UNIVERSITY OF NOVI SAD
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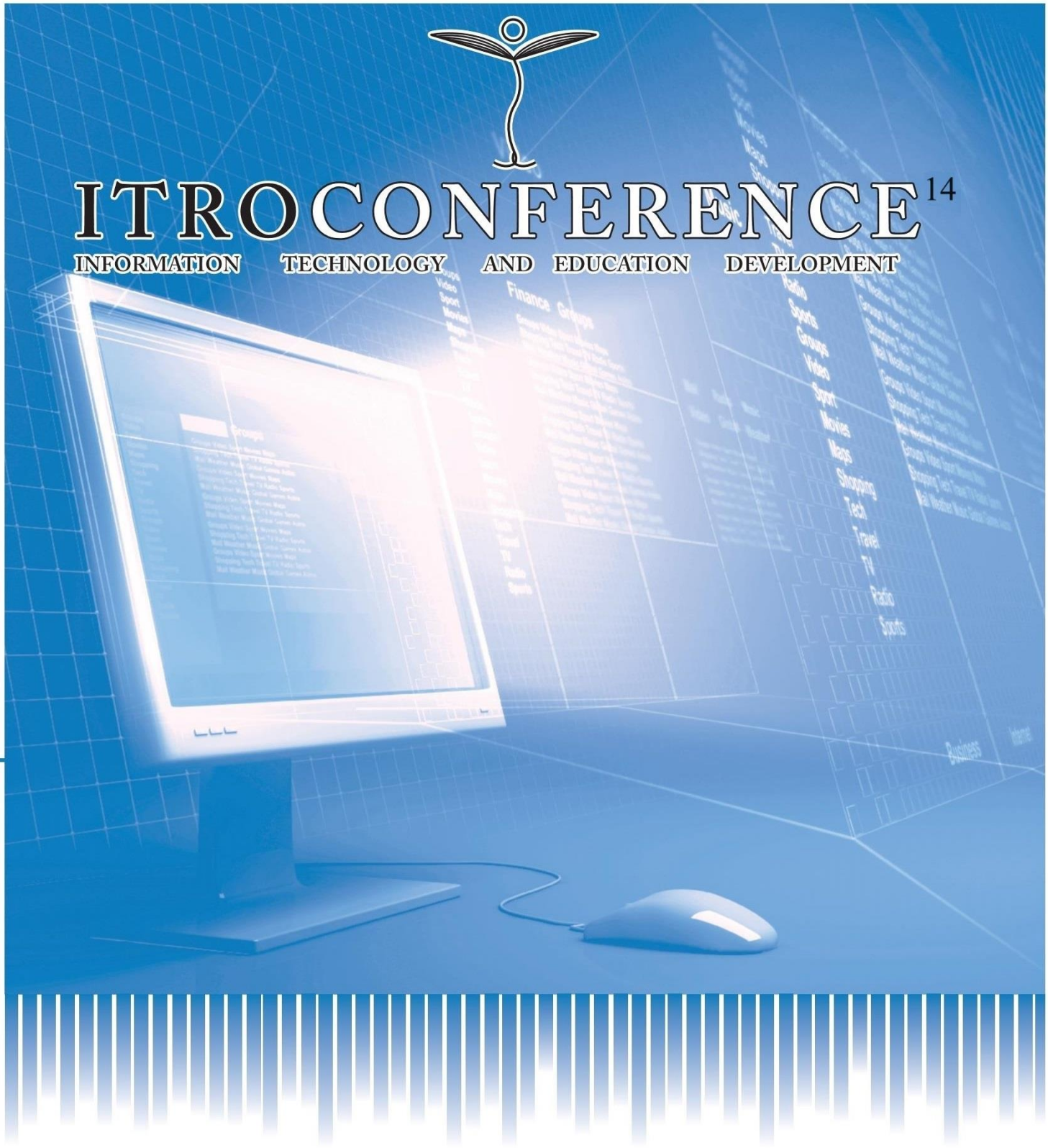
ITROCONFERENCE[14]

INFORMATION TECHNOLOGY AND EDUCATION DEVELOPMENT



PROCEEDINGS

ZRENJANIN, November 2023

UNIVERSITY OF NOVI SAD
TECHNICAL FACULTY "MIHAJLO PUPIN"
ZRENJANIN
REPUBLIC OF SERBIA

XIV INTERNATIONAL CONFERENCE OF

INFORMATION TECHNOLOGY AND DEVELOPMENT OF EDUCATION ITRO 2023

PROCEEDINGS OF PAPERS

XIV MEĐUNARODNA KONFERENCIJA

INFORMACIONE TEHNOLOGIJE I RAZVOJ OBRAZOVANJA ITRO 2023

ZBORNIK RADOVA

ZRENJANIN, NOVEMBER 2023

Publisher and Organiser of the Conference:
University of Novi Sad, Technical faculty „Mihajlo Pupin", Zrenjanin, Republic of Serbia

For publisher:
Milan Nikolić, Ph. D, Professor,
Dean of the Technical faculty „Mihajlo Pupin", Zrenjanin, Republic of Serbia

Editor in Cheaf - President of OC ITRO 2023:
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Circulation: **50**

ISBN: 978-86-7672-372-0

CIP - Каталогизација у публикацији
Библиотеке Матице српске, Нови Сад

37.01:004(082)(0.034.4)
37.02(082)

INTERNATIONAL Conference on Information Technology and Development of Education ITRO (14 ; 2023 ; Zrenjanin)
Proceedings of papers [Elektronski izvor] / XIV International Conference on Information Technology and Development of Education ITRO 2023 = Zbornik radova / XIV međunarodna konferencija Informacione tehnologije i razvoj obrazovanja ITRO 2023, Zrenjanin, November 2023. - Zrenjanin : Technical Faculty "Mihajlo Pupin", 2023. - 1 elektronski optički disk (CD-ROM) : tekst, ilustr. ; 12 cm

Sistemski zahtevi: Nisu navedeni. - Nasl. sa naslovnog ekrana. - Elektronska publikacija u formatu pdf opsega XI, 277 str. - Tiraž 50. - Bibliografija uz svaki rad.

ISBN 978-86-7672-372-0

a) Информациона технологија -- Образовање -- Зборници b) Образовна технологија -- Зборници

COBISS.SR-ID 143397129

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The Proceedings have been published in a digital format on the Faculty web site.

INTRODUCTION

International Conference on Information Technology and Education Development (ITRO) 2023, was held at the Technical Faculty "Mihajlo Pupin" for the fourteenth time. This year we have gathered our dear colleagues, scientists, researchers and students from several countries (Slovak Republic, Hungary, Macedonia, Bosnia and Herzegovina, India, Malaysia, USA and Serbia). They presented papers and promoted the results of research and scientific work in the field of information technology in education. The main course of the Conference was set up with some of the introductory lectures:

- "Challenges of the Technical Science Subject Teaching " held by Tünde Anna Kovács from Óbuda University, Bánki Donát Mechanical and Safety Engineering, Hungary;
- "VR Technologies in the Educational Process of Disabled People and in University Education On-line presentation" held by Csaba Szabó from Department of Computers and Informatics, Faculty of Electrical Engineering and Informatics, Technical University of Košice, Slovak Republic. Author and co-authors: Branislav Sobota, Štefan Korečko, Miriama Mattová, and Gabriel Stromp;
- "Analysis of Students' Academic Achievements in the Field of Mathematics and Computer Science" held by Gordana Jauševac from University of East Sarajevo/Faculty of Transport and Traffic Engineering, Doboj, Bosnia and Herzegovina. Author and co-authors: G. Jotanovic, G. Jausevac , D. Nedic, D. Mandic (from University of Belgrade/Faculty of Education), and D. Glusac (from University of Novi Sad/Technical faculty "Mihajlo Pupin", Zrenjanin);
- "Toward intelligent data analysis in higher education institutions" held by Nina Bijedić from Faculty of Information Technologies University Džemal Bijedić of Mostar, Mostar, Bosnia and Herzegovina. Author and co-authors: A. Joldić and D. Gašpar.

The other presented papers have cast light on various aspects of contemporary education in our country and abroad, such as: school without mobile phones, the phenomen of academic boredom, augmented reality learning environment, cloud technologies in education, etc. They addressed experiences, problems, questions, etc. in relation with information technologies and education development.

The conference was financially supported by the Provincial Secretariat for Higher Education and Scientific Research, Novi Sad. The Technical Faculty “Mihajlo Pupin” has provided the necessary technical support.

The ITRO Organizing Committee would like to thank to the authors of articles, reviewers and participants in the Conference who have contributed to its tradition and successful realization.

See you at the next ITRO Conference,

Chairman of the Organizing Committee
PhD Vesna Makitan

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INVITED

LECTURE

Challenges of the Technical Science Subject Teaching

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Abstract. The teachers and students are working together in the training process. Introduce information, manage the process of solving cognitive problems, and organize the student's practical training. The teaching of technical subjects is a challenge because of the complexity of the subjects. Also in the case of the technical subject, the teacher surmises the knowledge of the technical subjects such as mathematics, physics and chemics. The basic subject knowledge is not always grounded. Another problem is the motivation of the student. The teacher needs to wake up the curiosity of the students and also let them know the importance of technical science knowledge. The students need to feel that knowledge is valuable which can help to earn a good job and high quality life level. To hold the interest of the students the teacher can use several methods and tools such as presentations, books, animations, videos, and practice with real tools and materials. In the last decade, students have seceded from real life they use virtual tools and games. The technical sciences subjects teaching need empirical experiences, and can't be only theoretical studies. The teacher needs to find an optimal method during the teaching program to wake up and hold the interest and transfer information to the students which will be knowledge.

Key words and phrases: curiosity, motivation, knowledge, practice.

I. INTRODUCTION

Education is a priority for society and government. Today's students will be the future workers and key peoples in the economy and administration areas. The knowledge, skills and abilities that they leave school with when they enter the world of work are crucial. Many studies and surveys have been carried out to find the right teaching methods and provide the best possible training (Bagyinszki 2020). Also several research study analyse the methods of the education (Bitay 2022), (Black 2020), (Hannafin 1999). The new trends in higher education want to increase the afficiency of the education (Altbach 2009). One of the difficulties of education is that the teacher and the student socialise differently. This means that the teacher has grown up and learned in a different effects of environment. The teachers of today still went to the library and read books. The knowledge in a book was collected, organised and published over a long period by someone else. Today's students are exposed to a wide range of audiovisual stimuli, which has an impact on learning. It can therefore be argued that the age difference between the teacher and the student, which can be called a generational difference, can be a problem in the educational process. How can this generational problem be overcome? In this work, we will try to share what we have learned from research in the field of education and our own experience.

II. TECHNICAL SUBJECT CURRICULUM

The base of education is the curriculum of the subject. When the teacher prepares a curriculum for the subject he needs to consider what basic knowledge it expects students to have. In the case of the technical subject usually the teacher expects a depth of mathematical, physical or chemical knowledge. Unfortunately, the knowledge of the generation of the 21st century is different than the knowledge kind of the teacher, because of the different ages. The teachers learned the knowledge on the base of the reading and writing method. The new generation in the last 15 years has an audiovisual base knowledge because of digitalization. The difference between the knowledge kind is the depthless. The older generation's knowledge is a deep knowledge of „What you learned you always know the answer to", the new generation has a wide knowledge of „You know where you need to find the answer", more creativity in the answer finding (Dick 1995).

It can be concluded that several times the expected knowledge is missing. To prevent misunderstandings, your curriculum should include a review of the expected basic knowledge of the subject.

Once the basic knowledge has been repeated, the new knowledge should be taught. The transfer of knowledge consists of theoretical and practical steps. The consolidation of theoretical knowledge is done through practical exercises. The student must

understand the usefulness and importance of the new knowledge. By putting knowledge into practice, knowledge can be reinforced and its usefulness demonstrated. It is very important to practise by repetition of the knowledge transmitted. An important part of the curriculum is the summary and the test of the knowledge. Fort he students can be a good way a self-test, which can help to check the knowledge level and find the weaknesses. In this way, students can ask questions and consolidate their knowledge based on the answers.

III. WAKE UP THE CURIOSITY OF THE STUDENTS

Arouse the student's curiosity about the subject matter. This is not an easy task, as the student is exposed to a lot of information and fast audiovisual stimuli due to the daily use of the Internet. In many cases, however, they do not understand the reasons for the technical solutions they see and how the equipment works. However, if we try to answer the following questions during the lesson, we may be able to arouse the student's curiosity.

Why is the subject important? Which new knowledge is transferred in the subject?

The computer sciences and the communication technologies almost give new and interesting possibilities for the teacher to join the students interest (Bakar 2008), (Jonassen 1996), (Qurat-ul-Ain 2019). If we can arouse curiosity, we have already taken a big step forward, as the student's attention is focused on the subject being taught. The student also formulates several questions that need to be answered and continuously responded to. Today's students cannot follow static lectures over long periods. During a static lecture, the listener's attention and interest can be lost. During the presentations, we should use methods to break up the static presentation, e.g. short videos, pictures, animations, etc (Amutha 2016). In addition, interactivity (Delialioglu 2007), (Reeves 1997) is very important, allowing the student to ask questions and to answer them. Many teachers make the mistake of not letting students ask or answer questions during their lectures. They may even say that they should already know this. Unfortunately, by doing so, you lose the student's interest and will not be able to maintain their attention.

IV. THE MOTIVATION OF THE STUDENTS

Motivation is a very important part of the educational process. Once we have aroused the student's curiosity, we need to motivate him to work and acquire the knowledge. Learning is work, as the student has to concentrate and work on the task at hand. The student will work when he sees that his work is useful.

If you get answers to the following questions: Why is the transferred knowledge valuable? How can the knowledge help to earn a good job? Which jobs will be available? Why this knowledge is profitable?

These questions must be answered and emphasised in the educational process. If the student considers the knowledge provided to be worthless, he or she will not be motivated and will not want to learn. The motivation of the student also can increase by the way of a good example, invite the old students who are successful in his work. Student can find a true example which can be a role model.

