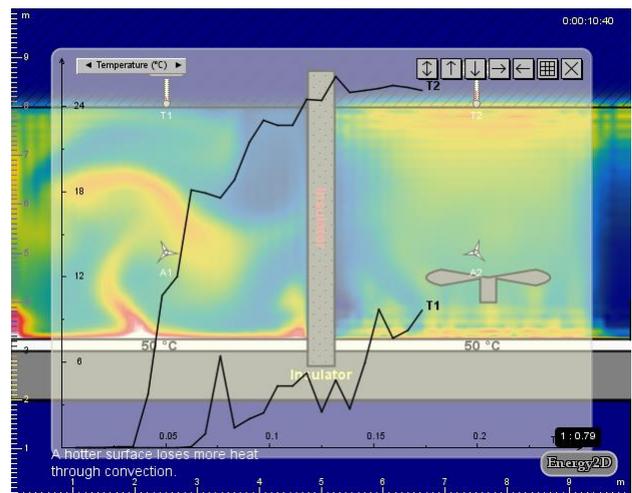
**Figure 1.** Simulation of the first and second law of thermodynamics

The Figure 1 represent the model of first and second law of thermodynamics, i.e. two blocks of same dimensions and material, joined together in an insulated system, causing heat transfer between each other. At the beginning of the test, block on the left had the higher temperature and energy than the block on the right. The sum of the total thermal energy of the blocks remains the same through entire test, and after certain time the temperature of the both blocks will approach the same value as shown on the graph of Figure 1.



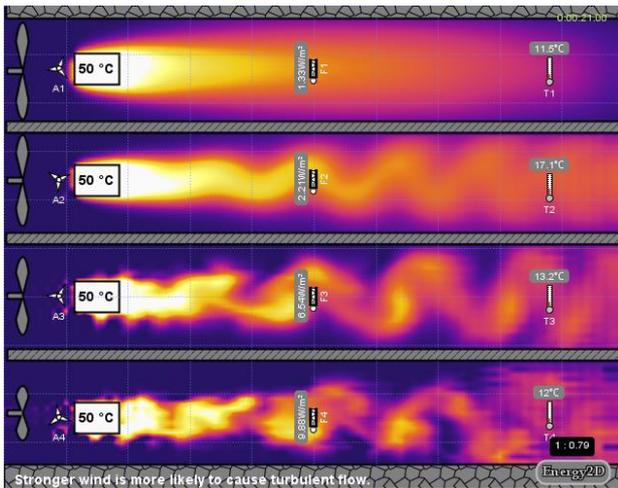
**Figure 2.** Simulation of the heat conduction through different materials

Since different materials have different heat conduction coefficients, heat transfer will take place at different speeds. At Figure 2, it can be seen that the heat travels faster through material with a higher conduction coefficient (e.g. metal) than through a material with a lower coefficient (e.g. wood) as can be seen in a graph.



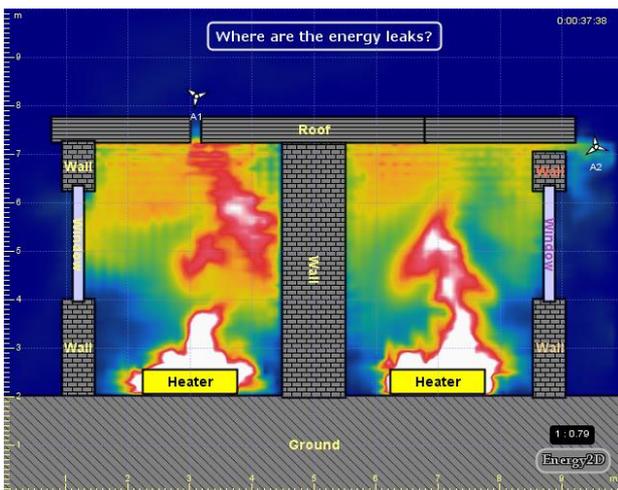
**Figure 3.** Simulation of the natural and forced convection

The Figure 3 shows the differences in natural and forced convection heat transfer at the same temperature source conditions. The left side shows natural and the right side shows the forced convection. It can be seen that the thermometers which are placed on the opposite material of the heat source shows different values of temperature.

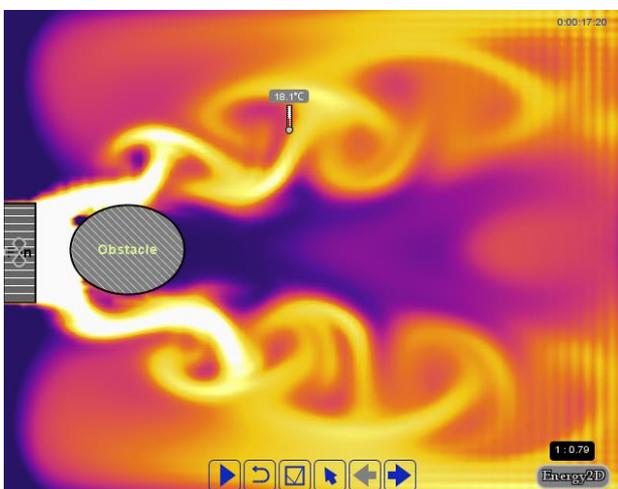


**Figure 4.** Simulation of forced convection with different wind speeds (higher speeds causing turbulent flows)

In Energy 2D, laminar and turbulent flows can be simulated. Figure 4 shows flows through the same chambers with increasing wind speeds in each chamber (from top to bottom), where it can be seen differences between each flow.



**Figure 5.** Simulation of air infiltration in a building with two leaks



**Figure 6.** Simulation of forced air flow around an obstacle

Energy losses through leaks are common problem in some applications. Two identical chambers in are shown in Figure 5 with the same heat source and different places of air leak.

### 3.2. Energy3D simulation program

Energy3D is a simulation-based engineering tool for designing green buildings and power stations that harness renewable energy to achieve sustainable development.

The program was written in the Java programming language with the goal to support the teaching and learning of engineering design. Two important features make Energy3D an appropriate tool for learning and teaching design. The first one is its intuitive interface for 3D modeling and its graphical representations of simulation results.

Students can sketch a structure or import existing form CAD file, place it in any day and location on a map like "Google Maps". Energy3D can add, combine, and modify standard elements to make a wide variety of designs.

To bridge the gap between the virtual and real worlds, Energy3D can deconstruct a 3D structure into 2D pieces and generate a layout of them for printing. Every piece is numbered and annotated to guide students to scale up to constructional materials such as cardstock or foam board. The entire deconstruction process is animated so that the user has an intuitive understanding of the relationship between the 3D representation of a house and its 2D pieces [8].

Based on computational physics and weather data, solar irradiance heat map can be evaluated. Solar irradiance heat map visualizes the distribution of solar radiation on surfaces on a daily basis which can be used for the solar energy potential analysis.

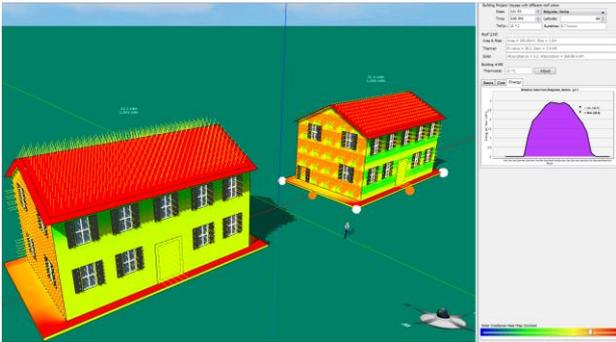
Both photovoltaic and concentrated solar power station can be designed, simulated, analyzed and optimized in Energy3D [7].

Energy3D offers integrated tutorials for students with models for understanding solar energy and other energy applications which is will not be show in this paper due to simplicity, and only some of the models integrated in Energy3D will be further presented in this paper.

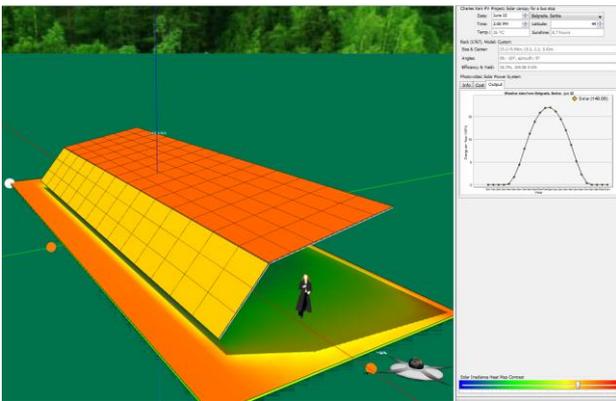
Solarize Your World is based on Energy3D software, a CAD tool anyone can use to design any type of solar power system in cyberspace and calculate its hourly, daily, or yearly outputs based on numerical simulation from first principles. With weather data of over 600 regions in 190 countries, Energy3D can produce satisfactory results for most parts of the inhabited world, enabling millions to work on local projects.

A simulation of solar irradiance map of two same houses with different roof colors for a location in Belgrade is shown in Figure 7. Simulation can be run for any day of year. Then, students can compare energy needed for cooling in the summer

and energy needed for heating in the winter (e.g. 1<sup>st</sup> July and 1<sup>st</sup> January) for both houses.

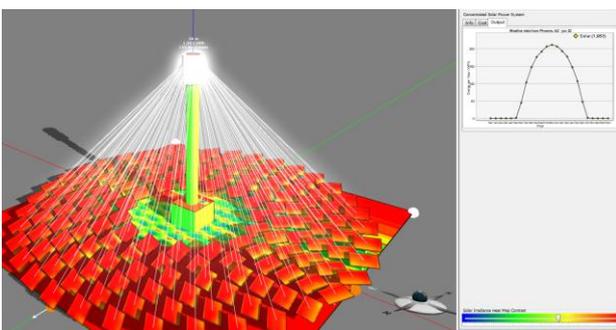


**Figure 7.** Solar irradiance map of two houses with different roof colors



**Figure 8.** Simulation of a solar canopy for a bus stop

Some of the software already designed examples of solar stations are shown in Figure 8 and Figure 9. Figure 8 shows a photovoltaic solar power station on a bus stop for a Belgrade location and sun conditions for the 1<sup>st</sup> July. Software allows students to design photovoltaic systems from scratch and to change dimensions, angles and orientation of panels, conditions, locations, etc.



**Figure 9.** Concentrated solar power tower

A concentrated solar power tower for a Phoenix Arizona location is shown in a Figure 9. Software can show absorbed solar potential energy in a graph or it can be exported as raw data. Additionally, software can project build and maintenance costs through 50 years of use.

#### 4. CONCLUSIONS

In the past decades the context of engineering education has changed dramatically. Because of the complexity of concepts, engineering education courses are suitable courses for using computer simulation techniques as pedagogical tools. Comparing the traditional teaching mode with teaching mode based on simulation technology can compensate for the limitations of the traditional mode and consequently improve teaching quality.

In this paper application of an educational tools Energy2D and Energy3D in technical education is analyzed. The most important advantages of these computer simulation in education are interactive feature, fostering students' visualization, and enhancing their problem-solving process. It is suggested that computer simulation in education cannot be considered as a stand-alone pedagogical resource since they cannot replace conventional classroom instructions, but it can make learning and understanding for students a whole lot easier and quicker.

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# Design of 3D Virtual Classroom in Second Life for Metal Cutting Technology Course

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**Abstract:** *The paper describes possibility of using 3D virtual classroom in Metal cutting technology at the Technical College Cacak. The classroom is designed with aim to overcome common problems at laboratory classes, such as lack of time to work with real 3D models. Virtual worlds such as Second Life enable upgrading the reality and development of 3D models within virtual classroom. The 3D classroom will be used to allow students to access the high quality 3D models of cutting tools in virtual world at any time.*

**Keywords:** *3D virtual classroom; 3D models; cutting tools; Second Life*

## 1. INTRODUCTION

The Metal cutting technology course provides elementary knowledge in the field of metal cutting. Through laboratory classes students gain practical knowledge that are necessary to successfully accomplish the course. Laboratory classes for machining cutting at the Technical College Cacak are performed in a mechanical laboratory, with a large number of different types of tools that are used in cutting processing. Over the years, the problem has been notice, that students don't have enough time to interact with presented cutting tools. The interaction is based on brief visual presentation, without further detailed study of the complex tool geometry.

On the other hand, use of virtual environments for distance learning and training shows significant growth in the recent years. The 3D worlds offer the ability to create complex, highly interactive simulations using in-world modeling and scripting tools [1]. Educators rapidly adapt these new technologies to their courses, since these tools solve several difficulties frequently associated with practical classes in engineering laboratories [2].

Second Life virtual world [3] is one of the most promising environments for teaching and learning. It enables large groups of students to interact with each other as well as within a three dimensional environment [4]. The Engineering Education Island that is dedicated to teaching engineering related subjects is introduced in [1]. Practical use of its additional functionality is also discussed. Preparation and implementation of Computer graphics course is described in [4]. Authors in detailed explained lesson implementation and evaluation in Sloodle environment, which presents

integration of Second Life and Moodle platform. Design of learning environments, called MecaTeam 3D, for mechanical engineering is described in [6]. It should help students improve their machining skills. However, to the best of our knowledge there are no descriptive case studies published on the use of Second Life in the fields of metal cutting technology education.

The main contribution of our current work is design and implementation of additional laboratory class in Second Life. Its main purpose will be to further introduce students with complex geometry of different metal cutting tools, and also to give them opportunity to learn at their own pace and time.

The rest of the paper is organized as follows: in section 2 (Uploading complex models to Second Life) we explain in detail how to upload complex models of metal cutting tools; in section 3 (Design of 3D classroom) we give overview of the main classroom elements and their purpose; in section 4 (Concept of one laboratory class in 3D classroom) we give explanation how first meeting in virtual laboratory will look like; and finally the section 5 provides the summary and future work.

## 2. UPLOADING COMPLEX MODELS TO SECOND LIFE

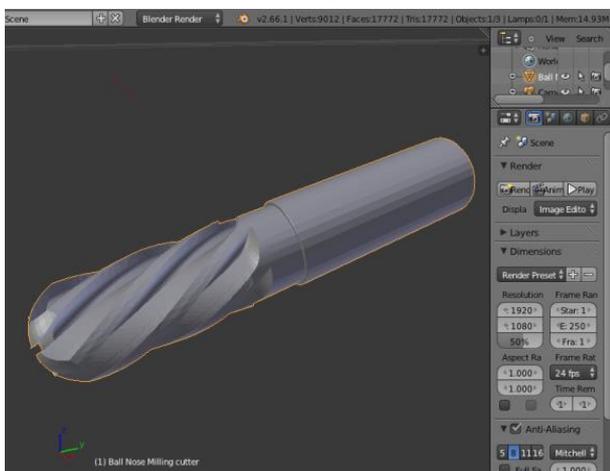
Second Life has user friendly and free 3D modeling tools that allow users to create basic 3D shapes called primitives. Those models can be resized, deformed or scaled and linked together to form, in some extent, complex 3D models. However, Second Life has limited capabilities for modeling objects with complex geometry. [7]. Due to this limitation, cutting tools that are very

complex consisting of large number of surfaces cannot be directly created or uploaded to Second Life.

The issue can be partly resolved, in two ways. Teachers can first develop models in some of the software packages for 3D modeling, such as SolidWorks, CATIA, etc. These tools achieve the highest degree of model fidelity. However, if teachers are not skilled in working with these software packages, they can join GrabCAD community, which is a place where engineers and designers from around the world share their CAD models [8]. GrabCAD library offers variety of complex models created in some of the CAD packages. Regardless of chosen method, it is only possible to upload models to Second Life if they consist of primitive shapes.

Blender application [9] turns out to be the best solution for resolving this issue. It is a professional free and open-source 3D computer graphics software product used for animated films, visual effects, art, 3D applications, etc. 3D modeling is one of the Blender's most important features.

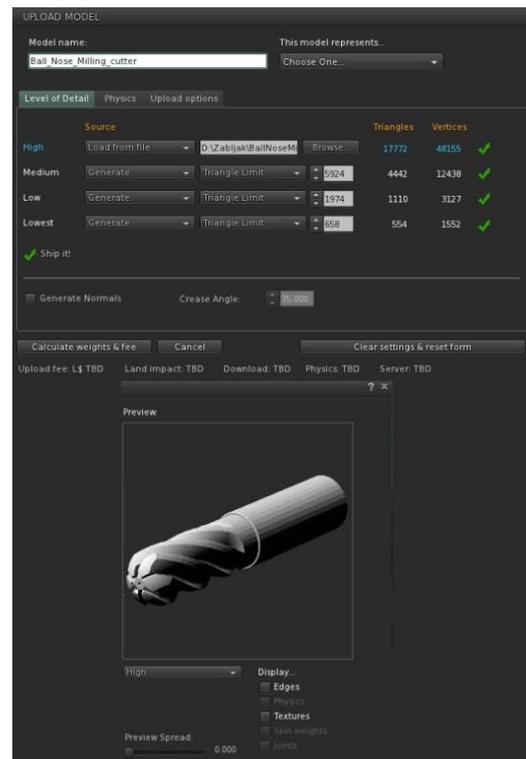
In order to import model into Blender, it needs to be in some of the following file formats: .stl, .3ds, .obj, etc, that are used as file formats for conversation between different 3D modeling software. To reduce number of triangles and vertices of the model, we used Blender's Decimate Modifier option [10]. It allows reducing with minimal shape changes (Fig. 1).



**Figure 1.** Model ball nose milling cutter in Blender program

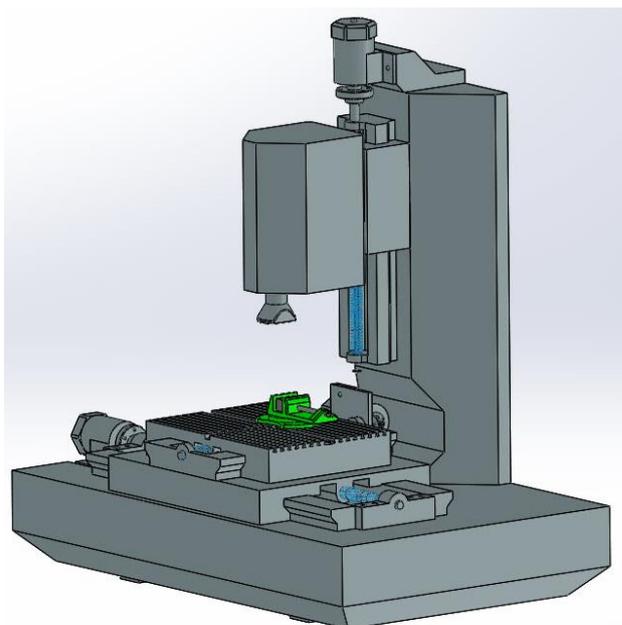
Define After preparation in Blender, process of uploading edited cutting tool model to Second Life requires several steps and adjustment of some important options (Fig. 2). In order to select Model with \*.dae extension teacher needs to go to Build menu that contains Upload option. Model's preview, with option for name and level of details, is presented in Upload dialog box. Card Level of Detail shows how many triangles and vertices does model have when it is in High, Medium, Low or Lowest level. Depending on the selected level,

preview of the model is changing. Edges or textures of the model can be seen with Display option.

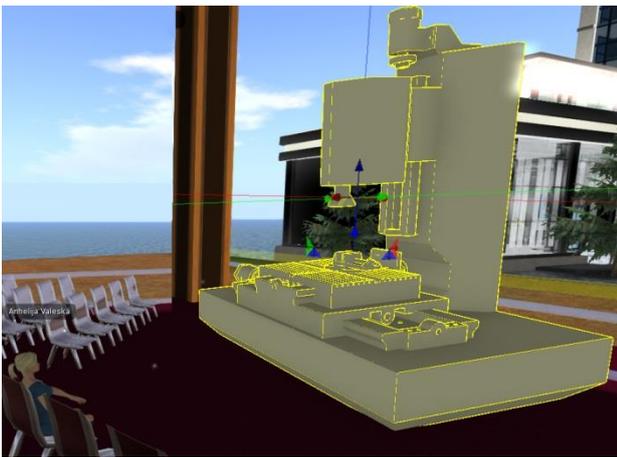


**Figure 2.** Uploading ball nose milling cutter model to Second Life

Besides cutting tools, the machine laboratory in Technical College Cacak contains different machines for metal cutting. 3D virtual classroom will also have 3D model of such machines. Fig. 3 shows milling machine in SolidWorks and Fig. 4 shows milling machine in Second Life.