V. HOLDING THE INTEREST AND TRANSFERRING THE KNOWLEDGE

It is not enough to wake up the interest in education, it must also be maintained. Very important, is the high professional knowledge of the teacher. Beginning teachers often do not have enough knowledge yet, so they need to be prepared for lessons. If the student feels that the teacher does not know the material he or she is trying to teach, the student's interest and motivation may be lost. It can be observed that teachers with industrial experience involved in the teaching of technical subjects receive more respect and attention. The teacher needs to be authentic. To maintain attention, it is advisable to use the possibilities provided by today's modern technology (video, animation) (Beyth-Marom 2005), (Koehler 2014), (Reeves 1997). The practical application of knowledge is also very important. The student gains experience during his activities. Your own experience helps you understand and master the course material. The teachers need to use the modern technology tools (Land 2000), (Lee 2003), (Weaver 2015), (Xin 2012).

VI. CONFIRMATION OF THE STUDENT'S KNOWLEDGE

The knowledge acquired by the student must be continuously reinforced. One way to do this is through continuous repetition, which helps to deepen knowledge. It is necessary to divide the curriculum into parts and summarize the individual parts. During learning, we have achieved results if the student can ask questions. Don't forget, there is no such thing as a bad question, just a question. All questions should always be taken seriously and answered. It is a good practice to reinforce knowledge if the student gives a presentation to his classmates from each of the smaller subjects which he has learned. This practice when the students teach each other (Boud 2014).

VII. TESTING OF THE STUDENT'S KNOWLEDGE

Checking knowledge is also an important educational task. The test can be quantitative or qualitative (test, essay, oral). The method of checking knowledge should be related to the type of study material. In many cases, the oral answer is appropriate, but there are subjects where checking the solution of the practical task is a good solution. The knowledge check can also be in a combined form, not only in writing but also with an oral presentation of the described material. We must explain the results of the test to the student as soon as possible so that he receives feedback on his performance.

VIII. CONCLUSION

Teaching the technical subjects is a difficult task. It is a fortune, that the technical inventions, machines and the computer sciences give always interesting novelty to wake up the curiosity of the students. To holding the student curiosity is the task of the teacher. Also the motivation of the students is a very interesting task, which needs lot of works. It must be understood that the teacher and the student do not always use the same language due to the generation difference. The communication is an essential part of education. The teacher must try to use precise language and simple sentences that the students can understand when imparting knowledge. There are people who are" born to be teachers", but those who do not have such skills can learn from a young age.

The teaching of technical subjects has human and technical aspects. Human aspects are, the teacher's professional knowledge of the subject, has soft skills such as presentation skills and pedagogical skills. There are people who are" born to be teachers", but those who do not have such skills can learn from a young age.

Technical aspects are, e.g. presentation, video, animation, books, etc. and the practical tasks. The practice is suitable for arousing and maintaining students' interest and reinforcing what they have learned.

On the base of my long time practice I can conclude that the teacher needs to increase own knowledge and try to keepink touch with the new generation and try to understand them. To be in touch with the student needs to talking with them not only during the lectures but also after it.

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VR Technologies in the Educational Process of Disabled People and in University Education

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Abstract – This article describes use of VR and related technologies in the educational process. Students work in unique laboratory (LIRKIS) with the latest virtual reality technologies (e.g. mixed/augmented reality, VR headsets, virtual CAVE, 3D scanning or 3D printing) during they study. The specialty is the usage of these technologies for handicapped people education. This paper presents our experiences in education of virtual reality in both ways: as subject of study and also as study tool. The first part of the article contains the description of the VR and related technologies use in the educational process of handicapped children/pupils. The second part contains some experiences in the deployment of VR technologies within the university education at the authors' home department (Department of Computers and Informatics, FEEI TU Košice).

Keywords: virtual reality, disabled people, university education

I. INTRODUCTION

Virtual reality (VR) is gaining more importance day by day. In addition to VR, related technologies such as mixed reality (MR) or augmented reality (AR) to associated in the XR (eXtented reality) application platform are being raised [1]. Standard users get in usually first contact with some VR technologies when play games via computers, smartphones or gaming consoles. Virtual reality is also used in industry sectors and research sectors for easy and cheap prototyping where it achieves good results. The best feature of virtual reality is that it can be used to create almost anything with cost-efficiency and without limiting to real world. One part of research with virtual reality that is gaining popularity is education. Education takes place at any age, with different target groups at school, in career fields and it can also be directed towards helping disabled people. For these purposes more and more hardware and devices are being made. Various devices and equipment for virtual reality had been made. The most common virtual environments at this level are:

- virtual CAVE (Cave automatic virtual environment) -based systems and
- VR headset-based systems.

The interaction of pupils/students with the teacher or other pupils/students in the group is also very important during the educational process. Collaborative/shared virtual reality (CVR/SVR) can be used with advantage in this case [2]. CVR is a new form of virtual reality that allows users to work virtually with others in the same virtual space, regardless of their physical location [3]. According to Flavián [4], collaborative systems represent a specific architecture and technological equipment for the possibilities of creating collaborative activities. The authors of [5] state the need for the physical presence of users or their virtual presentation in the form of avatars in collaborative environments. CVR is being used in education to help with learning and understanding of various skills.

The main purpose of this paper is to bring closer usage of VR and related technologies in the educational process, especially in two ways, which are also addressed within the projects in the authors' home laboratory LIRKIS (Laboratory of Intelligent inteRfaces of Communication and Information Systems). In the first part, the description of the VR and related technologies use in the educational process of handicapped children/pupils will be listed. Some experiences in the deployment of VR technologies within the university education at the authors' home department are the content of the second part.

II. DISABLED PEOPLE AND EDUCATIONAL PROCESS

Disabled people are not only people with physical or sensory disabilities, but also cognitive disorders (e.g. people with learning difficulties or impaired centering). About 15% of the world's population lives with some form of disability. They have significant problems integrating into society. Many of them need specialized tools and other assistive technologies for their day-to-day life [6]. Therefore, the VR

technology is also used to create a more natural use of the user interface with better accessibility. In order to create such an environment, it is necessary to understand these people as well as to access information and if they have specific problems and needs. However, these problems are specific to a particular type of disability, so they can be divided into the following categories:

- sensory disability:
  - visual,
  - olfactory,
  - auditory,
- physical disability, limited mobility
- mental disability,
- speech disorders
- learning disorders such as dyslexia, dysgraphia, dyscalculia,
- other types such as senility and different dependencies.

People with disabilities need to be supported by supportive technology, especially alternatives to user interfaces (text readers, screen readers, etc.). New technologies can help to gain more information, help in recovery, everyday activities and so on. Among the most supported groups are the vision and the hearing impaired. However, physically, and cognitively disabled, they are supported by a little less, although one of the first uses of VR was to train disabled people in a wheelchair in a virtual environment. This environment is more suitable for disabled people because they can learn and interact with world in safe environment of CAVE system. For example, disabled persons in wheelchair can move through space (Fig. 1), with our specially adjusted wheelchair which can monitor movement of wheels and this movement represent as movement in virtual world.

Fig. 1 Demonstration of the wheelchair user during safe movement training in the LIRKIS virtual CAVE.

Nowadays, the world is trying to approach these people individually. Various measures are being developed and possible solutions are being sought that may help handicapped people to facilitate communication, movement, and thus ensure the conditions for a fuller life [7]. Attention is focused on the development of specialized centers and auxiliary schools, including the Pavol Sabadoš special boarding school in Prešov. This school is a partner school within the project solved in the LIRKIS laboratory, and the examples presented in this article are from the process of solving this project. Children born with disabilities can learn to live with their handicaps from an early age and to be educated in all available ways. Therefore, most schools of this type use educational simulators, which serve as methods or procedures that create a virtual environment, will all important aspects of the real environment. Such simulators are used not only in healthcare, as aids in various medical procedures, but also as aids for teaching language and basic communication skills.

III. VIRTUAL ENVIRONMENT FOR EDUCATION

A particular effort was dedicated to modeling virtualized classes and objects with which user will manipulate and interact. Most of the environment for full virtual reality (not MR) was done using web based collaborative environment. Self-developed platform LIRKIS G-CVE [3] was used in this case. This platform meets all criteria, offering easy and intuitive controls, multiplatform support, easy environment sharing, and optimization also for older and less powerful infrastructure available in this school. This environment provides also easy prototyping and creating immersive 3D environment for collaboration among multiple users. Users can connect to this web based collaborative projects using simple HTTP link and mobile device or desktop using web browser (Fig. 2). Then they can observe and interact with given 3D objects. All this is happening under the supervision of a teacher.

Fig. 2 The pupil works with developed desktop VR application.

The most common collaborative environments at this level are mentioned virtual CAVE-based systems and VR headset-based systems.

CAVE system available in LIRKIS laboratory provides fully immersive virtual experience [9]. In our case it is a "room" where walls, floor and ceiling are made from 3D passive FULL HD LCD monitors [10]. User can move in that space and wears polarized glasses with markers for Optitrack. The main advantage of this compared to head-mounted devices (HMD) is freedom from uncomfortable wearable equipment. This is the main advantage when working with handicapped people, especially children/pupils. Many of these children/pupils cannot stand any wearable electronics such as interactive gloves or HMD (VR headset) devices belts and others. Nevertheless, HMD usage in contrast with CAVE still represents a viable way (including availability and price) for many disabled people.

IV. POSSIBILITIES TO IMPROVE EDUCATION OF DISABLED PEOPLE

There are many situations which can eliminate disadvantages of disabled people. With mostly virtual reality many aspects of disadvantages can be eliminated, expect for blindness. By creating virtual reality environment that simulates people present's, they can freely move in virtual space and look around. For group of people who are physically disabled, virtual reality opens the door to new opportunities such as running, swimming, climbing Mount Everest or skiing. For example, for people with phobia, there is possibility to face the fear under observation in a virtual reality or mixed reality using e.g. Microsoft Hololens (Fig. 3). In addition, all this is happening in safe simulated and controlled environment of virtual reality.

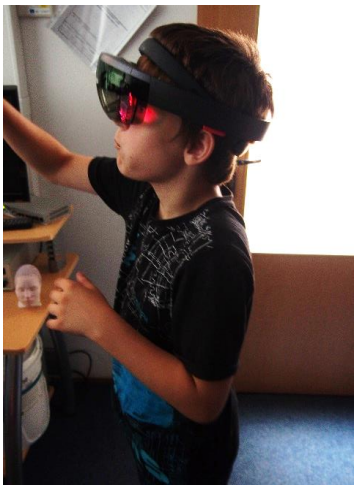

Fig. 3 Pupil using mixed reality and interact with virtual objects.

Mixed reality could be a part of treatment therapy after stroke or sports injury by improving or recovery of motor skills. This process of forcing brain to see something that is not really in the real world speeds up recovery of disabled limb. In this case related to physical outcome has been proven to be more effective than traditional rehabilitations [8]. People with mental disorders or learning disabilities for example with autism, can be present in stressed situations such as busy road or somewhere new. This process could reduce anxiety in safe environment. But of course, virtual reality can be used vice versa to give healthy people an idea about what people with epilepsy, Alzheimer's or conditions like autism might be going through by simulating a real experience.

Also, there is possibility to present learning subjects with live demos for small children. Children/pupils can see educational/"gaming" world and virtual objects together using virtual or mixed reality and freely move in a room (Fig. 4). This is how easy they can learn new knowledge while they are only play "games".

Fig. 4 Interaction with pupil during VR headset use (LIRKIS CAVE in background).

V. VIRTUAL REALITY TECHNOLOGIES AND UNIVERSITY EDUCATION

VR and related technologies have been used In our university pedagogical practice for approximately 15 years. Currently, these technologies are used at the authors' workplace (LIRKIS laboratory) mainly in exercises from selected subjects, e.g. User experiences and User interfaces, Development of computer games, Computer graphics, Virtual reality systems or Modeling and simulation, but also within the framework of bachelor's, diploma and, of course, doctoral theses. Since the equipment of the laboratory covers the entire virtualization sequence, the students come into contact with these technologies in a relatively wide range and they feel this state very

positively. They primarily work with systems based on VR headsets, but also with the CAVE virtual cave system (Fig. 5), which is unique compared to many other universities that do not have CAVE virtual caves.

VR headsets are widely used in many VR systems. In the LIRKIS Laboratory, there are utilized wearable VR headsets without limitations of a user by using cable connectivity (e.g. Oculus/Meta Quest or MS Hololens, Fig. 6). Smartphone based VR headsets are used also in learning process due to price and availability. These headsets with Bluetooth controllers offer full compatibility with a variety of smartphones. The visualization is directly computed using a smartphone and it provided by VR application.

Fig. 5 Examples of the learning process in the LIRKIS virtual CAVE.

Many VR development toolkits used in LIRKIS are focusing on web-based and cross-platform 3D applications. Students can work on their projects without the need to install special IDEs, the entire development and testing platform is available on the web. In addition to the development of virtual environments, the implementation of input devices is included in education. Frequently used input devices are VR joysticks/controllers, EMG sensors and/or smartphone sensors. The final use of VR headsets also serves to simulate various tasks which involve students in virtual collaboration.

In the field of education, our approach focuses on increasing the interest of students and the quality of our work in education. For this reason, we are expanding the teaching possibilities with different types of VR technologies. In order to improve the quality of teaching, we make these technologies more accessible and intensive for students than before. Students are also taught as future possible developers/programmers of VR systems. Therefore, students have unlimited access to VR devices and technologies to gain a lot of experience and knowledge both on the hardware level and on the software level.

Fig. 6 Students are working with different types of VR headsets.

At the software level, we support more technologies. For example, students learn in our lessons how to program simple 3D application using Unity cross-platform game engine which using C# as programming language. While creating 3D models, students learn to properly model virtual objects and use also Trimble SketchUp software with some advanced features. Also, they can use Blender or 3ds Max for sophisticated objects and creating some animations or videos. In Unity the task is to create 3D application with user (his avatar) movements and interactions/collisions with other virtual objects. They set gravity and observe how the application behavior changed and interact. They create menu with e.g. buttons. They also learn:

- how to create and load new scenes using menu,
- how to implement various input/output devices and
- how to transfer parameters among scenes.

Students also learn how to program VR and AR environment using A-frame framework and they are working with web-based collaborative environment projects. In this web environment, they learn how to represent their avatar in 3D space and how use information from smartphone sensors such the gyroscope or the accelerometer to represent movement of the avatar and represent his sight. In

these frameworks they can make own virtual scenes and add other users to their scene using web link. In this environment they can interact with other virtual objects. These objects can be part of the scene, so unmovable objects or dynamically created objects and these objects can be dynamically created and removed. Users can work with some privileges based on their roles.

CONCLUSION

The goal of our work is to make life easier for handicapped people, learn new things, feel new experiences, and bring them easy access to new technologies or knowledge and adapt user interfaces to their needs. We are also working on the use of new VR technologies in the university educational process of our department's subjects. In this way, our goal is to improve the educational process and maintain contact with new technologies and present them to students so that they can continue to use and develop the latest technologies, including VR technologies. We want virtual reality and associated technologies to be grasped by students in two ways: as a subject of a study and as a study tool.

ACKNOWLEDGEMENT

This work has been supported by the KEGA grant No. 048TUKE-4/2022: „Collaborative virtual reality technologies in the educational process “

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Analysis of Students' Academic Achievements in the Field of Mathematics and Computer Science

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Abstract - University education in the field of technical sciences contains curricula and programs in mathematics and computer science that complement and intertwine. It is necessary for students in their academic education to master certain areas contained in the mathematics curriculum in order to more easily follow the computer science curriculum. The goal of the research is to recognize and improve learning outcomes in mathematics curricula, in order to improve computer science students' achievements. The paper presents an analysis of the academic achievements of students in the field of mathematics and computer science in relation to curricula, learning outcomes, and student success rates. The research is conducted in order to improve the academic achievements of students in the field of computing, and based on changes and additions to learning outcomes in mathematics curricula.

Keywords: Computer-Aided Engineering Drawing (CAED), Computer-Assisted Mathematics Education (CAME), Project-Based Blended Learning (PjBL), learning outcomes, Jaccard index.

I. INTRODUCTION

Education in the field of technical sciences contains teaching curricula in mathematics and computer science that complement and intertwine. Otherwise, the improvement of teaching curricula and learning outcomes is often crucial for the modernization of the educational process in general. It is necessary for students at the academic level to master certain areas contained in the mathematics curriculum in order to more easily follow Computer Science courses.

In recent years, Computer-Aided Engineering Drawing (CAED) has become a key part of educational programs in engineering disciplines, namely traffic and transportation [1]. Computer-aided engineering drawing provides students with important skills and abilities, while simultaneously developing Information and Communication Technologies (ICT) competencies that enable them to work in a modern engineering environment [2]. However, the academic achievement of students in the field of Engineering Drawing using computers is often influenced by the quality of mathematics curricula. CAED requires a combination of theoretical knowledge in mathematics with practical application through the use of computer tools for drawing, modeling and simulation. Changes in mathematics curricula have the potential to significantly impact student understanding, application, and success in CAED. Also, changes in teaching curricula can significantly improve the understanding and application of mathematical concepts in the context of Engineering Drawing using computers, which directly affects the achievements of students in this area. These changes are often the result of continuous research, thoughtful planning and adaptation of educational programs to meet the specific needs of students and industry.

This study will explore specific methods and strategies for improving the academic achievement of Engineering Drawing students using computers through mathematics curriculum modification, offering practical guidelines for improving educational programs and learning outcomes.

II. RELATED WORK

The synergy between mathematics and computer-aided engineering drawing has been a topic of recent study, so there are numerous works and studies dealing with it. The literature on this topic explores multiple aspects concerning the relationship between mathematics learning outcomes and informatics learning outcomes, as well as the impact of teaching curricula on student achievement. Numerous studies highlight the key points for improving student achievement. The papers also present ways in which curricula and learning outcomes can be strategically adapted to enable better integration of theoretical principles with practical application.

The research presented in paper [3] deals with the design and analysis of a framework of computer experiments for modeling the relationship between track quality and vehicle safety. Also, the work deals with the application of mathematical modeling as a study reliability and safety of transport systems.

Study [4] looks at the effects of Computer-Assisted Mathematics Education (CAME) in the context of academic achievement. The aim of the research is to review the literature, based on Turkish samples and observing the effects of Computer-Assisted Education

(CAE) on mathematics achievement. As a result of this review, statistical data from 40 studies that met the inclusion criteria were combined and they are coded using a coding pattern.

Mursid et al., in a study [5], examined the effect of a Project-Based Blended Learning (PjBL) model and creative thinking ability on engineering students' drawing learning. Using a quasi-experimental pre-test and post-test design, the study included a sample of 80 students from two different departments of the Faculty of Engineering, UNIMED, North Sumatra, Indonesia. The ability of creative thinking of the students taught by the presented model was higher than the students of group II who used the ordinary blended learning model. The results of the research show the interaction between the effect of the PjBL model and the ability to think creatively on the learning outcomes of mechanical engineering students.

Study in [6] focuses on the assessment of the level of basic mathematical skills that determine the readiness of students to learn under the guidance of a teacher. The aim of the research is to increase students' ability to think mathematically. The research results showed that the use of augmented reality media with Unity 3D for improvement students' mathematical computational thinking ability produced better results compared to traditional learning methods, especially for students with lower initial levels of mathematical ability.

In [7], the effect of an educational virtual reality game called "Keşfet Kurtul" on the academic success of students in mathematics was considered. It has been determined that the educational VR game "Keşfet Kurtul" will increase academic achievement and maintain student achievement doing mathematics. The results show that the experimental the method has the same effect as the method applied in the school in comparison group, in terms of academic achievement and students' engagement in mathematics.

Research dealing with predicting student academic success and the factors that significantly influence it can improve student completion and graduation rates, as well as reduce dropout rates [8]. Abou Naaj et al. [8], examine the factors that influence the academic achievement of students.

There are many studies in the literature whose main goal is to learn the effects of "Computer Aided Education" (CAE) on academic achievement [9-11].

In the literature, there are papers dealing with Meta-Analysis of student achievements in relation to learning outcomes.

Alshammary et al. in [12], address digital platforms as educational resources with the aim of determining whether or not digital platforms improve learning outcomes.

The research used a Meta-Analysis approach of the overall size of the effect of these platforms on learning outcomes. The paper [13] examined the size of the set of effects of mediating variables including period of study, subject area, student evaluation and type of publication. The paper [13] presents the results of a Meta-Analysis of 37 contemporary experimental and quasi-experimental studies of summer math programs for students in grades pre-K-12, examining which resources and characteristics predict better student achievement. According to Lynch et al. [13], the results show that summer programs are a promising means of strengthening mathematics knowledge outside of school. The aim of the study [14] is to perform a Meta-Analysis of published data on the effects of active learning and the performance of Asian students in science, technology, engineering and mathematics (STEM) subjects.

The study [15] aims to find out how to develop the application of learning values based on the national curriculum for teachers and operators at the Pontianak Vocational High School level. According to Anantadjaya et al. [15], research produces learning assessment applications that can be used to recapitulate values, how knowledge and skills competencies.

The study [16] reports on three high school mathematics classes where teachers tried to improve their teaching and student learning using a digital tool. According to Viberg et al. [16], students have difficulty using tools effectively when teachers do not work to develop common practices in the use of technology. In the event that teachers themselves do not actively use the tool, they do not fully understand how students can learn from it, and they cannot help them synthesize the teacher's instruction and the tool.

Knowledge of mathematics is usually repeated in preparatory courses in Electrical Engineering and Computer Science. According to Greefrath et al. [17], the orientations of preparatory courses are, however, very heterogeneous and range from teaching skills to developing general competencies. The study [17], examined possible correlations between the results of the mathematics exam, attendance at the preparatory course and the results of the test at the beginning of the course.

The research [18], develops a methodology for improving and harmonizing the curriculum, ICT competences of teachers according to European standards and the needs of traffic faculties. The goal of the research is to modernize the teaching process with information technology, using new teaching tools and online tests to assess students' knowledge and skills.

III. STUDENT LEARNING OUTCOMES

Student learning outcomes include the results that students should achieve during their academic education. The outcomes help shape the curriculum, assess learning success, and guide instruction. Learning outcomes depend on the level of education and the specifics of the subject of study.

A. Learning outcomes of students in the field of Mathematics

Student learning outcomes in the field of Mathematics represent specific goals or results that students should achieve during their academic education in mathematical disciplines. In the field of Mathematics, at the level of academic education, students should:

- Understand basic mathematical concepts, such as numbers, operations, geometric shapes, algebraic expressions.
- Develop mathematical problem-solving skills, which includes identifying problems, developing strategies for solving them, and applying appropriate mathematical tools.
- Apply mathematics in real-world situations and understand its application in other disciplines, such as computer science, engineering, traffic and transportation, and more.
- Understand and produce mathematical proofs, which include logical reasoning and argumentation.
- Understand statistical methods, analyze data and probability concepts.
- Understand the basics of algebra and analysis, including functions, derivatives, integrals, and other mathematical concepts.
- Understand geometric concepts, shape properties and relationships between geometric objects.
- Understand computer mathematics, including programming and the use of computer tools for mathematical research.

The learning outcomes of mathematics should be adapted to the level of higher education, and to the specific subject of mathematics being studied. Teachers and educational institutions should define specific learning outcomes for each course to provide students with clear goals for their mathematics education.

B. Learning outcomes of students in the field of Computer Science

The learning outcomes of students in the field of Computer Science represent specific goals or results that students should achieve during their academic education in computer science disciplines. Learning outcomes in the field of computer science may vary depending on the specifics of the subject. In the context of general examples of learning outcomes for Computer Science, students should:

- Understand basic computer concepts such as hardware, software, operating systems, computer networks and computer security.
- Master programming and software development include the ability to program in different languages, develop software applications, and solve problems using computer algorithms.
- Understand how databases work, how to design them, manage data and create queries to extract data.
- Understand the algorithms and data structures of different algorithms, the complexity of algorithms and the application of data structures.
- Develop skills for creating web pages, developing user interfaces and understanding web technologies.
- Acquire knowledge in data security and protection including understanding the security of data transmission and storage, identifying vulnerabilities and developing protection and security measures.
- Understand the basic concepts of artificial intelligence and machine learning and how to apply them to problem solving.
- Acquire knowledge in the field of computer networks including understanding, communication protocols and network security.

Learning outcomes in the field of Computer Science are tailored to specific curricula and courses, and faculties define their own learning outcomes to provide students with clear guidelines for education in computer science disciplines.

IV. SIMILARITIES BETWEEN LEARNING OUTCOMES OF MATHEMATICS AND INFORMATICS

The aim of this research was to determine the similarities between learning outcomes in the field of mathematics and computer science. The discovery of similarities is for the purpose of improving the quality of the teaching process and student achievement at the university level of education.

Mathematical and computer disciplines together encourage logical thinking in students. Mathematics requires understanding the logical connections between statements, while computer science encourages structured thinking to solve problems. Both fields involve thinking in terms of creating algorithms. Mathematics applies algorithms to solve problems, while computer science develops algorithms to perform certain tasks on computers.

Mathematics and computer science involve abstract concepts. In mathematics, this may include abstract algebraic structures or concepts such as infinity. In IT sectors like algorithms or computing theory, abstract ideas are used.

Also, both areas encourage problem-solving skills. Mathematics does this by solving mathematical problems, while computer science involves identifying problems and developing solutions using computer tools and techniques.

Mathematics and computer science encourage critical thinking. Students in these disciplines must be able to evaluate information, develop arguments, and logically justify their conclusions.

The previously mentioned areas have a wide range of practical applications. Mathematics is used in various scientific and engineering fields, while computer science provides tools and techniques for solving problems in technological contexts. Mathematics and computer science deal with modeling and problem solving. In mathematics, this involves mathematical modeling of the

real world, while computer science uses models to solve computational problems.

Although these disciplines are different, their learning outcomes have overlaps that contribute to the development of critical thinking, problem-solving skills and applicable knowledge in a wide range of fields.

V. LEARNING OUTCOMES AND STUDENT ACHIEVEMENTS

In this research, learning outcomes play a key role in the formation of student achievement. Learning outcomes represent specific goals, abilities, or knowledge that students should acquire during their engineering education.

Therefore, learning outcomes provide clear guidance to students about expectations related to their knowledge, skills and abilities. That is, it helps them focus on specific goals and know what they need to achieve. Also, learning outcomes are often the basis for student evaluation and assessment. They allow teachers to assess whether the student has successfully achieved the defined goals and understood the material. Clearly defined learning outcomes can motivate students as they provide guidance for progress. When they are aware of what is expected of them, it is easier for them to direct their efforts towards achieving those goals. The learning outcomes enable the adjustment of the teaching process according to the needs of the students. Teachers can adapt teaching methods to better support the achievement of defined outcomes for each student. They are often aligned with the needs of industry and the labor market. Students who achieve targeted outcomes often have better opportunities for employment or career advancement. Quality defined learning outcomes are key to successfully managing the educational process and achieving high student results. They provide clear guidelines for learning, assessment and skill development, directly influencing student achievement.

Achievements of students in the field of mathematics and computer science can be very diverse and depend on various factors such as individual abilities, commitment to studies, quality of the educational program and the environment in which students are educated. Students can achieve high grades, explore new concepts and technologies, and even contribute to research and development in these fields. Some students often participate in competitions, conferences and workshops and have the opportunity to work on projects that can be useful for industry or the academic community. Other students may have solid grades and achievements, but focus more on practical application of knowledge through projects, internships or industry work.