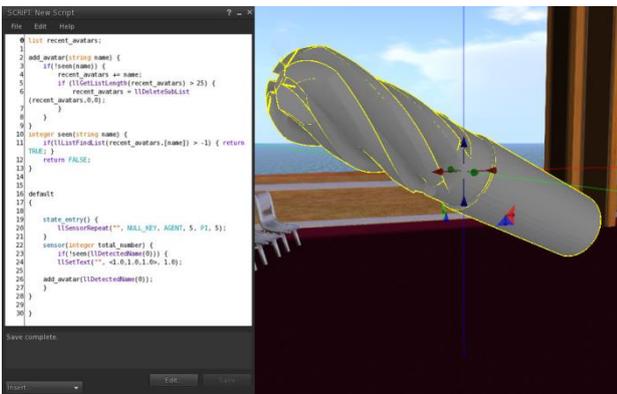


**Figure 3.** Milling machine in SolidWorks



**Figure 4.** Milling machine in Second Life

Uploaded model can be further modified in Second Life. Beside simple modification, such as changing size or color of model, Second Life offers complex modification such as adding interactivity to model through different programming scripts. The Linden Scripting Language (LSL) which is official Second Life programming language is used to add functionalities to cutting tool models. Fig. 5 presents LSL script that is used to give models' ability to rotate. When users approach, model will rotate, thus allowing users to observe it from different angles.



**Figure 5.** LSL script for rotation

### 3. DESIGN OF 3D CLASSROOM STRUCTURE

3D laboratory classroom is set within Second Life, and its organizational structure is based on users' activities that are grouped at particular 3D classroom floors. There are five floors and each one contains particular activities.

Registration Area is set at the first floor (Fig. 6). It has two main purposes. At the beginning it serves as gathering area before class starts. At the end of class visitors are expected to answer questions with the Choice tool.



**Figure 6.** First floor of 3D classroom

The Choice tool (Fig. 7) can be used as a polling device to collect visual display students' preferences. In our class, we predicted that users go through all five levels of 3D classroom, and then to return to the First level and give their answers to Choice tool in what extent they are satisfied with 3D classroom. We set Choice question "How do you like this type of laboratory class?", and add following options: "I like it, and I would like to have more classes like this", "I like it, but I prefer traditional mechanical laboratory" and "I don't like it". These options then are listed as different colored bars on which users could click. The 3D choice bars will immediately grow once students submit their choice. This tool will give us general overview of students' satisfaction with the presented 3D classroom. For more detailed analysis, we are preparing evaluation, which will be more complex and presented to students in near future.



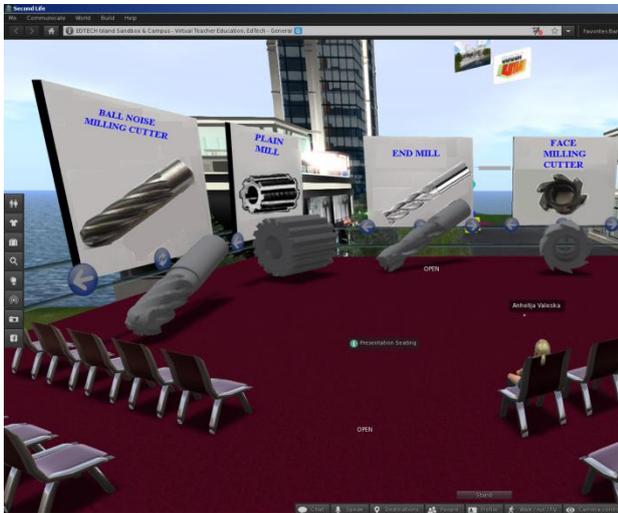
**Figure 7.** Choice tool at the first floor

Second floor is set as Presentation Area (Fig. 8). At this floor we placed different milling cutting tool models, such as ball nose milling cutter, end mill, face milling cutter, etc. When student approaches the model it begins to rotate, thus allowing student to observe it from all sides.

Above each model is placed presentation about that particular tool. We used Presenter slideshow

tool to set up presentations. Beside slide image, presentation can be video or a website.

Models that are placed on the second floor are used only for presentation purpose. Teacher can also share models from his inventory with students.



**Figure 8.** Second floor with cutting tools models and presentations

Meeting Area is set on the third floor of 3D classroom (Fig. 9). Here, teacher and students can discuss about cutting tools that they saw in Presentation Area. Also this area can be used for different sessions about some important issues, problems, etc. For the purpose of our class we placed in the center Milling machine surrounded by chairs.



**Figure 9.** Third floor of 3D classroom

At the fourth floor (Fig. 10) students will test their practical knowledge through solving particular assignments. Here, students will have different assignments to accomplish. For example, they will have to choose particular model that teacher assigned to them.



**Figure 10.** The fourth floor of 3D classroom

At the fifth floor students will test their knowledge about particular tools through quizzes (Fig. 11). Quiz chair is used for providing multiple-choice questions. In order to take quiz student has to place its avatar on quiz chair. When answer shows student can choose some of proposed options. If the student answers correctly, the quiz chair will rise half a meter, and if the student answers incorrectly, the quiz chair will descend.



**Figure 11.** The fifth floor with Quiz chair and Scoreboard

Beside quiz chair we placed Scoreboard tool, which displays points that user gained in quiz chair in order of highest to lowest. This will encourage users' competitive spirit.

Following section presents concept how one laboratory class in 3D classroom will look like.

#### 4. EXAMPLE OF ONE LABORATORY CLASS IN 3D CLASSROOM

At the mechanical laboratory at the Technical College Cacak students first see real milling tools, such as ball nose milling cutter, end mill, face milling cutter, etc. After the class, teacher arranges meeting in the 3D virtual classroom. Meeting is arranged in the particular time so that all students can participate. Prior to the meeting they need to have their avatars created. Each avatar presents in the Second Life. At the scheduled time, teacher meets students in the Registration Area, and explains them how 3D

classroom works. At the Presentation Area on the second floor teacher introduces students with every 3D model of milling tool that are presented in front of them, and that they already saw in the mechanical laboratory. They can start presentations that contain important theoretical information, such as what types of milling tools exist, different geometry of each tool, etc. Also, students learn how to observe tools from different positions. After detailed observation of presented tools, teacher guides students to the Meeting Area at the third floor. There they have comprehensive discussion about tool they have seen. Through teacher's guidance students make comparison between real models and virtual ones. In that way they improve their theoretical knowledge.

At the fourth floor where the practical assignments are placed teacher explains what kind of assignment students can take, but they do not do them at that meeting. They are left for the student to solve them in their own time and pace.

Unlike practical assessment, at the fifth floor students do quiz to see what theoretical knowledge they gained at that particular meeting.

At the end of the class in the virtual classroom, teacher leads students to the Registration Area where they fill questionnaire about that particular class. This feedback will help teacher to decide about further meetings.

It should be noted that this is how virtual class will look like each time a new topic is processed. After the first meeting students can come to 3D virtual classroom whenever they choose, and learn at their own pace.

## 5. CONCLUSION

Although students participating Metal cutting technology course at Technical College Cacak have laboratory classes in the mechanical laboratory, they have not enough time to interact with presented tools. On the other hand 3D virtual worlds offer ability to create complex, highly interactive 3D models that will provide students the opportunity to practice at their own time.

In this paper we have presented the following results:

- Referred to some related work of Second Life application regarding training with 3D models
- Explained in detail implementation of complex 3D models to Second Life
- Applied Linden Scripting Language to enhance models' interactivity thus allowing students to better understand 3D models
- Described 3D virtual classroom
- Gave concept of one laboratory class in 3D virtual classroom

The importance of proposed approach is reflected in providing student with opportunity to work with

complex 3D models that are often not available in real world practice. Future work will be related to conducting laboratory class in 3D virtual classroom and its evaluation.

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# Numerical Analysis of The Profile in the Aero Tunnel

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**Abstract:** Contemporary product and process development involves the application of various software tools and technologies. The assessment of aerodynamic characteristics is an essential part of the optimal aero profile design process. This paper presents a numerical analysis of the aero tunnel profiles using Catia and Ansys Fluent software packages, and obtaining an effective method of determining the aerodynamic characteristics of the profile, which is based on viscous-non-viscous interaction. Ansys Fluent software package provides a wide range of tools for efficient application in the design of aero profiles, which reduces the time and cost of developing aero profiles compared to the classic approach to the development of physical models. The paper presents the graphs of the obtained values of the field velocities and pressures of the tested profile in a modeled aero tunnel with given boundary conditions. Special attention is devoted to monitoring the pressure changes and the air flow velocity at an object in the aero tunnel.

**Keywords:** aerodynamic; aero tunnel; modeling; numerical analysis

## 1. INTRODUCTION

A computer design system is a set of software tools and technologies that provide engineers with a number of benefits while working on the development of product design. Computer modeling is based on geometric transformation. Continuing market demands, as well as market competition for new and cheaper products, have a direct impact on the faster development of computerized CAD (Computer Added Design) programs. On the other hand, CFD (Computational Fluid Dynamics) presents a branch of fluid mechanics in which numerical analysis and data structures are used to solve and analysis fluid flow problems. Modern three-dimensional (3D) software packages are used for modeling and simulating the interaction of liquids and gases with surfaces defined by boundary conditions.

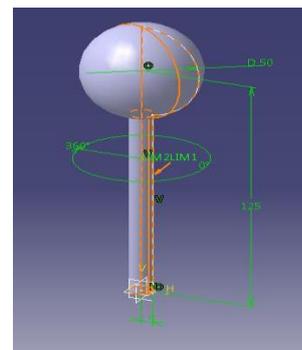
In this paper, a 3D analysis of the aerodynamics of the physical model in an aero tunnel is presented using a software package for numerical analysis of fluid dynamics. The simulation of the air flow in the aero tunnel and the aerodynamic characteristics of the given profile were performed. The procedure for 3D modeling of the object and aero tunnel is presented using the CATIA V5 software package and simulation of fluid flow through the aero tunnel, using the Ansys Fluent software package.