However, it is important to note that grades alone do not necessarily reflect all students' abilities or potential. Sometimes students who have excellent theoretical knowledge are not at the same time skilled in practical application, while others who may not have the best grades may have outstanding skills and abilities that are valued in the industry. The key factors influencing student achievement in these areas are motivation, work ethic, approach to learning, and the opportunities they have during their studies. Also, teacher support, availability of resources and infrastructure also play an important role in achieving high achievement.

VI. INFLUENCE OF TEACHING CURRICULUM ON STUDENT ACHIEVEMENTS

Student achievement is often closely related to the quality of teaching curricula. As curricula shape the way of teaching and the arrangement of material, they can have a significant impact on student achievement.

Quality curricula provide structure and a clear sequence of material. This allows students to gradually build their knowledge from basic to more complex concepts. Curricula that are aligned with current traffic and transportation trends and needs can motivate students as they see how their learning can be applied in the real world. Also, well-designed curricula include clear evaluation methods that allow students to demonstrate their understanding. The feedback they receive helps them improve their knowledge. Advanced curricula provide opportunities for additional research, more challenging projects, and specialized courses that can stimulate ambitious students. Quality teaching curricula also support teachers by providing them with guidance, resources and tools to effectively impart knowledge.

VII. ANALYSIS OF ACADEMIC ACHIEVEMENTS OF STUDENTS IN MATHEMATICS AND COMPUTER SCIENCES

In order to improve the academic achievements of students in the field of Computer Science, an analysis of the teaching curricula in the field of Mathematics was carried out at the Faculty of Transportation in Doboj, University of East Sarajevo, Bosnia and Herzegovina. The research had the task of examining the influence of teaching curricula in the field of Mathematics on the achievements of students in the field of Computer Science at the Faculty of Traffic in Doboj.

The analysis of students' academic achievements included:

- Analysis of the achievements of students of the Faculty of Traffic in Doboj for the subjects Mathematics I and Engineering drawing using computers (area of computer science). The student attended the course in Mathematics I in the first semester, and the course in Engineering Drawing with the use of computers in the second semester, the first cycle of studies. The achievements of first-year students for the two academic years 2021/2022 and 2022/2023 were analyzed. A total of 120 students participated in the research, 70 students in the academic year 2021/2022 and 50 students in the academic year 2022/2023.
- Curriculum research was carried out specifically on learning outcomes in specific areas of Mathematics I and Engineering Drawing using computers. The goal was to find areas in mathematics curricula that are required as prerequisites for taking the subject Engineering drawing using computers. That is, to recognize

and include the learning outcomes in the Mathematics I syllabus that are necessary for a better understanding of the course in Engineering Drawing with the use of computers. We focused on learning outcomes from Mathematics I (matrices, vector spaces, determinants, elements of mathematical logic, set theory and algebraic structures).

- The achievement analysis included tracking student progress through the 2021/2022 and 2022/2023 academic years. In the academic year 2021/2022, a cross-section of the state of achievement of students in Mathematics I and Engineering drawing using computers was made. In the academic year 2022/2023, the teaching curriculum in Mathematics I was modernized. The modernization increased the number of teaching hours in Mathematics I from 2 hours of lectures to 3 hours of lectures and two hours of exercises to 3 hours of exercises on a weekly basis. The teaching syllabus was also modernized by improving the learning outcomes. Learning outcomes are expanded and enriched with: matrices, vector spaces, determinants, elements of mathematical logic, set theory and algebraic structures. Also, the number of hours provided for the study of these areas has been increased depending on the requirements of the studied area. In the academic year 2022/2023, a cross-section of the state of achievement of students in Mathematics I and Engineering drawing using computers was again made.

The data analysis was done with the aim of identifying the improvement or deterioration of students' achievements during their academic journey.

VIII. RESULTS AND DISCUSSION

The results obtained from the data analysis present the relationships between passing and achievement of students in the teaching subjects Mathematics I and Engineering drawing using computers. The data were analyzed before and after the modernization of the teaching curriculum in the subject Mathematics I, during the academic years 2021/2022 and 2022/2023. The modernization of the curriculum of the subject Mathematics I, study program Traffic was carried out in the 2022/2023 academic year.

The analysis of the passing rate of students in the academic years 2021/2022 and 2022/2023 was done based on Jaccard similarity according to formula (1).

$$I_J = (n(M_1 \cap E_{duc}) / n(M_1 \cup E_{duc})) * 100\% \quad (1)$$

I_J - Jaccard index.
M_1 - Achievements of students in Mathematics I.
E_{duc} - Achievements of students in Engineering drawing using computers.
$(n(M_1 \cap E_{duc})$ - The number of elements that contain both sets.
$n(M_1 \cup E_{duc}))$ - Total number of elements in both sets.

The results of the data analysis based on Jaccard similarity were carried out for the purpose of identifying weak areas in the curriculum of Mathematics I and Engineering Drawing using computers, and for the purpose of improving the performance of students in these disciplines.

The results of the analysis of student achievement, average grades and the total number of students attending the course in Mathematics I and Engineering Drawing using computers are shown in Figure 1.

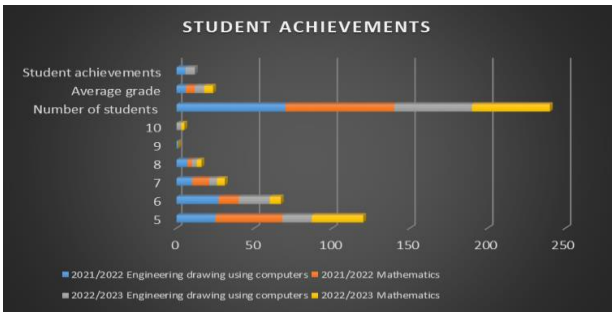

Figure 1. Student achievements in relation to the average grade and the number of students

The display in Figure 1 presents how the change in the curriculum in Mathematics I made in the 2021/2022 academic year affects the academic achievements of students in Mathematics I (2022/2023) and Engineering drawing using computers (2021/2023). Student achievements in the 2021/2022 academic year in Mathematics I and Engineering drawing using computers were a total of 5.83, and in the 2022/2023 academic year they were a total of 5.90. Which means that an increase in the achievements of students in both subjects together was recorded by 0.07.

The data in Table I represent the number of students who passed the course; the number of students who did not pass the course; passing of students; average grades; maximum grades from the teaching subjects Mathematics I and Engineering drawing using computers, and the percentage display of the Jaccard index.

TABLE I. DISPLAY OF STUDENTS' PASSES, AVERAGE GRADES AND MAXIMUM GRADES

	2021/2022		**2022/2023**	
	Mathematic I	***Engineering drawing using computers***	***Mathematic I***	***Engineering drawing using computers***
Passed exam.	27	45	17	31
Failed exam.	43	25	33	19
Passing grade (%)	39%	64%	34%	62%
Average grade	5.63	6.03	5.72	6.08
Max. grade	8	9	10	10
Jaccard index (%)	81.60%		100%	

From the results of the data analysis shown in Table I, we can see that the passing grade of students in the subject Mathematics I dropped from 39% to 34%, after

the modernization of the teaching curriculum. The average rating increased from 5.63 to 5.72. The passing grade for the Engineering drawing using computers course also dropped from 64% to 62%, and the average grade increased from 6.03 to 6.08. Which means that the modernization of the teaching curricula of Mathematics I had a greater impact on students with better results, and less on students with a grade of 6. In other words, by modernizing the curriculum, we managed to improve the achievements of students globally at the expense of passing students. The indicator of synchronization of teaching curricula in Mathematics I and Engineering drawing using computers is shown by means of Jaccard's index. The value of the Jaccard index for the academic year 2021/2022 is 81.60%, and for the academic year 2022/2023 it is 100%. The above data show that the similarity in the level of student achievement for the subjects Mathematics I and Engineering Drawing with the use of computers after the modernization of the teaching curriculum in Mathematics I was brought to 100%. Which was the goal of this research.

IX. CONCLUSION

The results of the data analysis showed that changes in the teaching curriculum of Mathematics I can have a significant impact on the achievements of students in the subject Engineering drawing using computers. Adapting the learning outcomes in Mathematics I allows for the integration of specific mathematical concepts that are important for computer-aided engineering drawing, and can facilitate students' understanding and application of those principles in practice.

Adapting the mathematics curriculum can focus students on acquiring knowledge of matrices, vector spaces, determinants, mathematical logic, set theory, and algebraic structures, which are essential for computer-aided engineering drawing. Also, changes in the Mathematics I curriculum may allow for a better connection of theoretical mathematical concepts with concrete applications in engineering drawing software. This can improve students' understanding and motivation.

Connecting mathematics to engineering drawings through an interdisciplinary approach can help students better understand the importance of mathematical principles in real-world engineering situations. It should be noted that improving student achievement in computer engineering drawing through changes in the mathematics curriculum requires careful planning and coordination to ensure that mathematical concepts are relevant, applicable, and easily understood in the context of engineering drawing. The integration of mathematics in this context can significantly improve the understanding and application of theory in practice.

In future research, updating the curriculum may include the introduction of modern learning tools such as specialized engineering drawing software. The integration of mathematical concepts within these tools can facilitate the application of theory in practice.

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Toward Intelligent Data Analysis in Higher Education Institutions

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Abstract - As the world rapidly evolves into a "knowledge society," Higher Education Institutions (HEIs) are under increasing pressure to assume a central role as the hubs of human creativity and learning. HEIs are increasingly turning to innovative technological solutions to increase the efficiency and efficacy of their key processes to satisfy high expectations. Recently, the possibilities of inference automation via the deployment of machine learning algorithms (ML) related to HEIs issues have been explored, mainly concerning students' performance and drop-out. Yet, there is a lack of a comprehensive approach to ML application in HEIs that might lay the groundwork for the development of autonomous AI entities to aid in data-driven decision-making. The goal of this paper is to provide a critical assessment of recently published studies on ML in HEIs, with a particular emphasis on the alignment of applied techniques with core HEIs processes.

Keywords—higher education institutions, machine learning, processes

I. INTRODUCTION

Higher education institutions (HEIs) are often viewed as essential players in social, political, and economic life worldwide. In a volatile world characterized by climate change and biodiversity loss, digital transformation, and an aging population, as well as the consequences of the global pandemic crisis and its economic fallout, HEIs are recognized as key players in post-pandemic recovery and in shaping sustainable and resilient societies and economies [1]. Their contribution to societal prosperity is undeniable, and their importance in the progress and achievement of educated individuals is well acknowledged [2]. Furthermore, technological advancements and the digital shift are changing how people live, work, and interact, disrupting how HEIs operate. HEIs are supposed to generate knowledge for new technologies and societal innovation. The number and diversity of stakeholders HEIs serve and rely on enable their performance to continue to grow, as do their expectations [3]. HEIs are increasingly turning to innovative technological solutions to boost the efficiency and effectiveness of their core processes in order to respond successfully to all challenges and satisfy the expectations of many interested stakeholders.

Every year, a massive amount of data is collected at HEIs. Yet, these data are not being used effectively to produce knowledge and insights that may be used to improve the quality of core HEIs processes. Machine Learning (ML) is a branch of artificial intelligence (AI) that can aid in the faster and more accurate processing of HEIs data. Namely, ML enables computers to learn and adapt on their own. It's all about teaching computers to adjust their behavior in order to increase the likelihood that their actions will have the desired effect, where that effect is assessed in terms of how often the desired outcome is achieved [4]. ML's growing popularity can be attributed to its high accuracy, short processing time, and wide range of accessible methods and algorithms that can be applied to classification or regression issues [5]. The ability to develop models that may be integrated into decision-making processes is cited as the primary advantage of ML [5] [6]. Although many researchers and practitioners have investigated the use of ML in HEIs, they often focus on identifying and classifying students as well as predicting student performance, overlooking the possibility of holistic modeling.

This paper aims to critically evaluate recently published papers concerning ML in HEIs, focusing on aligning applied approaches with fundamental HEI operations. As a result, the following research questions (RQ) were posed:

- RQ1: Is there research on the potential use of ML for all key HEI processes?
- RQ2: Which key HEI processes have received the most attention in research addressing ML?
- RQ3: Is there research on if or how HEIs stakeholders use ML results to monitor and enhance key HEI processes?

II. KEY PROCESSES AT HEIS

Generally, HEIs three core processes (Fig. 1) are teaching and learning, research, and cooperation with business and society [8], [9], [10] [11]. The European strategy for universities [1] and the European University Association's (EUA) vision for 2030 [3] agree that universities should provide an open, transformative arena for common knowledge production through research, education, innovation, and culture. They, together with other stakeholders of society, would shape the future of a knowledge-driven society.

Due to the preceding, there will be essential shifts in core HEIs processes, making room for the prospective application of ML.

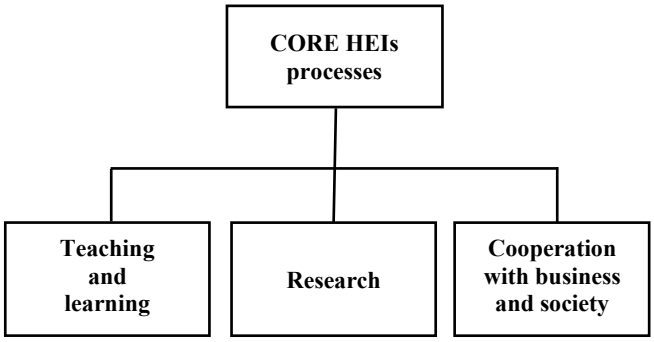

Figure 1. Core HEIs processes.

In this paper, the focus is on two core processes: teaching and learning and research. The third core process, cooperation with business and society, varies the most amongst universities in terms of organization and, often, in the name itself. This process's implementation is also very diverse and is heavily influenced by the institution's environment. As a result, this process was omitted from the analysis in this paper, though it should be noted that this does not imply that it is less significant but just that it is not currently the focus of ML application in HEIs.