## 2. 3D MODELING AND CATIA V5 SOFTWARE PACKAGE

Nowadays modeling cannot be imagined without the use of modern CAD systems, which enable both 2D and 3D modeling of parts, production of circuits, generation of technical documentation, simulation of work and analysis of elements and systems. Previously developed software programs for 3D modeling can be divided into:

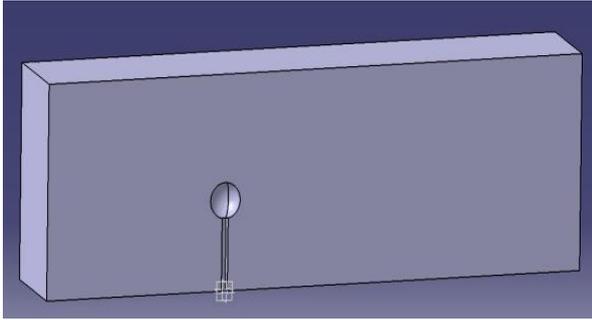
- Software programs for drawing contours and diagrams;
- Software programs for shell modeling;
- Software programs for modeling the shape of geometric bodies, machine parts and assemblies.

In the paper, the CATIA V5 software and its Part Design module, as well as Sketcher drawing module (Fig. 1), were used to create 3D models.



**Figure 1.** The tested profile modeled in the CATIA V5 software package

Fig. 2 shows the cross section of the formed aero tunnel with the profile set.



**Figure 2.** Cross section of the aero tunnel with profile

Volumetric modeling refers to the process of creating parts by combining volumetric objects to obtain a 3D model. Such models are based on 2D sketched profiles. Finished technical elements of type draft, fillet, chamfer or thickness are created by commanding the command over the existing geometry of the 3D model to create a more complex model, i.e. in order to carry out its upgrade, which is explained in more detail in [1].

CATIA V5 is a software program used in the automotive and aerospace industry. It represents an associative system that includes and connects all the stages and activities of the production company. The program's association and flexibility enable the implemented changes in the model to be reflected in all stages of product development, which increases the control of the implemented changes on the model and therefore becomes available to all members of the product development team.

Since these are very demanding graphical tools, it is necessary to use multi-core processors in order to achieve the proper process speed when creating virtual 3D models [1, 2, 3, 4].

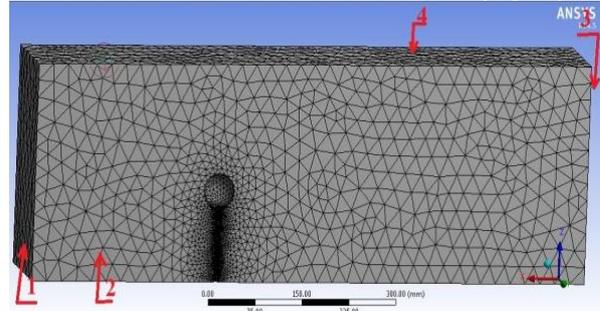
### 2.1. Simulation procedure and network generation

Modeling of the product prior to its use in order to meet the requirements for better, better quality, reliable and durable characteristics can be performed by simulations that evaluate the behavior and design of new products.

The Ansys software program contains CFD analysis that includes analytical areas, from aerodynamics, combustion, heat transfer, chemical reactions and many other areas where problems can be solved by numerical simulations of fluid mechanics. Ansys Fluent enables complete mesh flexibility, including the ability to solve flow problems using unstructured meshes that can be relatively easily developed into complex geometries. Ansys Fluent is a software program that is ideal for simulating compressible and

unstable fluids in complex geometries, including the use of alternative physical methods [5, 6].

After starting the ANSYS Workbench module, a start window opens where basic numerical simulations are selected in order to load the geometry of the aero tunnel from the CATIA software program. The next step is to start the ANSYS Meshing, where there are options for setting global mesh parameters, in this case the defaults-CFD and the Solver-Fluent list (Fig. 3).



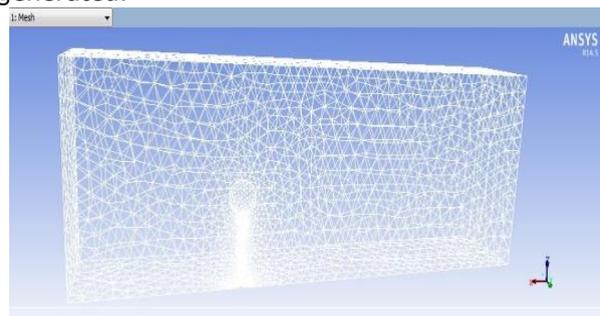
**Figure 3.** Generated mesh by the Tetrahedrons method with given boundary conditions

The model with the given boundary conditions is ready for numerical analysis in ANSYS Fluent.

The resulting network is the result of defined global parameters. Changing these parameters will result in a different meshing. In complex geometries, it is very difficult to obtain a high-quality mesh; therefore, the block-based approach to mesh forming provides the possibility of obtaining a better quality mesh by defining local parameters. In order to gain the best possible control of the mesh, it is necessary for each volume to define the method of generating the mesh [7].

### 3. STARTING ANSYS FLUENT MODULE

After the ANSYS Fluent module is started, the initial window opens in which basic numerical simulations are selected in order to load the generated mesh of the test aero tunnel, the File>Read>Mesh command (Fig. 4). After loading the mesh, there is a message about the number of nodes where it should be noted that there is no warning in the comments, as this is a sure indicator that the mesh has not been correctly generated.



**Figure 4.** Loaded generated mesh

The definition of a mathematical model should be done according to the type of fluid flow. The  $k$ - $\omega$  ( $2\text{ eqn}$ ) option is selected from the Model list and after that the corresponding fluid is assigned in this case it is air.

The boundary conditions set the parameters at the input and exit from the domain. At the input, the air flow velocity is set at 10 m/s; in the same way, set the specified values at the exit from the domain, while the boundary conditions on solid surfaces of the estimated domain are automatically assigned (Fig. 5) [8, 9].

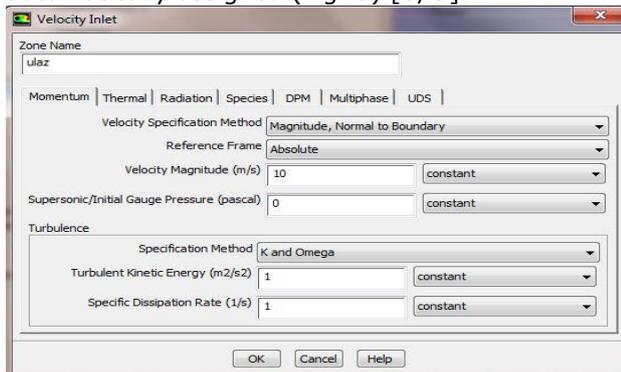


Figure 5. Setting boundary conditions

### 3.1. Setting up the initial solution-initializing the iterative process

In order to complete the simulation of fluid flow through the aero tunnel, it is necessary to set appropriate parameters through which the characteristics of the fluid flow can be controlled. By setting parameters for iterative monitoring, defining a surface monitor at the output, by setting up initial solutions, i.e. initialization comes to the start of the iterative process (Fig. 6).

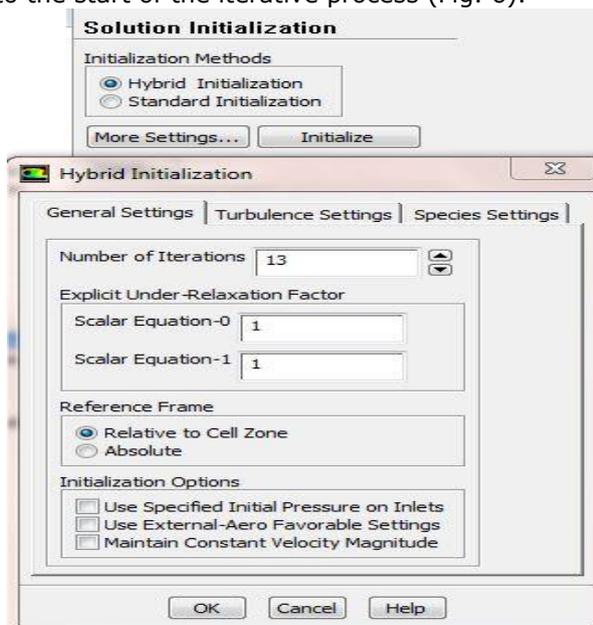


Figure 6. Initialization of the iterative process

Through the Run Calculation card, the number of the desired iteration is assigned, in this case 1000

iterations are selected, which gives a graphical representation of the flow of the iterative process (Fig. 7).

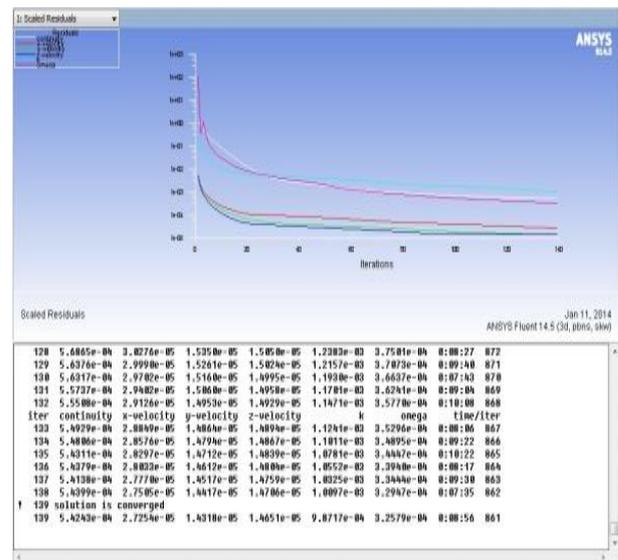


Figure 7. Graphical representation of the iterative process

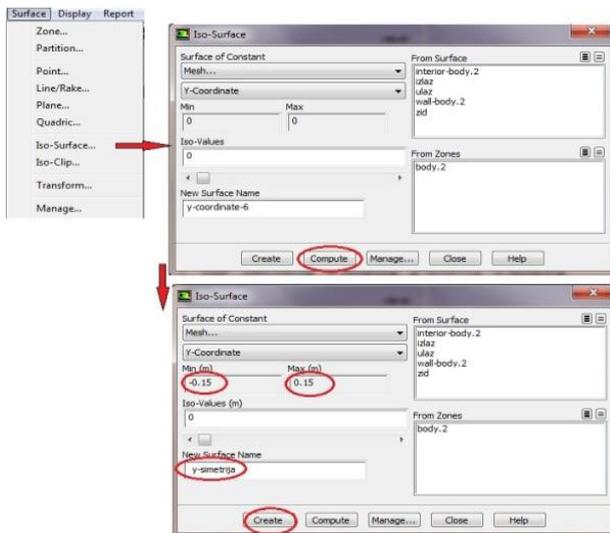
In Fig. 7 it is noticeable that the process converged on the 127th iteration for the entire model and the process lasted 2 minutes and 38 seconds. The process was done for half of the model where the solution converged on the 139th iteration, but the iteration process lasted 1 minute and 28 seconds.