Learning and teaching at the university level should be a collegial and collaborative process involving the entire university community and external partners. Teaching should be essential to academic practice, inextricably tied to research activities, and regarded as scholarly and professional. Universities should create an environment conducive to learning by incorporating and promoting multiple facets of their objectives. There is a wide range of reasons why students enroll in higher education, from those looking to further themselves professionally after high school to those entering the system at a later age or for a different reason entirely. Students should be able to use a wide range of adaptable, multi-, and interdisciplinary learning pathways that put them at the center of the learning process [3].

The following sub-processes comprise the teaching and learning process [8],[9],[10]:

- Curricula development and review
- Course development and review
- Preparation of teaching and teaching materials
- Teaching
- Evaluation of acquired knowledge (examination).

Most HEIs already have data stored in their IS about curricula, syllabi, students, grades on exams, teachers, teaching materials, etc. That makes a good starting point for expanding digitalization and more widespread use of ML applications or artificial intelligence.

Regarding the research process, HEIs should remain crucial and will be significant drivers in this endeavor, working with diverse partners. HEIs should continue pushing knowledge boundaries better to comprehend the physical cosmos and the human condition. They should foster cross-disciplinary conversation and promote multi- and interdisciplinary research. Open Science, which makes research available to everybody, should become the default method of developing knowledge. Universities should advocate for a varied non-commercial publishing system and be personally involved by promoting and supporting non-commercial and smaller publishing initiatives. The research's data and other results should be FAIR (Findable, Accessible, Interoperable, Reusable) [3].

The research process is made up of the sub-processes listed below [8],[9]:

- Literature finding
- Data collection
- Documenting research work
- Disseminating research work.

Currently, there are multiple global databases of scientific works and research (e.g., ScienceDirect, Scopus, etc.), as well as research networks where researchers publish the results of their work (e.g., ResearchGate, Academia, etc.), allowing for mutual connection and discussion. The European Union, for example, invests heavily in projects and initiatives aimed at strengthening and developing science and research, as stressed in the new European university strategy. In conjunction with Horizon Europe, Digital

Europe, and other EU and national instruments, the Erasmus+ European Universities initiative should support ambitious transnational alliances of higher education institutions in developing and sharing a common long-term structural, sustainable, and systemic cooperation on education, research, and innovation, creating European inter-university campuses where students, staff, and researchers from all over Europe can enjoy seamless mobility [1]. Also, it is to be predicted that ML methodologies and AI applications will be used more extensively to improve the efficiency of the research process.

In order for the university's three core processes to run well, many supporting activities (processes) are required [2],[8], [12]:

- Strategic planning and governance
- Human resource management
- Academic Administration
- Student service
- Finance and Accounting
- Infrastructure
- General affairs
- Marketing and communication management.

Since the ability to develop models that may be integrated into decision-making processes is cited as the primary advantage of ML methods [6], this paper focuses on supporting processes related to strategic planning and governance. This process comprises the following sup-processes [8], [12]:

- Planning
- Performance management
- KPIs
- Quality assurance

Following this, the authors discuss research into ML's application across various HEI functions. Although these studies have demonstrated the great applicability of ML in HEIs, particularly regarding student performance, student drop-out, and student classification (profiling), they have all failed to execute or take any action based on their findings [5].

III. Review of Up-to-Date Research on ML in Key HEI Processes

As the starting point for analyzing published research results, the authors use the results presented in the literature review [13]. The presented results refer to the application of various ML methods in the following:

- Prediction of student performance and identification of students at risk in e-learning with 37 research papers and nearly 30 different ML techniques,
- Predicting student drop-out with 20 research papers exploring the topic deploying 16 different ML techniques.

Remedial action based on prediction results is presented in 19 papers, 12 regarding solely the attribute of the student's performance, and 7 regarding other attributes such as learning outcomes, NQF domain, and some specific student attributes existing in the HEI's IS.

Regarding the HEIs' processes, the conclusion is that out of 57 different research papers treating the matter, 12 can be classified as related to the subprocess of KPIs (measuring students' performance) and 7 as related to performance management. The remaining 38 papers treat the teaching process, subprocesses of examination, and teaching. Some of the newest research in the field of ML application in higher education [14-17] show a similar tendency of "l'art pour l'art" drive for research, still exploring various ML techniques and their efficiency, thus increasing the number of papers supporting the subprocess of evaluation by 2, the subprocess of teaching by 1 [17], and subprocess of KPI's by 1 [16]. On the other hand, some research results are classified as strategic management, reporting on the ML deployment in enrollment prediction [18-19].

It was more difficult to find recent papers on ML in the HEIs' research processes: literature finding, data collection, documenting, and disseminating research work, for such research is usually linked to what is considered a software product and, as such, falls under licensing. Nevertheless, there is some recent research [20] on the implementation of intelligent libraries and a review of the underlying methods [21], which is, in essence, of the first two subprocesses.

Another scarcely explored topic related to the teaching process is research on ML-supported curriculum development [22-25]. Research in this area mainly emphasizes the potential of methods in data-driven curriculum development.

Minor involvement of researchers in the research related to strategic management and governance, as illustrated in Figure 2, could be interpreted as a lack of faith in the HEIs' management into the power of ML-supported decision-making since the fundamental drive for research comes from the researchers per se or from the department managers.

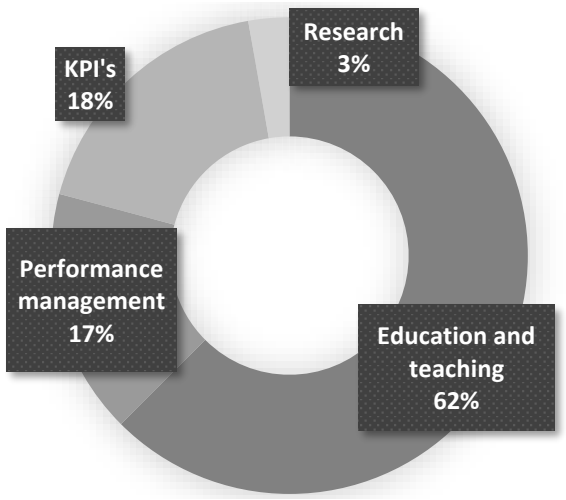

Figure 2. The breakdown of research on ML applications in HEIs' by processes.

This statement is also supported by research on ML deployment in overall HEIs management presented in [26-28],

The summary of the world-vide research results from the ML-supported HEIs' data analysis is as follows:

- Researchers have explored various methods and proven they are useful for analyzing specific areas. The most common research areas are a prediction of student performance, identification of students at risk, and prediction of students' drop-out.
- A comprehensive list of numerical and descriptive variables proved to be significant and thus relevant attributes for specific topics. The commonly used variables are student grades and personal record data.
- There is a lack of published research reporting the implementation of the results to benefit HEI's performance.

Even if data analysis per se is almost almighty these days, bearing in mind that researchers are using a vast number of constantly improving methods, there still is the fact that many results remain in the void, never reaching the intended end users. Therefore, the next step in the research is to identify end users' specific needs for information and relevant data for ML-based inference. One can argue that some of the most important aspects of the data analysis for its end users, when observed from the HEI point of view, are:

- To what extent, and does it at all, do ML analyses performed on a particular process influence the HEI's overall efficiency?
- If the ML results indicate poor university performance:
    - How serious is the potential "harm" to the university's performance and/or reputation?
    - Is it possible to change the circumstances leading to a negative outcome?
    - Which department should react first?
    - Which departments/individuals should be involved in the recovery process?

Since the stakeholders in the university management/administration do not have to be data-analysis literate, meaning that they do not necessarily have the knowledge needed to interpret outputs from the data-analysis methods, as well as that data analysts do not have to be literate in the processes that end users know so well, it turns out that the results might prove hard to interpret. That implies that the most logical next step is to develop an intelligent interface to link the two very often disjoint knowledge sets. This smart interface or the intelligent agent should translate data analysis results so that end users can understand them. Still, it should also translate the demands for information to data analysts. It does not mean it can replace the experts on either side, but it can take some workload from them.

Furthermore, the agent should be able to learn from the data as well as from the human inputs and responses. For example, suppose a data analyst provides results on students at risk. In that case, the output can be generated in such a way that the report consists of the data (numerical and visual) that the end user can easily understand but should also include a projection of the result on the HEI performance, which again should be such that end user can easily understand it. Furthermore, when identifying students at risk, data analysts gain useful data on the characteristics of future freshmen, so that information should also be forwarded to the recruitment department as input. Therefore, to create an intelligent agent as an upgrade for the existing HEIs' information systems, one should carefully link the processes from the information flow point of view, add the underlayer of the existing data, and an overlayer of the departments, involve data analysts and specialists from the departments, install the agent and let it start learning, and hope for the best. The good thing about upgrading HEIs' information systems with intelligent agents is that most work is already done through various research on data

analysis and university processes, quality assurance reform, and other processes of higher education development worldwide. Furthermore, the rise of intelligent chatbots also raised awareness of the possibilities of AI. In essence, it has shown the whole world how far semantic analysis has progressed to the benefit and fun of everyone willing to board the ship of an AI-supported future.

IV. CONCLUSION

Machine learning and artificial intelligence are among the fastest-growing scientific disciplines worldwide, becoming the foundation for research in various fields. Research in higher education management is catching up with the trend, but it seems that the dominant drive for research is individual research interest, supplemented by data availability. That naturally leads to the conclusion that HEIs' management, even if the most important data user, still prefers a less automated approach to data-driven decision-making. Furthermore, this implies that since there is a lack of strategic planning for machine learning-supported decision-making at the highest level, there is scarce research on some of the processes. So the answer to the first research question is that while there is research on the potential use of ML for some key HEI processes, there is no research on the synthesis of all of them. The most explored machine learning subprocesses fall into the teaching and learning category, with the examination process in the lead, which is again a consequence of individual drive for research. A strategic approach is visibly related to the subprocesses of KPIs and performance management, but such research barely reaches 34% of the published research. Only a small portion of research deals with how HEIs stakeholders use ML results to monitor and enhance key HEI processes, and they fall into the performance management subprocess.

The next step in adding data-driven intelligence to HEIs' information systems should be introducing intelligent agents based on models of key processes and their relations. That could help employees and students reach the goal of academic excellence less painfully and more efficiently.

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The Phenomenon of Academic Boredom Among Adolescents in the Digital World

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Abstract: This paper presents research with the basic goal of establishing the impact ICT use among adolescents in the Republic of Serbia, and of verifying the existence of a statistically significant correlation between this and their osećanje akademske dosade i njihovog odnosa prema obrazovanju. Within the framework of the use of ICT, that is, socio-digital engagement of adolescents, particular attention was paid to reading habits (classical vs digital), multimedia perception and life on social networks. This research was conducted by examining the opinions of 14-19 year-old adolescents regarding their use ICT tools, the Internet and social networks, and their relationship related to education and they feel academic boredom. The results were obtained from 599 questionnaires consisting of 45 questions distributed among a representative, focused sample of adolescents: seventh and eighth-grade primary, grammar, and high school pupils in the Republic of Serbia. Data processing included a descriptive, correlative and regression analysis which showed that academic boredom among adolescents is related to their socio-digital engagement. The obtained results provide a foundation for the prediction of educational strategies regarding mandatory ICT integration in teaching courses, and the implementation of ICT in realizing teaching content.

Keywords: digital reading, multimedia, social networks, education, academic boredom

I INTRODUCTION AND MOTIVATION

The primary motivation for this research proceeded from the now-firm opinion that young people's online activities may strongly reflect their offline behaviors and contexts [1]. Do today's teenagers really find classes boring? And do the modern technologies that adolescent members of Generation Z consume as part of their natural ecosystem have an impact on academic boredom? Understanding the development of children's affect, and how it operates in the social and school context, offers useful possibilities to impact and positively influence children's learning and achievement [2]. Academic boredom is a term used for a type of emotion related to school, learning, and curricular activities, and in recent years it has become a topic of interest for educational researchers. It refers to the type of motivational distraction experienced by students in schools during the performance of an academic task. School is associated with a place where boredom is certain and expected, a "necessary evil" that must be "endured". However, the primary research question posed in this research is whether academic boredom is related to the rich socio-digital engagement of students, which in the last decade is absolute, undeniable, unquestionable and can be said to be part of the natural ecosystem in which new generations are born and grow up.

II THEORETICAL BACKGROUND

A. Academic Boredom

Academic boredom is a complex and underestimated problem in schools in many countries [3]. Academic boredom and the perceived course experiences of final year Education Studies students at university. Academic boredom is a term used to describe emotion experienced in connection with school, learning and teaching duties, and has begun to enter the vision of educational researchers in recent years. Academic boredom is boredom experienced by students in schools and while they complete academic tasks and boredom is an important motivational driver, but it has received considerably less attention in educational research than other achievement emotions such as anxiety and enjoyment of learning [4]. Boredom is generally perceived as a kind of negative, deactivating, and activity related achievement emotions [5]. In the studies found, academic boredom is differentiated into epistemological, cognitive, social boredom or simply boredom of the teaching topic. Boredom is a unique emotional experience consisting of five dynamically interacting components: affective (unpleasant, aversive feelings), cognitive (altered perceptions of time, mind-wandering), motivational (desire to withdraw from the situation or change the activity), physiological (low arousal), and expressive (vocal, facial, postural expressions [6].

The relationship between academic boredom and EFL achievement: Examining the mediating role of behavioral engagement academic boredom has hurts students' academic outcomes. Such conclusions were reached by Putwain at all in 2018 in their research that enjoyment and lower boredom

predicted greater subsequent achievement and, in turn, greater academic achievement predicted subsequent greater enjoyment and lower boredom. Evidence of academic boredom exists. Can the predictors of academic boredom be clearly distinguished to influence their minimization? Can the intensive multimedia information consumed by adolescents be among the predictors?