The convergence process will stop when residuals reach a certain value or after a given number of iterations, in this case it is 1000 iterations. The exact number of iterations varies depending on which platform is being used, and a dialog with information is given that tells us about the convergence [10].

The point at which solutions are no longer changing with ever subsequent iteration is convergence. Convergence criteria, together with the reduction of residuals, also help in determining the complete simulation solution. Convergence criteria represent predefined conditions over residuals that indicate a certain level of convergence achieved [11].

### 3.2. Creating a level of symmetry for a full model tested in an aerotunnel

The free flow of fluid in the aero tunnel was obtained by the numerical domain, where the size of the domain analysis was made for the full profile of the aero tunnel in accordance with the recommendations [12]. In solving the problem, the analysis was compared to the plane of symmetry, since the software package provides this approach. A symmetrical plane for the full model was formed according to Fig. 8.



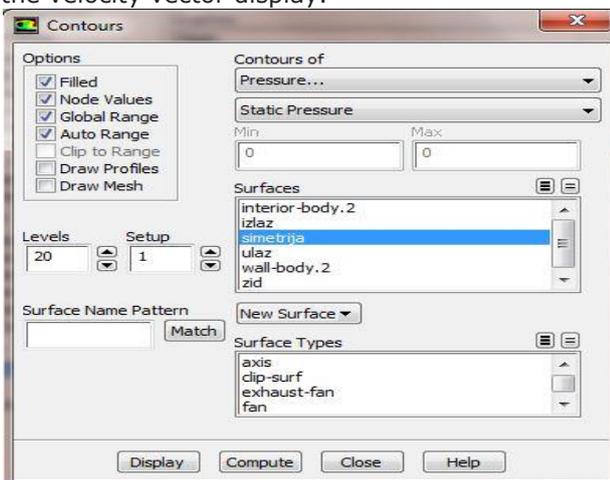
**Figure 8.** A procedure for forming a symmetric plane for a full model of aeroprofile

The input speed is given as a boundary condition, defined at 10 m/s, on one side of the domain, while on the other side of the domain a pressure limit (0 Pa) is used.

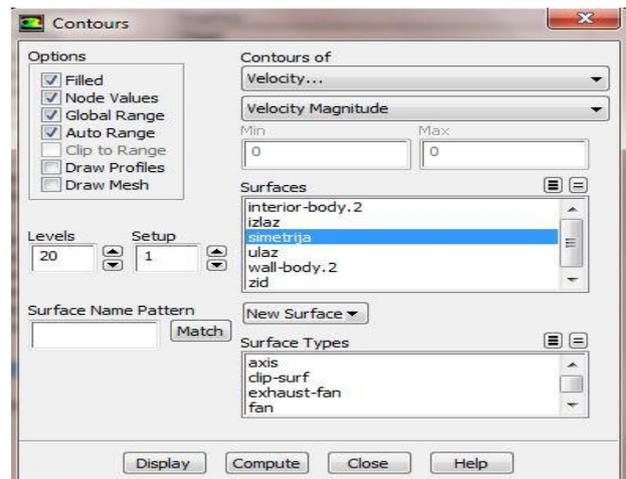
The air density during the analysis was 1.225 kg/m<sup>3</sup>, dynamic viscosity 1.7965 E-5 kg/(ms) and ambient pressure 101325 Pa.

**3.3. Analysis of results**

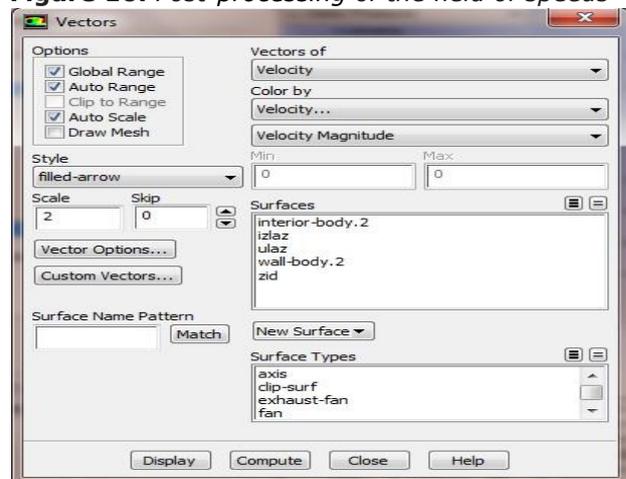
Post-processing of results in ANSYS-it is scored through the Graphics and Animations tab>Contours; Vectors>Set Up (Fig. 9, 10 and 11) to display the speed field, the pressure field, and the velocity vector display.



**Figure 9.** Post-processing of the pressure field



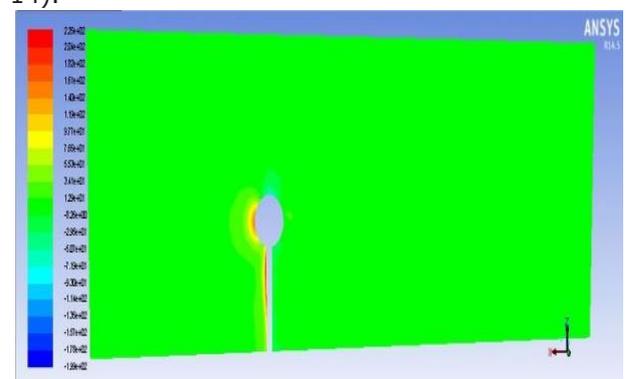
**Figure 10.** Post-processing of the field of speeds



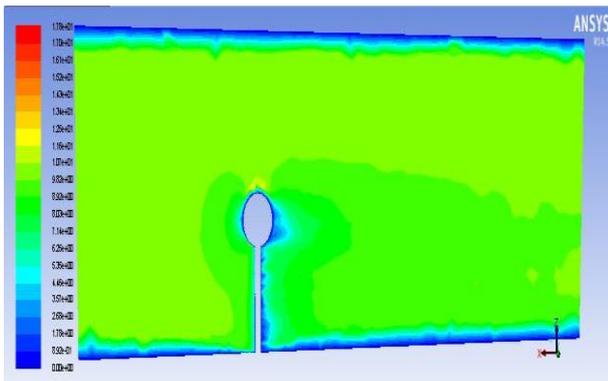
**Figure 11.** Post-processing of the vector velocity display

Post-processing (analysis of results) gives us an insight into the modeling of the desired process with calculated values.

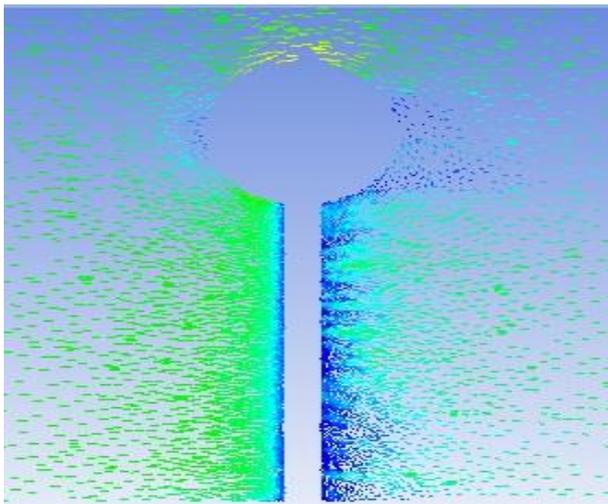
In the second part of the analysis, the results of simulation of the speed and pressure for the analyzed profile were obtained (Fig. 12, 13 and 14).



**Figure 12.** Display of the pressure field for the whole model in the aero tunnel



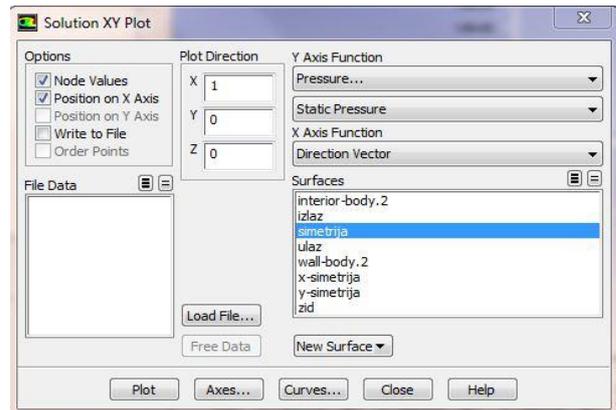
**Figure 13.** Display the velocity field for the entire model in the aero tunnel



**Figure 14.** Vector display of speeds for the entire model of the tested profile in the aero tunnel

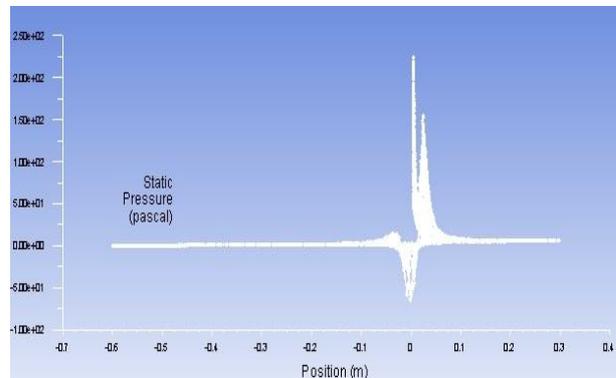
In figures 12, 13 and 14, the obtained values of the tested model of the profile in the aero tunnel are presented, where the pressure and velocity fields are clearly formed in relation to the given boundary conditions. Obviously, the software provides great opportunities in the profile construction itself to get the proper aerodynamic characteristics of the profile being tested.

By setting all of the steps presented, the conditions for diagramming the flow parameters are created. The Plot card is used for diagrammatic pressure display, and through it in the Options list activates Node Values and Position on X Axis. In the Plot Direction list for box X, number 1 is selected, then for field Y number 0. From the drop-down list Y Axis Function, Pressure was selected and then Static Pressure. From the X Axis Function drop-down list, Direction Vector was selected, and in the Surfaces field, symmetry was selected and finally the Plot command was activated (Fig. 15).



**Figure 15.** Plot card adjustment procedure for displaying the pressure diagram

After setting the parameters and activating the Plot card, a diagram pressure display is obtained (Fig. 16).