One such research was in 2018, in which Serbia and 7 other countries (Bulgaria, Georgia, Hong Kong, Ireland, Mexico, Panama and Spain) were involved, participated of the Program for International Student Assessment (PISA) to provide robust and generalizable evidence on the specific association between boredom in academic settings and academic achievement [7]. The results showed academic boredom among large, representative samples of 15-year-old students. It is also interesting here to highlight the impact of ICT: students who make extensive use of ICT for leisure and for learning both at school and at home are more likely to express being bored in class and during self-study at home than students with little or no ICT use. The important role of teachers is emphasized. teachers' enthusiasm moderates the association between ICT use and boredom[4].

Environmental, functional, and attentional theories of boredom lead to different predictions about relative feelings of boredom while engaging in different academic activities – such as being in class in school and engaging in self-study at home – and while engaging in academic activities rather than non-academic activities – such as spending time with friends [4]. Also, research was conducted that related to pedagogical and methodical procedures that the student respondents singled out as the most influential. Sharp (2019) pointed out for example that one of the common methodical techniques traditional lectures with a perceived excess and inappropriate use of PowerPoint stimulates the actual onset of boredom more than other interactive forms of delivery [3].

B. Socio Digital Engament

Socio-digital engagement is a complex term that refers to the way of life of adolescents in the modern civilizational conditions of the 21st century and represents a socio-technical phenomenon involving people`s actions with digital technologies in an engagement ecosystem. Children are born, grow up, are educated, and mature in the digital ecosystem. They communicate quite naturally through technical media, physical devices, digital haptics, and platforms. Considering the context of engagement, a growing number of engagement studies examine engagement in online, digital, and virtual settings.

In the comprehensive study Children of Europe on the Internet [8] among children and young people, it was found that the majority of the surveyed students from Serbia (86%) use the Internet on a daily, which equates them with children and young people from other European countries. (98%) from the oldest age group (15-17 years old), according to their statements, access the Internet daily from a mobile/smartphone. The surveyed students spend on the Internet, on average, more than 3 hours a day, the oldest up to 4 and half hours. More than a fifth of students, according to their statements, spend up to 7 hours a day on the Internet on weekends, while two-thirds of them spend between 4 and 7 hours.

Socio-digital practices appear to have transformed how adolescents live their lives, as well as how they socially relate to each other and the world around them [9]. The question that arises is: does this changed way of everyday life increase the experience of academic boredom?

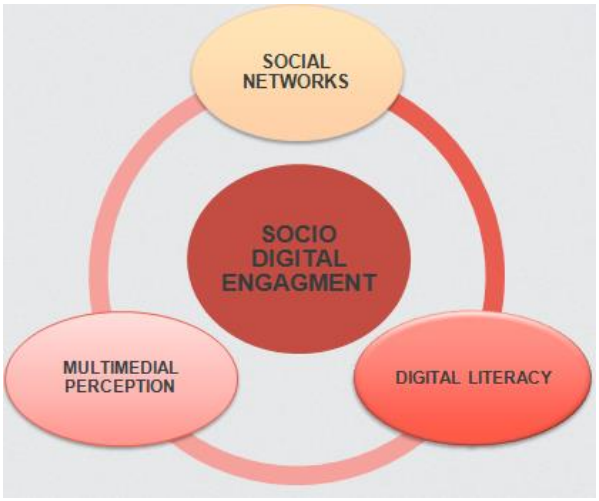

Figure 1. Socio digital engagement

III RESEARCH METHODOLOGY

A. Research sample

The research was conducted on students in upper grades of elementary school (7th and 8th) and high school. The sample consists of 599 respondents. According to gender, there are 329 female respondents and 270 male respondents, aged 14-19 years. The sample size is calculated as N>50+8xm (m=number of independent variables) 50+8x42=386, which in both cases shows that when looking at dimensions as variables and items, the sample size is representative. [10].

B. Research instruments

Data collection was carried out through an online questionnaire containing 45 questions. The first group of questions is general data on gender, age and place of residence (urban/rural). Further, the questions are grouped into 5 dimensions: general habits in reading books (BOOKi, i=1-7), inclination and habits in using digital text (DIGi, i=1-10), inclination and habits of using multimedia in learning (MMi , i=1-5), addiction in the use of social networks (SOCi, i=1-20) and BOR (BORi, i=1-8). The reliability scale was confirmed by Cronbach's alpha reliability coefficient of 0.866, which is considered good [11]. Data distribution by analyzing P-P plots shows that the data are approximately regularly distributed. The dimensions MM, DIG, BOOK and SOC were observed as independent variables while the dimension BOR was observed as a dependent variable.

C. HYPOTHESES

In accordance with the set research question, research objective and defined variables, basic and auxiliary hypotheses were formulated:

Basic hypothesis:

H0: There are statistically significant relationships between BOR and MM, DIG, BOOK and SOC

Auxiliary hypotheses:

H1: There is a statistically significant association of BOR with MM, DIG, BOOK and SOC.
H2: There is an influence of MM, DIG, BOOK and SOC on BOR.

D. Statistical analyses

Relationships between variables will be determined through correlation analysis and multiple linear regression. Pearson's correlation analysis will determine whether there is a statistically significant relationship between BOR and MM, DIG, BOOK and SOC. Multiple linear regression will be used to examine whether there is an influence of MM, DIG, BOOK and SOC on BOR.

IV. RESEARCH RESULTS AND DISCUSSIONS

Descriptive statistics of the variables are listed in Table 1. It can be seen that the highest values are for the MM and BOOK dimensions, while the other dimensions have slightly lower values.

Table 1. Deskriptivna statistika

	N	Min	Max	Mean	SD
MM	599	1	5	3,03	,943
BOOK	599	1	5	3,08	,920
DIG	599	1	5	2,88	1,032
SOC	599	1	5	2,88	,842
BOR	599	1	5	2,65	,879
Valid N	599				

The statistical association between the dimensions of BOR with MM, DIG, BOOK and SOC is shown through Pearson's correlation in Table 2. Statistically significant values are marked with *, and it can be concluded that there is a strong correlation between the observed variables. The correlation is at the 0.01 level, and depending on the sign, it can be determined whether it is a positive or negative correlation. It can be seen that BOR is significantly related to all dimensions, negatively with MM (-.245), BOOK (-.455), and positively with DIG(.127) and SOC(.333), therefore it is expected that there is the influence of independent variables on the dependent variable. It is also observed that there is no multicollinearity in this model, there is no multicollinearity between the independent variables, because all values are below 0.7. Based on the results of the correlation analysis, it is concluded that the first hypothesis (H1) is confirmed..

Table 2. Korelaciona analiza

	MM	BOOK	DIG	SOC	BOR
MM	1	,319**	,325**	-,013	-,245**
BOOK	,319**	1	-,020	-,132**	-,455**
DIG	,325**	-,020	1	,147**	,127**
SOC	-,013	-,132**	,147**	1	N
BOR	**-,245****	**-,455****	**,127****	**,333****	1

**. Correlation is significant at the 0.01 level (2-tailed).

To examine the influence of the MM, BOOK, DIG and SOC dimensions on BOR, a multiple linear regression was performed. The analysis resulted in 4 proposed predictor models, which can be seen in Table 3. The four models were reached by gradually adding predictors and thus the models were formed.

The first model consists only of the BOOK dimension and based on the R coefficient it can be seen that it explains 45.5% of the variance (BOR). In the second model, the SOC dimension was added and together with BOOK, they explain 53.2% of the variance. In the third model, in addition to BOOK and SOC, the MM dimension was added, where they together explain 54.4% of the variance. Finally, all independent variables were added to model four, which together explain 55.8% of the variance. This means that all four dimensions contribute approximately 56% to the model.

Based on the R square change, it is concluded how much each newly introduced variable contributed to the change in the model. It can be seen that BOOK and SOC contribute the most, while the values of MM and DIG are much weaker. In the ANOVA part, the models are presented as a whole, with all added variables, and SIG shows us that all models are statistically significant.

Table 3. Model Summary and ANOVA statistics

Model Summary				ANOVA[a]	
	R	**R Sq.**	**R Sq. Change**	**F**	**Sig.**
1	,455a	,207	,207	155,571	,000[b]
2	,532b	,283	,076	117,388	,000[c]
3	,544c	,296	,013	83,225	,000[d]
4	,558d	0,312	,016	67,195	,000[e]

a. Predictors: BOOK
b. Predictors: BOOK, SOC
c. Predictors: BOOK, SOC, MM
d. Predictors: BOOK, SOC, MM, DIG

The Coefficients table shows how much each variable contributes to the model. The last Model 4 is considered the most significant, where it is observed that all predictors have a significant Sig. that is, they have a statistically significant effect on the BOR. When observing the order of importance of the predictors, the beta coefficient is observed, which represents a unique contribution when the influence of other variables is removed. In model 4, it can be concluded that the dimensions BOOK (-0.363) and SOC (0.263) have the strongest influence, while dimensions MM (-0.170) and DIG (0.136) have a weaker influence. The validity of the model was confirmed by VIF and Tolerance values, where all values are > 0.10 for Tolerance and < 10 for VIF. Based on the regression analysis, it is concluded that the second hypothesis (H2) is confirmed, and therefore the first hypothesis (H0).

Table 4. Coefficients statistics

Coefficients					
Model		**Stand. Coefficients**	**Sig.**	**Collinearity**	
		Beta		**Tolerance**	**VIF**
1	BOOK	-,455	0,000	1	1
2	BOOK	0,433	0,000	,982	1,018
	SOC	0,276	0,000	,982	1,018
3	BOOK	-,379	0,000	,881	1,135
	SOC	,282	0,000	,981	1,019
	MM	-,120	0,001	,897	1,115
4	BOOK	-,363	0,000	,869	1,151
	SOC	,263	0,000	,961	1,040
	MM	-,170	0,000	,788	1,269
	DIG	,136	0,020	,860	1,163

a. Dependent Variable: BOR

It is interesting to consider the individual answers of the students. For example, to the very explicit and clear question "Are you bored at school?", 12.2% of them answered in the affirmative, and 78.05% in the negative. 9.76% of them are undecided. However, answers were received to indirect questions that lead to a slightly different conclusion. For example, with the statement: I like it when the teacher asks us to be active, almost 80% of them showed complete or partial disagreement. Also, 48.87% fully or partially agree with the statement "I don't really pay attention in class, I'm thinking about something else".

Exceptions to the interpretation of the given results refer to the limitations of the interpretation and use of the results: the research is based on the estimations of the examinees themselves, namely by using questionnaires. One of the limitations is the application of the research to easily accessible participants via a web questionnaire. In this way, the researcher has no contact with the respondent, cannot follow his non-verbal reactions and in a certain way the depth of the research is lost. Also, the limitation refers to the possible superficiality of the students and their lack of concentration on the questions, given that it is the age of adolescents who have a problem focusing.

CONCLUSION

The initial research question for the research is whether there is a connection and influence of socio-digital engagement and academic boredom among adolescents in the Republic of Serbia. The initial hypotheses about the existence of a connection between the use of information

technologies, i.e. socio-digital engagement of adolescents and the existence of indicators of academic boredom, have been proven. Statistically significant connections between these two variables were shown, as well as that socio-digital engagement can be considered a predictor of academic boredom.

However, the appearance of academic boredom cannot be exclusively linked to the influence of technology in students' lives, because the concept of boredom and its connection to schools has been present for decades, but it has only recently been scientifically researched. There are opinions that, although boredom is primarily considered a negative and frustrating emotion with negative outcomes, in the modern age it can become a creative potential [12], that is, that there is a significant function of boredom, which is to encourage the organism to search for alternatives. The contribution of this and similar studies is in the realization that these alternatives can go in many directions, thus also in the direction of unwanted and negative consequences, such as different types of incidents and violence. Timely detection of boredom among adolescents and careful planning of lessons, and we add monitoring of children's socio-digital engagement, is necessary in order to prevent demotivating situations, and is of the greatest importance because it encourages cooperation, school satisfaction and student success, and reduces the possibility of including students in various unacceptable behaviors, among which peer-to-peer violence stands out [13]. Also, future research would go in the direction of elaborating the elements of academic boredom and socio-digital aspects of the daily and academic life of adolescents.

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The Challenge of Modern Education - a School Without Mobile Phones

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Abstract: The development of technologies at the beginning of the twenty-first century brought many changes in the concept and approach to the educational process. In the first years of this century, efforts were made to digitize the teaching process as much as possible, and the purchase of devices for teaching purposes was primary for all actors of education. Already after the first decade, we reached the point where over 50% of students have a mobile phone, and at the end of the second decade, that percentage exceeded 90%. Now, at the beginning of the third decade, the question arises whether the mobile phone still has a place in school. The paper discusses the advantages and disadvantages of a complete ban on the use of mobile phones during the entire teaching day, the effects on the teaching process, social life and discipline of students.

I. I. INTRODUCTION

One of the forms of technology that is undergoing extremely rapid development and innovation in the 21st century is mobile phones. Their progress and revolution are based on the emergence and development of other technologies, such as communication technologies in general, computers and the Internet. Mobile phones today are called "smart phones" because they offer many diverse options for users and integrate a large number of functions and operations. They are usually used for communication, which was the primary reason for their creation, but they are also used for entertainment, business, spatial orientation, shopping, banking, information and education. [1]

In recent years, the use of mobile phones has become more frequent among younger minors, both at home and at school. The mobile phone has become an integral part of almost every child's life.