**Figure 16.** Diagram display of the pressure made for the whole model of the profile examined in the aero tunnel

This way of analysis gives a great advantage in the testing and simulation of the flow of the process itself [13, 14, 15].

#### 4. CONCLUSION

Modeling the process as well as interpreting the results of modeling and simulation help in analysis and setting the conditions for applying to real processes. Numerical simulation provides a detailed analysis of simulation results, so that based on the analysis, corrective measures can be proposed, optimized project solutions as well as identification of process influencing parameters. Optimizing the design solution through numerical simulations greatly influences the reduction of the cost of testing and construction.

The results of the simulation of the aero tunnel profile obtained in this paper provide an insight into the characteristics of the movement of the speed parameters and the pressure of the fluid flow in the aero tunnel.

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# Health Care Analysis Using Statistics

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**Abstract:** *In this paper, the data of a total of 215 patients with nine registered variables were processed. By applying appropriate statistical analysis, it has been found that variables within the groups do not have a normal distribution. Therefore, nonparametric analytical techniques were used. The results showed that the amount of consumed alcoholic beverages per day depends on the sex and that the mean value of the rank of this mark is higher in the male gender. Furthermore, tests have shown that marital status and the number of consumed caffeine drinks per day are dependent variable. The dependence of the marital status and the number of hours of sleep on weekends has been established. The paper also examines the correlation between some variables. The tests showed the existence of a negative correlation between the variables of the level of education and the number of cigarette smokers per day. The obtained results indicate that the level of education affects smoking behavior, which means that the prevention program should be the most intensive in the secondary school.*

**Keywords:** *statistics; health care; nonparametric techniques; hypothesis testing.*

## 1. INTRODUCTION

Over the past decades, a great increase in the use of statistical methods has been documented for a wide range of medical journals, [1]. Developing new practice and improving care of patients is primary goal of health care research, [2]. Since the appearance of individual cases may show smaller or larger deviations from the average or typical, it is necessary to observe in large numbers, in mass, to reveal what is in their general and legal, [3]. Hypothesis testing is prevalent in quantitative research in the field of health care, [4]. Results of testing depend on: how participants are selected and treated; process of data measurement; elimination or reduction of bias; planning a visit; expectations of patients and researchers; treating unwanted events; problem management, [5]. When assumptions of parametric data are violated nonparametric test are used, and they can be used to analyse alcohol consumption directly using the categories, but results tend to be more conservative than parametric tests, [6, 7].

Since youth is increasingly prone to bad habits, at the early age, disadvantages of such habits should be pointed out through prevention programs.

The aim of the research is to determine the possible existence of relationships between individual random variables, as well as their intensity.

## 2. RESEARCH METHODOLOGY

In this paper, nonparametric techniques are represented as research methods, because the

data don't have a normal distribution within the observed groups. The following techniques have been used:  $\chi^2$  independence test, Mann-Whitney U test, Kruskal-Wallis test, and Spearman's correlation.

The data on which the analysis was performed are used at the Medical Faculty in Kragujevac, within the course Medical Statistics and Informatics. The analysis used a sample of 215 patients, with the following variables being registered: sex, marital status, education level, smoker, number of cigarettes per day, number of alcoholic beverages per day, number of caffeinated beverages per day, number of hours of sleep in working days and number of hours of sleep on the weekends. Data was processed using statistical program SPSS.

## 3. $\chi^2$ INDEPENDENCE TEST

$\chi^2$  test of independence is used to test the independence of two categorical variables. We are testing the null hypothesis  $H_0$ : Sex and smoking behavior are independent variables, against the alternative hypothesis that it is not so. If the value of the test statistic or significance given in the Asymp.Sig. (2-sided) column is greater than the significance threshold (0.05), we have no reason to reject the null hypothesis and decide that these two features are independent, that is, the result is significant with the threshold significance of 0.05, or 95% confidence level. Otherwise, we reject the null hypothesis, our result is not significant and we decide that the observed features are dependent.

In Table 1, we can see that 12.7% of women are smokers and 87.3% are not. In men, 13.5% are smokers, while 86.5% are not smokers.

**Table 1.** Cross-tabulation of variables sex and smoker/non-smoker

			Smoker		Total
			Yes	No	
Sex female	Count		16	110	126
	% within sex		12.7%	87.3%	100%
	% within Smoker		57.1%	58.8%	58.6%
	% of Total		7.4%	51.2%	58.6%
male	Count		12	77	89
	% within sex		13.5%	86.5%	100%
	% within Smoker		42.9%	41.2%	41.4%
	% of Total		5.6%	35.8%	41.4%
Total	Count		28	187	215
	% within sex		13%	87%	100%
	% within Smoker		100%	100%	100%
	% of Total		13%	87%	100%

Since we have a 2x2 table, we read the value of Continuity Correction (Yates Correction). The corrected value is 0.000 with a significant of 1.00 > 0.05, so we can conclude that our result is significant (Table 2). Therefore, we accept the null hypothesis that sex and smoking behavior are an independent variable.

**Table 2.** The results of  $\chi^2$  independence test of variables sex and smoking behavior

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (1-sided)	
Pearson Chi-Square	0.028 <sup>a</sup>	1	.866		
Continuity Correction	.000	1	1.000		
Likelihood Ratio	.028	1	.866		
Fisher's Exact Test					
Linear-by-Linear Association	.028	1	.867	1.000	.511
N of Valid Cases	215				
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 11.59.					
b. Computed only for a 2x2 table.					

#### 4. MAAN-WHITNEY U TEST

Mann-Whitney U test is a nonparametric alternative to the t-test of independent samples. The Mann-Whitney test compares the median group that converts to ranks, so the distribution is not relevant. If the values differ from each other, then in one group there will be higher ranks, and in the other smaller.

We tested the hypothesis of the equality of medial values in the sexes for each of the following variables, in particular: the number of caffeinated drinks per day, the number of hours of sleep per working days, the number of hours of sleep on weekends. In all cases, we obtained Asymp.Sig. (2-sided) > 0.05, indicating that we should accept the null hypothesis, that is, we consider that the median of observed observations is the same (there is no statistically significant difference between the median of observed variables in women and in men, at a confidence level of 95%).

In Table 3, a nonparametric Mann-Whitney report is presented with a different conclusion. We test the hypothesis that the medial values of the variable - the number of alcoholic drinks per day in men and women, are different. For more than 30 elements in the sample, SPSS calculates the amount of z-approximation, which is now a continuous random variable, while the variable - the number of alcohol beverages per day was discrete random variable. This approximation also includes correction due to the interconnection between the data. The first table Ranks displays descriptive group information, the mean rank (mean rank gender has a higher rank that corresponds to a higher value on an uninterrupted scale of a new variable), and sum of ranks.

In the second table, the z-approximation test statistics is -2.482 with a significance level of  $p = 0.013 < 0.05$ , which means that the result is not statistically significant and we reject the null hypothesis. Medial values of the variable - the number of alcohol beverages per day, in men and women are different, [8].

**Table 3.** Report from SPSS for Mann-Whitney U test for the variable: number of alcoholic drinks per day

Ranks	Sex	N	Mean Rank	Sum of Ranks
Number of alcoholic drinks per day	Female	126	99.67	12558.00
	Male	89	119.80	10662.00
	Total	215		
<b>Test statistics<sup>a</sup></b>				Number of alcoholic drinks per day
Mann-Whitney U				4557.000
Wilcoxon W				12558.000
Z				-2.482
Asymp. Sig. (2-tailed)				.013
a. Grouping Variable: Sex				

Median both groups (female and male sex) can be seen in Table 4.

**Table 4.** Median both groups (female and male sex)

Sex	N	Median
female	126	.1250
Male	89	1.0000
Total	215	1.0000

The size of the impact can be calculated using the following formula:  $r = z / \sqrt{N} = (-2.482) / \sqrt{215} = -0.169$ .

In this example,  $z = -2.482$ , and  $N = 215$ ,  $r$  is therefore 0.169. This would be considered as a very small influence on Koen's criterion ( $0.1 =$  small impact).

### 5. KRUSKAL-WALLIS TEST

The Kruskal-Wallis test is a nonparametric alternative to oneway anova, and is used to compare the results of three or more groups. Like all the nonparametric tests, the Kruskal-Wallis test is not as powerful as one-way anova.

We test the null hypothesis  $H_0$ : There is a difference in the number of drunk caffeinated drinks compared to marital status, against an alternative hypothesis that is not so (Table 5).

**Table 5.** SPSS report for Kruskal-Wallis test for the variable: number of caffeinated drinks per day

Ranks	Marital status	N	Mean Rank
Number of caffeinated drinks per day	Single	41	81.13
	Married	151	114.48
	Divorced	17	108.32
	Widowed	6	127.58
	Total	215	
<b>Test statistics<sup>a</sup></b>		Number of caffeinated drinks per day	
Chi-Square		10.185	
Df		3	
Asymp. Si		.017	
Kruskal Wallis Test			
Grouping Variable: Marital Status			

Median rankings show that most caffeinated drinks are consumed by respondents with marital status, widow.

Based on Table 5, we can see that the level of significance is less than 0.05, so we can conclude that the difference in the obtained values of the continuous variable between these four groups is significant, which means that we accept the null hypothesis.

We still do not know which groups differ statistically, so several subsequent Man-Vitney tests need to be done. In addition to all the pairs, it is necessary to do the Bonfferoni correction of alpha value (alpha value is divided by the number of planned tests  $0,05 / 6 = 0.008$ ).

Based on the analysis we concluded that the group of free and married group differ in the number of drunk caffeinated drinks during the day. The size of the impact is  $r = -3.102 / 14.66 = 0.211$ , which is at the boundary between small and medium impacts.

In this part we will carry out some more research using Kruskal-Wallis test.

We will test the null hypothesis  $H_0$ : There is a difference in the number of hours of sleep on weekends in relation to marital status, against an alternative hypothesis that there is no difference.

**Table 6.** SPSS report for Kruskal-Wallis test for the variable: number of hours of sleep/weekend

Ranks	Marital status	N	Mean Rank
Number of hours sleep on the weekends	Single	41	127.78
	Married	151	106.25
	Divorced	17	74.15
	Widowed	6	112.67
	Total	215	
<b>Test statistics<sup>a</sup></b>		Number of hours sleep on the weekends	
Chi-Square		10.008	
df		3	
Asymp. Sig.		.019	
Kruskal Wallis Test			
Grouping Variable: Marital Status			

Based on the results of the tests shown in Table 6, we conclude that there is a difference in the values of the tested markings, depending on the marital status, because the level of significance is less than 0.05. This means that we have no reason to reject the null hypothesis, with a significance threshold of 0.05.