Schools are already seeing the need to limit the use of mobile phones or introduce strictly defined rules when and how they can be used. [2] From the idea that it becomes one of the basic teachings of the modern educational process, we come to the conclusion that it is actually one of the basic obstacles to the development and progress of young people. No device has experienced such wide and rapid application and use as the mobile phone. Its actual sociological impact on society is still insufficiently researched. Therefore, within the theoretical-empirical discussion of technology and society, it is imperative to discuss mobile phones as a separate and unique technology. [3] The adoption of mobile phones by young people is a global phenomenon of the last few years. [4]

Ling [5] points out that one of the most popular ideas when using mobile phones is that of providing the appearance of security and protection. It is also one of the main reasons that lead to buying and owning a mobile phone. Security and protection have become part of the social image of mobile phones, which we use when understanding and understanding the integration of mobile into our lives. [6] The desire for security and protection is one of the main reasons why parents want their children to have mobile phones. It is also the card that children play when they ask their parents to buy them a phone. [3]

We have reported the paradoxical nature of the sense of security and protection afforded by the mobile. They say that for an individual, a mobile phone can have both beneficial and harmful effects in terms of security and protection. The user can call for help or report an accident, but this will encourage many to engage in riskier behavior and consciously expose themselves to a potentially dangerous situation. [7] Possession of a mobile phone also reduces awareness, distracts the user's attention, slows reactions, and thereby increases the possibility of accidents, especially traffic accidents, which are very common among young people. [8]

One of the main disadvantages of using mobile phones among young people is the emergence of

digital violence. This can lead to unforeseeable consequences for the upbringing of all actors of violence. Cyberbully, as violence through new technologies is now modernly called, represents a new danger for young people, especially children. This type of violence includes any communication activity using cyber technology (sms, mms, photo or video, phone, mobile, and email, chat, Skype, web, blog) that can be considered harmful to an individual. This includes all forms of messages that make an individual feel threatened - it can be a text message, a video message, a photo, a call - that is, any repeatedly sent message whose goal is to insult, threaten, cause any form of damage to the owner of the mobile phone. New technology erases social inhibitions and allows the individual to say and do things they might not in face-to-face interaction, providing a false sense of security and power. Many experts, especially in the field of psychology, pedagogy and sociology, warn of a new scourge brought by the development of new technologies. [9] We have been warned that violence committed via mobile phone is often worse than that which happened face to face. Namely, when the abuser harasses verbally, the victim will often not remember every word addressed, while by sending a message, the victim exposes himself to violence every time he re-reads it. Also, mobile violence can happen at any time, and it is difficult to avoid it. [10] We can point out that the victim of violence through new technologies typically feels very powerless to refuse or fight against the bully. Even greater powerlessness is created by the possibility that the victim is attacked 24 hours a day, seven days a week and that in his own home, which is otherwise the greatest place of safety and protection. [11]

Using a mobile phone allows young people to expand their own freedom, but at the same time it also expands parental control and authority. It is very important to see the fact that the use of a mobile phone without full supervision in children can have incalculable consequences on growing up, social life, emotional and physical changes during growth and development.

II. The idea of a school without mobile phones

The idea of tarting an initiative for a school without mobile phones project came immediately after the Covid pandemic, as it was realized that the harmful effects of bringing mobile phones to school outweigh the positive effects on security control and improvement of teaching and learning. In the first stages, the prohibition of mobile phones was given as a recommendation for each teaching subject, by the teacher himself defining whether the mobile phone will be kept in the backpack or left on the chair. Here, the conclusion was reached that the desire to use the phone exceeds the desire to follow the rules for some students. Many cases of illegal use of mobile phones for the purpose of copying tests, using applications for "quick and easy" homework, recording illegal video and audio recordings of classes or various situations during vacations and posting content on social networks, as well as the inability to separate students from their mobile phones in class as a kind of addiction, led to the idea that the school should prevent these and similar situations by removing mobile phones from children during their entire stay at school. The goal would be to improve the concentration and attention of students in class, to promote socialization and interaction among students during vacations, to improve their spatial orientation and creativity, to direct them to look for information in places other than the Internet, and in general to point out that can "get through" a school day without a mobile phone. Therefore, the school joined the pilot project Schools without mobile phones, which was also supported by the Ministry of Education, Science and Technological Development.

With the beginning of the second semester of the 2022/2023 school year. The teachers' council, with the consent of the parents' council, decided to completely ban mobile phones from students in the school. Each school day begins with students putting their mobile phones in special boxes at the school security upon arrival at school and taking them after the end of the school day.

In the following chapters, we will present a qualitative assessment of this measure seen from the point of view of mathematics, physics and informatics teachers.

II. QUALITATIVE ASSESSMENT OF TEACHERS - ONE YEAR LATER

A. Mathematics teacher's view

The students' reactions were expected. Most of the students did not believe that this could happen even though it had been announced before. They believed that carrying a phone is their right that no one can challenge. It was a challenge to work with them during that period. They showed some kind of restlessness and uneasiness both in classes and during breaks. Results on control tasks and written tests were in decline. On the other hand, the collective awakening of entire departments was

noticeable. Interest in the material and participation in the class gradually grew. Also, from being estranged on vacations, we slowly moved on to a somewhat clumsy, but more frequent conversation. Students became more focused on each other and helped each other in situations when needed. Even in the case of written tests, they tried to remember the tasks in order to convey to their friends what was on the test, instead of taking pictures of the tasks in secret so that those working later would have time to do them, and then copy those solutions on the test.

On the other hand, the quality of teaching in today's age of digitization has undoubtedly declined. In mathematics classes, I often asked students to research a term or find a definition on the Internet in order to simultaneously point them to verified and unverified sources of information. That way of working proved to be interesting for the students, they absorbed information faster and easier, they competed to find a better definition or an example from life and they connected mathematics with the world around them. Also, I often used a platform like mozaBook to show them geometric bodies and their elements, then rotations of certain geometric figures and the formation of oval geometric bodies, relationships between lines in space or planes and lines, demonstration scales from phet applications as a model for equations or interactive construction board. They could watch it all on their mobile phone or tablet and try it out in class. Quick quizzes or assignments that I would leave on Google Classroom were always available for them to work on in class, which saved us time rewriting assignments or printing materials.

However, in a way, we won there as well. The students tried to write down all the definitions and tasks done in class, as well as the assigned homework instead of painting the blackboard and copying at home. They used the textbook more as the only means of finding information related to the lesson in class. The creativity and imagination initiated by the lack of digital means led the children to team up and make geometric bodies out of wire on their own that made it easier for them to complete tasks and understand space. They themselves initiated the creation of panels with different topics and areas of mathematics. Through the construction of irrational numbers, they created real small works of art that are now standing on the cabinet panel.

B. Views of teachers of informatics and computer science

During the 2022/2023 school year, mobile phones in informatics and computing classes were used for certain applications and platforms that enabled children to research information, take photos and videos that were later used for various school projects. By limiting usage, students are encouraged to focus more on the material at hand, and are encouraged to use their imagination and creativity. It has been observed that topics such as children's safety on the Internet arouse greater interest among children, because after a few months of reduced time spent on mobile devices, students have an increased dose of caution. Without the use of mobile phones, students often suggest to the teacher a lesson in nature and the use of certain teaching aids such as drones and Mbot robots in the school yard. Students show interest in participating in various IT workshops, where communication among students is in the foreground. Certainly, the use of digital devices in the modern world is necessary, so even in the classes of informatics and computer science, students are forced to use them. The difference between using mobile phones and computers in the office is that the computers in the office are not personalized, but each student has a uniform profile that can be used exclusively for teaching. Such computer use excludes any form of potential digital violence, and disables the distractions that phones can bring. Since students do not use mobile phones during other classes during the day, and do not have access to digital content, when they come to the informatics and computer science class, their interest in the content that they can have access to in class, which are exclusively educational in nature, is significantly increased. By the fact that the interest in the subject is greater, the productivity of the students is also greater. And so, during the preparations for the school day, the students also proposed the preparation of a collage that would present their view of digital technologies.

C. View of the physics teacher

It is my experience that students, when they are not denied the use of mobile phones, cannot break away from the influence of social networks and the games they play on their phones. This is one explanation for the trend towards less independent learning at home. We had the opportunity to see this at school in the past few school years. During breaks, and more and more often during classes, students stare like crazy at the screens of their mobile phones, not having the strength to resist this habit, even when we warn them about it. If no one at

home disturbs them from constantly looking at the mobile phone screen, students spend all their time on it, often at the expense of time needed for sleep. The habit becomes an addiction of epidemiological proportions.

The benefits of eliminating cell phones at school are great. Attention in classes is undivided, there are no isolated students staring at phone screens during breaks, we have completely abolished the possibility of secret recording and sharing on social networks, which is becoming a trend and a problem that is difficult to deal with. And which, unfortunately, continues when their mobile phones are returned, regardless of education about the dangers of such behavior.

Communication between students is visibly better, and there is also a great progress in communication between students and teachers. The number of inappropriate appeals to the teacher has decreased, which was expressed especially in situations where the teacher indicates the illegal use of a mobile phone. The number of unnecessary calls to parents for every little thing was also reduced, which disturbed both parents and teachers. Of course, the students are left with the option that, in justified cases, they can take their phone and call their parents.

It would seem that we have canceled the benefits of using modern technology in the classroom in this way, which is, of course, a huge shame. The use of mobile phones in classes is diverse and would greatly improve teaching. Unfortunately, the use of mobile phones in the classroom is also very difficult to implement. The reasons are that not all students have an available internet connection, we do not have the right to ask for a regular mobile phone, the installation of certain applications requires parental permission and the like. Even when the city handed out free tablets to students, since their service was not efficient, it quickly became apparent that their use in class was disrupting class dynamics. Until the awareness of the appropriate use of new technologies changes, until we find a way to counter the addiction to social networks and games, it is far more effective to deny students access to cell phones during classes.

III. CONCLUSION

A mobile phone, no matter how necessary it is today, should still be the privilege of adults. Children, although adept at using the phone, can find themselves facing serious challenges that they very often cannot cope with. Frequent forms of violence among children, antisocial behavior, attention and learning disorders can be overcome by restoring the once standard learning methods. By reading and playing, encourage companionship, empathy and a sense of belonging to the real world in which we live, and tear the child out of the imaginary world of the screen. A year later, we can see children talking to each other, running after the ball, playing and thinking.

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SCIENTIFIC PAPERS

Migration and Redesign of an Existing Website to a New Server

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Abstract - In this paper, the migration of a website to a new server is presented, what that process included, how it is carried out and what are the initial and final goals. The process of redesigning is also presented. The emphasis is on migration. The introduction introduces the reader to the issue of web content and presents why WordPress is different from other challenges. We will also get to know what hosting is and what is a domain and what their roles are. In the first part, emphasis on "migration" is given, what represents, how that process takes place and what are the benefits and goals that can be obtained after the completion of that process. The second part has already presented the redesign of the site and what that process includes. The conclusion recalls the main features of WordPress web content and the possibilities of its application.

I. INTRODUCTION

A website is a collection of publicly available, interconnected web pages that share a single domain name. These are online pages that you can view using the Internet and web services on a computer or smartphone. Websites can be created and maintained by an individual, group, business, or organization to serve a variety of purposes. The website is also known simply as "the site".

Together, all publicly available websites make up the World Wide Web (Information system that enables access to documents and other web resources over the Internet).

To understand this better, here is an analogy! Just like a physical "site" on land where we build a house and live, we create a website on the Internet and our information lives on it. And, just like the addressee of our house, our page will also have a unique address called a “web-address". With the web address, Internet users can easily find our website and access information on it.

These pages, known as web pages, contain information or services from businesses or organizations. Information can be in different formats such as text, images, videos, audio and animation, and services can be of different types.

A. What is a Wordpress Website?

A WordPress (WP) site is any site that uses WordPress as its content management system (CMS). WP powers both the back part of the site (the interface where the user logs in to make changes or add new content) and the front part (the visible part of the site that visitors see when they open the site).

The possibilities are endless when it comes to customizing WP sites. WP themes and plugins can add new design options and additional functionality.

There are several types of websites that can be built in WP, some of them are:

- Blog – provides information on various topics.
- Website for entertainment – watching movies, videos, playing games, etc.
- E-commerce website – provides product sales over the Internet and billing through an online billing system.
- News portal – readers are updated with the latest news.
- Education website – of schools, universities or independent academic organizations that provide information on various available courses or offer online learning materials.
- Website for business - clients browse, contact, and ask for offers that interest them, schedule meetings, etc.
- And many others.

Today, the possibilities for making money with WordPress range from running online stores to building websites for clients to consulting with WP. And on the part of the user or buyer, regardless of the scope of a business, blog or learning site, having a website is super important nowadays. This is understood because, often, they do online research before planning to study, buy something, etc. This means that it has a great meaning for clients, i.e., users, and for owners.

B. What is a Domain and Hosting

Domain and hosting are the two most important things needed to create a website. The website works when these two things work together. Domain and hosting can look very similar to beginners. But there are many different terms. We need a domain or hosting to have our website online, open and working. And the website should be "public" so that it can be accessed.

C. Difference between Domain and Hosting

In simple terms, the domain name is the name of our website on the Internet. We need to register the name of our site with a domain registration company to get a unique web address. Imagine that we have a phone book, where we mark the name of each person, and then their phone number. We're probably not going to remember all the phone numbers, are we?

So, every website on the Internet has a web address that locates the position on the website. When we enter the web address of the website into our web browser, the browser moves down the network, finds the location of the desired page and presents the information for us.

This is where web hosting comes in. The storage location where files and content are stored on our website is called web hosting. Hosting services are also called web hosts and servers. Basically, these special computers are in a remote location. They consist of huge memories and very powerful processors. Some of the popular web hosting companies are Hostinger, GreenGeeks, Bluehost, GoDaddy etc.

D. Domain Registration and Hosting with Different Companies

A frequently asked question is, should I buy a domain name and hosting from the same company? As soon as we explain what domain and hosting are, it is important to clarify this one. It is not necessary to order together.

The domain name is controlled by the domain registrar and works perfectly with any web hosting company. But there is a huge advantage to ordering our domain name along with a hosting plan. Although they work together, domain versus hosting are different things. Many of the companies also offer domain registration and web hosting plans. By choosing a hosting package, the domain name registration is automatically prepared and connected to the selected hosting plan. This is perhaps the easiest way to have our site online on the Internet.

II. WHAT IS WEBSITE MIGRATION

"Migration" can sound like a dangerous phrase. Some people will say "site migration" which means the whole process of moving from one website to another. For others, "migration" is moving content from one platform (your old CMS) to a new platform (your new CMS). CMS (Content Management System) is a software application that enables users to create, edit, collaborate, publish, and store digital content.