We will additionally make a comparison of groups free and married, and a group married and divorced. For both comparisons, the level of significance is less than 0.05 ( $0.029; 0.036 < 0.05$ ), which indicates that there is a difference in the number of hours of sleep on weekends in relation to the indicated groups.

In the following part we carried out analyzes on the sub-sample of the observed sample, which included all cigarette smokers. This sub-sample is divided into groups depending on the level of education (Table 7).

**Table 7.** SPSS Report for Kruskal-Wallis test for variable: number of cigarettes per day

Ranks	Education level	N	Mean Rank
Number of hours sleep on the weekends	Primary school	3	94
	Secondary school	23	131.80
	Post secondary school	26	115.25
	Undergraduate degree	60	108.13
	Postgraduate degree	103	101.18
	Total	215	
<b>Test statistics<sup>a</sup></b>		Number of cigarettes per day	
Chi-Square	14.940		
df	4		
Asymp. Sig.	.005		
a. Kruskal Wallis Test			
a. Grouping Variable: Education level			

The significance level is  $0.005 < 0.05$ , so we can conclude that there is a statistically significant difference between the groups compared to the number of cigarettes smoked. We can determine which groups differ more or less differently from the Mann-Whitney U test (Figures 8, 9 and 10).

**Table 8.** SPSS report for Mann-Whitney test on the difference in ranking of variable secondary schools and undergraduate student in relation to the number of cigarettes per day

Ranks	Education level	N	Mean Rank	Sum of Ranks
Number of cigarettes per day	Secondary school	23	48.65	1119.0
	Undergraduate degree	60	39.45	2367.00
	Total	83		
<b>Test statistics<sup>a</sup></b>		Number of cigarettes per day		
Mann-Whitney U	537.000			
Wilcoxon W	2367.000			
Z	-2.261			
Asymp. Sig. (2-tailed)	.024			
a. Grouping Variable: Education level				

Based on the Table 8, by examining the mean values of the ranks, we can see that the variable-secondary school has a higher rank corresponding to the higher value of the continuous variables. Test statistics show a statistically significant difference between the number of cigarette smoking groups of high school and undergraduate student, and this number is significantly higher for the first group.

**Table 9.** SPSS Report for the Mann-Whitney test of the rank of variable secondary schools and postgraduate studies in relation to the number of cigarettes per day

Ranks	Education level	N	Mean Rank	Sum of Ranks
Number of cigarettes per day	Secondary school	23	78.26	1800.00
	Postgraduate degree	103	60.20	6201.00
	Total	126		
<b>Test statistics<sup>a</sup></b>		Number of cigarettes per day		
Mann-Whitney U	845.000			
Wilcoxon W	6201.000			
Z	-3.813			
Asymp. Sig. (2-tailed)	.000			
a. Grouping Variable: Education level				

In Table 9, we can see the results of the Man-Vitney test that showed that there is a difference between groups of secondary schools and postgraduate studies in the number of smoked cigars.

**Table 10.** SPSS report for Mann-Whitney test rank difference variables undergraduate and postgraduate studies in relation to the number of cigarettes per day

Ranks	Education level	N	Mean Rank	Sum of Ranks
Number of cigarettes per day	Undergraduate degree	26	71.65	1863.00
	Postgraduate degree	103	63.32	6522.00
	Total	129		
<b>Test statistics<sup>a</sup></b>		Number of cigarettes per day		
Mann-Whitney U	1166.000			
Wilcoxon W	6522.000			
Z	-2.016			
Asymp. Sig. (2-tailed)	.044			
a. Grouping Variable: Education level				

Also, the test statistic showed a statistically significant difference ( $0.044 < 0.05$ ) between undergraduate and postgraduate studies in relation to the number of cigarettes smoked, as shown in Table 10. In all of these above-mentioned results, the higher mean value of the rank means higher consumption of cigarettes.

## 6. SPEARMAN'S CORRELATION

“Correlation” as a popular term implies simply a relationship among events. It refers to a quantitative expression of the interrelationship, or association, namely a coefficient of correlation.

The level of association is measured by how tightly or loosely the (x,y) observations cluster about the line. Because this coefficient is standardized by dividing by the standard deviations, it lies in the range  $-1$  to  $+1$ , with 0 representing no relationship at all and  $\pm 1$  representing perfect predictability. A positive coefficient indicates that both variables tend to increase or decrease together, whereas with a negative coefficient, one tends to increase as the other decreases, [9].

**Table 11.** Spearman's correlation between the level of education and the number of cigarettes per day

Correlations		Education level	Number of cigarettes per day
Spearman's rho	Education level	Correlation Coefficient	1.000
		Sig. 2-tailed	.001
		N	215
	Number of cigarettes per day	Correlation Coefficient	-.220**
		Sig. 2-tailed	.001
		N	215

\*\*Correlation is significant at the 0.01 level (2-tailed)

Based on the results shown in Table 11, we can conclude that there is a negative correlation (small) between the level of education and the number of smoked cigarettes. The negative correlation indicates that with increasing the level of education reduces the number of smoked cigarettes.

## 7. CONCLUSION

The need for extensive statistical research in the field of health care will be inevitable in the future to monitor the negative health habits that affect the quality of life of the population in order to present a program of prevention.

When creating a prevention program, statistical analyzes should be performed on large sample and it is necessary to collect data with as many characteristics as possible in order to get more accurate information.

The results obtained showed that there was a difference in the number of alcoholic drinks between men and women. Single and married differ in the number of caffeinated drinks per day. The number of cigarettes smoked differs depending on the level of education, and with the increase in the level of education, the number of cigarettes smoked is reduced. Group of secondary school is predominant in the smoking intensity of groups of undergraduate students and postgraduate studies.

It is necessary, from the beginning of the primary school, that children should indicate the harmfulness of smoking in order to develop awareness of what is good and what is bad. A more intensive prevention plan should be implemented in secondary school.

In order to achieve a better prevention plan it is necessary to take more characteristics some of the following during the examination, e.g. financial situation, number of children as well as their age, number of family members, place of residence... Continuous and planned population testing is the key to improving the habits of the population.

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# Student Attitudes about Cheating in High Education

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**Abstract:** *This paper presents an attempt to obtain some insight into the phenomenon which all stakeholders in the process of education deal with. That phenomenon is definitely bad as for the acquisition of knowledge is concerned, but students from all over the world apply it through the process of their education. It is most pronounced in high education. Namely, we wanted to examine students what do they think about cheating in situations which cover several aspects of studying on high education institutions. A total number of 237 students from 11 study programs on four faculties were anonymously surveyed. Questionnaire with mostly closed questions was used for the survey. The results confirmed the situation which we are facing in the process of teaching – students do cheat. However, some of the results could be useful to professors to reduce the extent of cheating: (1) 40.08% of students ranked Pressure of high stakes test (one chance only) as the greatest reason to cheat; (2) 53.19% of students said that they would be less likely to cheat if the goal of a class is that they learn and master the material and they can retest if they haven't met that goal.*

**Keywords:** *survey; questionnaire; assessment scale; exam cheating; students*

## 1. INTRODUCTION

Cheating at faculties, although not new, is a raising problem both for the community and for the individual [1]. This problem is increasing with technology development. Term cheating at universities is recognized as academic dishonesty, with Internet plagiarism as one of the most common forms [2]. There are many other definitions of cheating and all of them include some variety of unethical behavior. In this regard, teachers tend to get new task-finding appropriate mechanisms for test cheating prevention.

According to Kaufman [3], "students are sacrificing their education for what they think are indicators of success" and they put sign equal between success and grade.

There are many reasons for test cheating and almost every student who cheats has its own. However, all the reasons for cheating could be integrated into one: environment and test give possibility for cheating [4].

With information technology development educational process got new dimensions. Teachers use many opportunities of learning management systems, online virtual environment, online communication and e-testing. With new opportunities for teaching and learning, new cheating methods appeared. Scott [5] identified

Internet as a major culprit for academic dishonesty. With technology development, students get possibility to use sophisticated methods as "bugs for cheating". Beside that "old" methods are still in use.

There are many related research which are dealing with test cheating, but with different purposes and goals. Tonković et al [1] surveyed 565 students from University of Zagreb. They examined the current and earlier behavior related to cheating, attitudes towards cheating, and the assessment of the unacceptability of certain forms of cheating, the adequacy of penalties, and situational (un)justification of cheating, with conscientiousness, as the dimension of personality, and socio-demographic characteristics of students. David [6] performed research about relation of cheating and personal values, self-esteem and mastery. Also, the same author examined frequency and type of cheating.

Blau and Eshet-Alkalai [7] examined the following research questions:

- comparing digital vs. non-digital cheating, plagiarism, fabrication, facilitation;
- most common and legitimate type of digital academic dishonesty;
- relation between the dishonesty pervasiveness and legitimacy.

Authors in [8] demonstrated how dishonest students cheat on the exams and what teachers can do to prevent this from happening. Some authors, like in [9] explored utility of an Internet Based Simulated Environment (IBSE) in eliciting and recording the behaviors of lying, cheating, and defiance.

Considering the fact that cheating is most prevalent at the college level [10], authors of this research wished to identify:

- Attitudes of students about cheating in general;
- The extent of the use of technology in the process of cheating;
- Reasons for cheating;
- Frequency of cheating and
- Relation between students' satisfaction with teaching and cheating.

The goal will be achieved through few tasks: creating questionnaire, choosing sample for research, conducting research, analyzing results.

The paper has following structure: Introduction section which includes related research, methodology, results and discussion and conclusion.

## 2. METHODOLOGY

During the summer semester of 2017/18, 237 students were anonymously surveyed. Questionnaire with mostly closed questions was used for the survey. The survey included students from four HEIs, whereas three were from Serbia (Faculty of Technical Sciences in Čačak; Faculty of Hotel Management and Tourism in Vrnjačka Banja – Both from University of Kragujevac; and Faculty of Biology in Belgrade from University of Belgrade) and one from Austria: FH Joanneum in Graz (University of Applied Sciences). Number of students by institution and by study program is presented in table 1.

The questionnaire consisted of 10 questions whereas one assessment scales with 5 statements; 3 were double choice questions; 3 were multiple choice questions; 1 was a ranking question and 1 was an open question. Thus, we could say that questionnaire was divided into 5 parts:

*Part one:*

- Three statements (presented in table 2) to which students responded with YES or NO and Agree or Disagree;

*Part two:*

- Three statements (presented in table 3) from which students chosen one from the given answers (or more in one case);

*Part three:*

- A question where students ranked 7 given reasons for cheating (listed in the next chapter) from 1 (the least reason to cheat) to 7 (the greatest reason to cheat);

*Part four:*

- Assessment scale with 5 statements related to quality of teaching where we examined the correlation with cheating. 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 five:*

- An open question where students could write down whether they have ever dealt with the consequences of cheating on the exam and if yes, which ones.

**Table 1.** The structure of the sample

HEI	Study program	Sem.	No. of stud.
Faculty of Technical Sciences, Čačak	Information technologies (IT)	4	41
	Entrepreneurial Management (EM)	4	12
	Engineering Management (IM)	4	21
	Technics and informatics (TI)	6	5
	Computer Engineering (CE)	6	4
<b>Total from FTN</b>			<b>83</b>
Faculty of Hotel Management and Tourism, Vrnjačka Banja	Hotel Management and Tourism	8	58
<b>Total from FHMT</b>			<b>58</b>
FH Joanneum, Graz	Production technology and organization (PTO)	2	16
	Sustainable food management (LEB)	2	30
<b>Total from FH Joanneum</b>			<b>46</b>
Faculty of Biology, Belgrade	Biology (B)	2	25
	Molecular Biology (MB)	2	17
	Ecology (E)	2	8
<b>Total from Faculty of Biology</b>			<b>50</b>
<b>GRAND TOTAL</b>			<b>237</b>

## 3. RESULTS AND DISCUSSION

Table 2 presents the answers of the surveyed students on questions in the first part of the survey. Numbers of Yes and No (Agree and Disagree) answers are presented, as well as their percentage values.

**Table 2.** Answers in the first part of the survey

Statement	Yes		No	
	No.	%	No.	%
1. Cheating on homework or a minor assignment is not as bad as cheating on a test or plagiarizing a paper.	198	83.54	39	16.46
2. I would be more likely to cheat on an assignment that I would consider "busy work", something that I won't need later, than on an assignment whose objectives I will need for other classes later.	170	71.73	67	28.27
3. I believe cheating is wrong.	169	71.31	68	28.69

The majority of students (71.31%) believe cheating is wrong. But, similar percent (71.73) would be more likely to cheat on an assignment that they consider "busy work", something that they won't need later, than on an assignment whose objectives they will need for other classes later. Also, they think in an even greater percent (83.54), that cheating on homework or a minor assignment is not as bad as cheating on a test or plagiarizing a paper.

Table 3 presents the answers of the surveyed students on questions in the second part of the survey. Number of answers for every given answer of the question is shown as well as its percentage.

As we can see, cheating on minor assignments is more present among students than cheating on major assignments – 26.58% of students never cheated on a major assignment while 18.57% never cheated on a minor assignment. Students cheat whenever they have a chance in 11.39% on a minor assignment and in 4.64% on a major one. There are more students who cheated once on a major assignment (20.25%) than who cheated once on a minor one (13.08%), but from the overall point of view, this also favors the assertion that students tend to cheat less on major assignments.

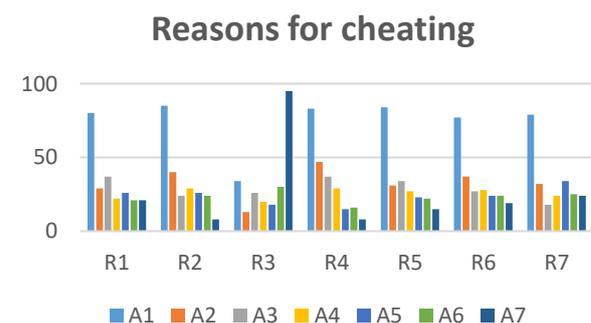
Interesting fact is that 47.68% of students have not used technology to cheat but have observed or know other students who have, while on the other hand, 42.62 used a cell phone, i-pod or tablet to look up information during a test and 10.55% gave or received information during a test through a cell phone. So, we can conclude that almost half of surveyed students have not used technology to cheat and the other half have used it.

**Table 3.** Answers in the second part of the survey

Question	Answer	
	No.	%
<b>4. I have cheated on a minor assignment (homework, classwork, small assignments) (1 answer only)</b>		
1. Never	44	18.57
2. Once	31	13.08
3. Two or three times	79	33.33
4. More than three times	56	23.63
5. Whenever I have a chance	27	11.39
<b>5. I have cheated on a major assignment (tests, projects, quizzes). (1 answer only)</b>		
1. Never	63	26.58
2. Once	48	20.25
3. Two or three times	73	30.80
4. More than three times	42	17.72
5. Whenever I have a chance	11	4.64
<b>6. I have used technology to cheat in the following ways (multiple answers possible)</b>		
1. Plagiarizing from the Internet.	32	13.50
2. Using a cell phone, i-pod or tablet to look up information during a test.	101	42.62
3. Giving or receiving information during a test through a cell phone.	25	10.55
4. I have not used technology to cheat but have observed or know other students who have.	113	47.68
5. Other	8	3.38

Figure 1 shows the rankings of the given reasons for cheating (third part of the survey). There were 7 reasons (marked with R1 to R7):

1. Pressure from parents to get good grades.
2. Pressure from teachers to do well.
3. Pressure of high stakes test (one chance only).
4. Pressure to do better than peers.
5. Threat of not being able to participate in sport or activity.
6. Threat of losing privileges like pocket money from parents.
7. Rewards offered for getting good grades like money or material things like i-pods, phones...



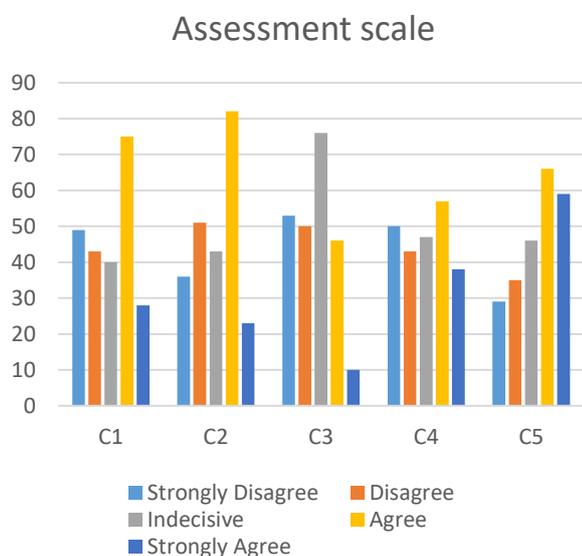
Interesting is that students ranked every reason, except the third, as the least reason to cheat. The third reason „*Pressure of high stakes test (one chance only)*”, was ranked as the greatest reason to cheat by 40.08% students. What we could conclude from this is that students would be less likely to cheat if there was another chance for every test and activity during the semester. Definitely the least good reason for cheating, by students' opinion were 2 and 4: „*Pressure from teachers to do well*” and „*Pressure to do better than peers*”.

Figure 2 shows the answers of the surveyed students on claims from the assessment scale (fourth part of the survey). Claims, which are all related to quality of teaching, are marked with C1 to C5 which correspond to:

1. I cheat more on exams that are not directly related to my future profession.
2. I cheat more on exams where I am not satisfied with the quality of teaching.
3. I cheat more on exams that have no pre-defined rules about all our obligations on the course.
4. I cheat more on exams where there are no serious sanctions if I'm discovered.
5. If the goal of a class is that I learn and master the material and I can retest if I haven't met that goal, I would be less likely to cheat.

Students mostly agree with all the claims except for the third one – they do not think that lack of pre-defined rules about their obligations on the course influences on cheating on exam (43% vs 23%). Also, greatest number of indecisive students was present on that question (76/235).

We obtained an interesting observation with claim 5. Namely, 53.19% of students (in contrast to 27.23%) agree that they would be less likely to cheat if the goal of a class is that they learn and master the material and they can retest if they haven't met that goal.



As for the fifth part of the survey is concerned, students mostly answered that they did not suffer any consequences of cheating on the exam. But they also wrote some interesting things such as:

- No, only indirectly: Because other students cheated and I didn't, my mark was below the average;
- No, because I do not cheat;
- Yes, I was thrown out of that exam;
- Yes, my cell phone was taken away;
- As far as the homework is concerned, I do not consider it to be a cheating because I learn when I copy. I do not care if I'm going to copy it from a notebook, from the Internet or from someone else – I'll definitely know what I have copied.

#### 4. CONCLUSION

Some general observations from this research are:

- 71.31% of students believe cheating is wrong;
- 71.73% of students would be more likely to cheat on an assignment that they consider "busy work", something that they won't need later, than on an assignment whose objectives they will need for other classes later;
- 83.54% of students think that cheating on homework or a minor assignment is not as bad as cheating on a test or plagiarizing a paper;
- 11.39% of students cheat whenever they have a chance on a minor assignment;
- 18.57% of students never cheated on a minor assignment;
- 4.64% of students cheat whenever they have a chance on a major assignment;
- 26.58% of students never cheated on a major assignment;
- 47.68% of students have not used technology to cheat;
- 53.17 used a cell phone, i-pod or tablet to look up information during a test and gave or received information during a test through a cell phone;
- 40.08% of students ranked *Pressure of high stakes test (one chance only)* as the greatest reason to cheat;
- 53.19% of students said that they would be less likely to cheat if the goal of a class is that they learn and master the material and they can retest if they haven't met that goal.

It turned out that cheating is a common phenomenon among students. But, according to the surveyed students, their attitude towards cheating is not positive since 71.31% of them believe cheating is wrong. Nevertheless, they do cheat but they distinguish minor and major

assignments as well as subjects they think they will use in their future career and the ones they will not. Also, it seems that they would not cheat if all the courses would have second chance for passing some of the content and if they would have an option to test themselves if they have met the goal of the class.

Presented findings suggest that academic dishonesty is an integral part of our education system. We can seek justification and say that educational system does not act in a vacuum but reflects wider social, political and economic processes. However, we saw that cheating could be reduced if professors would invest a little more effort and imagination in designing and conducting their courses.

In future research authors will broaden the sample and conduct various statistical analysis. Also, we will consider connection of cheating with gender, year of study, type of HEI (faculty or college), study program, the field which HEI belongs to, etc.

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