In short, migration in our case is moving an existing website from one server to another, that is, from one hosting platform to another. Migration is one part of a much larger project. Planning, designing, developing, and moving content all fall under "migration".

The most common form of site migration is moving from one domain or hosting to another. However, the transition from HTTP to HTTPS (for secure communication over a computer network) and changing the URL structure (page address) are also types of migration.

In some cases, site migration is necessary for our business and of course there are many benefits, but we need to be careful. Many mistakes can occur, which will have a bad impact on the site, traffic will be reduced by half, or we will change the usability of our site so much that your income will drop off the cliff.

Those risks may sound daunting, but they can all be overcome by following tried and tested site migration strategies - like the ones we will cover below.

With adequate preparation, even a huge migration of pages can achieve the desired result. Careful planning and precise organization are the keys to pulling off an efficient migration that sets our site up for future success.

A website migration is any change to the website large enough to affect indexing and search engine visibility.

That change can be a visual refresh, an update to the internal structure, a change to a new CMS or an update to the software or a change to the platform. Many platforms work on a system for software versions, so companies that use those tools may need to migrate every few years while new versions are published, which is the basis for that type. Site migrations fall into these main categories and may include multiple changes from this list:

- Change to content
- Structural changes
- Change to design
- Software upgrade
- Changing the platform

During the initial phase of planning the migration to the site, it is necessary to think about the elements of the huge picture, how the content management system (CMS), visual design and structure of the pages need to be changed. It will be necessary to take time before starting the whole procedure to review the design, structure, and tools and to decide what the site migration plan will cover.

- Setting expectations and goals

Any significant change to the entire site causes a short-term drop in traffic and should be prepared for that. Our goal should be to minimize the amount and for how long traffic on the site decreases. If our migration is done well, it will result in long-term traffic growth as errors are detected, corrected, and optimized.

Establishing a goal will not even help to direct our migration plan in the right direction. A well-organized website migration should have these three goals as its focus:

1. Preserving and optimizing for SEO and links

The goal of website migrations is to make necessary changes or improvements while maintaining search engine optimization (SEO). Also, we want to make sure that we keep the links active so that users can continue to find our site.

2. Migrating to the entire content

You must be sure that we won't lose any content during the migration to our site - no matter if it's images, text or the entire page.

3. Improving the design, performance, or functions of the website

If we focus our energy on the structure and content of our site, the migration is a good opportunity to adjust and improvements. And we evaluate our options and make decisions for visible changes - such as updating the visual design, improving the performance, etc.

The purpose of our migration of our already existing site from one host to another is to improve performance, in accordance with the most modern standards and the reason is more cooperation and familiarity with the GreenGeeks platform.

III. CHOOSING A NEW HOSTING SERVER

People constantly change their so-called web hosts, for various reasons. Some are simply dissatisfied with the speed or quality of content distribution systems. Others find the same quality of service at a lower price or with favorable payment terms.

If you find yourself in this situation that we already found ourselves in, then it is a good time to look for a better web hosting company. However, transferring our website can seem like a complicated task. But with a good analysis, explanation of the terminology, consideration of the issues and procedures, with step-by-step instructions, we can confidently proceed towards the realization of our set goal.

We spend a lot of time researching web hosts before choosing a new service. We read a series of reviews on the Internet and feedback from clients, we saw some of the deals offered by other hosting providers, their pricing systems, server configurations, etc. We aim to choose something suitable for our site.

A big decision should be made after finding a suitable new provider, we should consider that, at some point in the future, we may decide to switch from that hosting service as well. For this reason, it

is recommended that we register our domain with a third party, because this way, whenever we change web hosts, our domain will not be affected. There are companies in our country that offer web hosting, but foreign companies are more numerous. In our case, the choice for hosting went to a foreign company with which someone from our environment has been working for a long time and shared positive and quality experiences.

In our case we are talking about an already existing website, which was previously also hosted by the foreign company Namecheap. But because the site was previously maintained by another registrant it was not only necessary to change the current registrant to another, but also to change the web hosting provider, which in this case would be GreenGeeks.

IV. MIGRATION PROCESS

At the beginning, an additional domain (subdomain) was added, which the system stores as part of our main domain name. This was done with the aim of returning the same name to the domain as it was before, that is, to take away the current temporary name.

Installing WordPress is not difficult; however, it will take some time. We have hosting from GreenGeeks, where installing WordPress is very easy and takes a few seconds.

Access to the back end of the site was taken over by the previous registrant. With successful access to the so-called background part of the site, we can see everything that is available there. The site was created with the help of Avada themes and several plugins. For direct announcement and editing with the help of WordPress, it is only necessary to add /wp-admin to the URL of the site, where with the username and password we directly access the back end of the site.

A zip file with a licensed migration plugin has been added to the WordPress dashboard using the Add New option in the Plugins section. For more reliable and trouble-free migration, we used a special licensed plugin (WP Migrate), because with manual switching the procedure is longer and mistakes are possible. A plus reason for that decision was that manual switching requires importing the database and files through the terminal.

After add-on installation, the next step is to select everything that needs to be moved starting from the database. First, the connection information for the site from which the files and database should be downloaded so that they can be migrated is completed. Whether moving the site to a new server or from one platform to another, the process is the same. The only thing that is often mentioned is that it should be noted that there may be a maximum file size allowed for uploading, which is not the case with us.

After providing the necessary information, the migration is started with the transfer to the database (1), mobile attachments (2), themes (3), plugins (4), all other files (5). With the last transfer of all files, the site was transferred successfully.

Previously, the domain of the site was from the Macedonian platform MARNET, from which, when we sent a request to change the domain data, we received an EPP code with which the transfer of the domain could then be performed. When we tried to transfer the domain to another platform, only the EPP code was enough, which made the transfer successful.

The last and most important step in the entire migration procedure was the email follow-up to Support on the new server to change the name of the primary domain to the original domain.

Along with that, the domain was pointed to the hosting platform, that means connecting the domain to the hosting to make the site work. Finally, an SSL certificate (for a secure connection between server and client) was installed on the server which ensures that the domain name in the certificate matches the domain name of the site being visited. With that, the site is now https.

V. SITE REDESIGN

Redesigning a website generally implies a huge renovation on the pages focused on optimizing the content and structure to improve the user experience.

The theme with which our site got its overall appearance is Avada Builder. Avada has intuitive visual front-end design and editing tools to quickly create beautiful websites. It has a highly advanced grid with the option for easy customization without changing the code, graphics with ultra-high resolution, it has an automatic update on the theme directly through the administrative interface on WordPress and many others. The best part is that you can design anything without adding a single line of code.

In addition to the background part, there is an Avada Live Editor option, which was actually created to complement the default interface for building, and so the site, in addition to being able to be edited in the background in the Dashboard (back-end), can also be edited directly through Avada Live when your change is immediately visible before it is saved as a change (front-end).

VI. CONCLUSION

A website is compared to a book, where each page corresponds to a website. The website presents a kind of collage consisting of various contents: texts, images, sounds, animations.

The emphasis is placed on the site migration, which would safely lead to the conclusion that with adequate preparation, even a huge migration of the pages can achieve the desired result. Careful planning and precise organization are the keys to pulling off an efficient migration. In addition to the accuracy of the migration, good website design is also essential in today's web development.

All of this is very important for successful work, and all of that depends the most on the ideas and sensibility of the author.

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Programming Drones in Elementary Education

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Abstract - This paper presents the use of drones in primary school education from the perspective of using different programming languages and applications. The Tello drone is shown as the most used for programming in elementary schools. Three programming languages and four applications used for programming the Tello drone were analyzed. The analysis showed that the most convenient to use is the DroneBlocks application, which is based on visual block programming, while for textual programming it is recommended to use the PyCharm application, which is based on the Python programming language. At the very end, the necessity of recognizing the need to introduce programming, as a separate subject, into primary education as part of the Education Development Strategy in the Republic of Serbia until 2030 was defined.

I. INTRODUCTION

An unmanned aircraft is an aircraft, the crew of which is not in the aircraft, and which is controlled remotely or whose flight is autonomous [1]. An unmanned aircraft is also called an unmanned aerial vehicle (UAV) or drone. At the beginning of their development, these aircraft were used exclusively for military purposes, while recently a significant expansion in the civilian sector has been noticeable. This was primarily due to reduced acquisition and maintenance costs, as well as wide application possibilities. Today, drones are used in industry, agriculture, transportation, education and many other spheres.

The Ministry of Education, Science and Technological Development, in cooperation with Rotary clubs, through the "For a better school" project, donated a large number of drones to elementary schools in the territory of the Republic of Serbia. These drones are primarily intended for application within the subjects of engineering and technology and informatics and computer science. In addition to controlling and filming a drone, from the mentioned subjects it is possible to deal with programming drones in various programming languages and applications.

This paper presents programming languages and applications that can be used to program drones. After the introduction, the second chapter presents drone models that are most often used in primary education. In chapter number three, programming languages are presented, which can be used to program the mentioned models of drones. The fourth chapter describes the procedures and ways of programming using the mentioned programming languages, using compatible applications. In the fifth chapter, a comparative analysis of programming in the mentioned programming languages and applications is presented. The conclusion and direction of further work and research in this area are presented in the last chapter.

II. DRONES IN PRIMARY SCHOOLS

According to the curriculum of teaching and learning in primary schools, drones are not studied as a separate teaching topic in any subject. However, due to their increasing popularity, many technical and informatics teachers cover them within their subjects with certain changes in the operational plan or within various sections or free teaching activities. The most common drone in elementary schools is the Tello model.

A. Tello drone

Depending on the equipment it has and certain integrated accessories, the Tello model has several versions, such as Ryze, Edu, Combo. Common to all versions is that the base of the drone is identical, and therefore its basic characteristics. In education, the Tello Edu version is mainly used, which differs from the basic version by the built-in SDK 2.0. The picture below shows the construction diagram of the Tello brand drone.

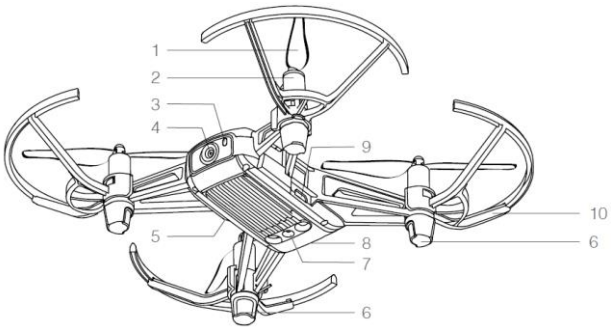

Figure 1. Construction of the Tello drone [2]

Figure 1 shows the following elements of the drone:

1. Propellers
2. Engines
3. Indicator
4. Camera
5. Power button
6. Antennas
7. Visual positioning system
8. Battery
9. Micro USB port
10. Protectors for propellers

The table below gives the specification of the basic characteristics of the Tello drone.

Table I. Specification of the basic features of the Tello drone

Maximum flying speed	28,8 km/h (8 m/s)
Maximum flight radius	100 m
Maximum flying height	10 m
Flight autonomy	13 min
Camera	5,0 Mpix
Interface	Micro USB Charging Port
Mass	80 g

The Tello drone is suitable for indoor use, both for control and programming. Small dimensions and solid maneuverability (agility) make it safe for use in larger cabinets or gymnasiums. If it is used outside, it is necessary to check the weather conditions regarding the occurrence of wind. Due to its small mass and the absence of adequate stabilizers, the Tello drone is susceptible to the influence of wind.

B. Tello applications

Applications are used when controlling and programming the drone. An application with the same name as the drone (Tello) is used for control. In addition to the Tello application, the drone can also be controlled using the Keyboard Control module, which is available on the Drone Blocks application, if it is installed on the computer (as a Google Chrome extension).

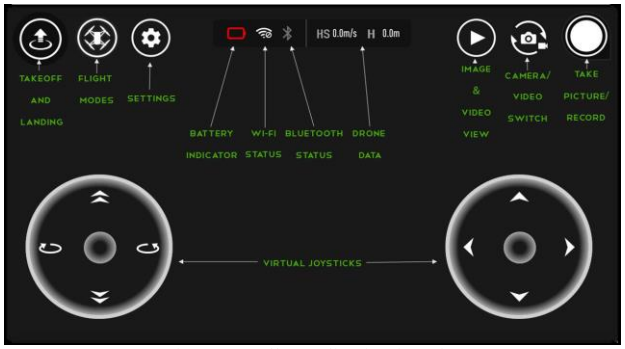

Figure 2. Tello application interface [3]

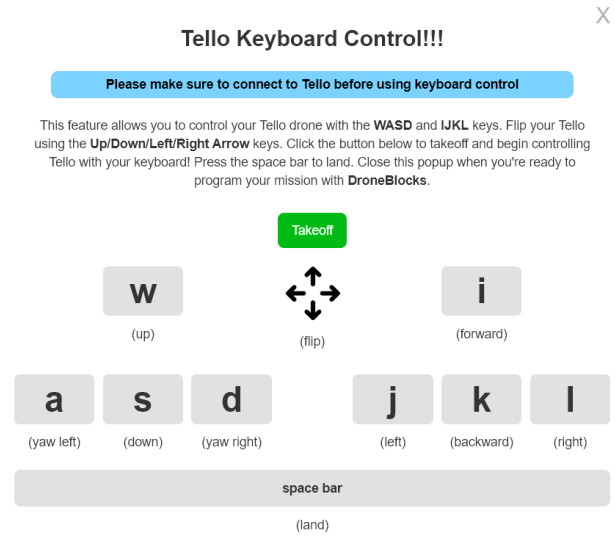

Figure 3. Keyboard Control module

It is possible to use several applications for programming, depending on the programming language used. For the needs of visual block programming, it is possible to use Scratch and DroneBlocks applications, and for text programming DroneBlocks Code (Java Script) and PyCharm (Python).

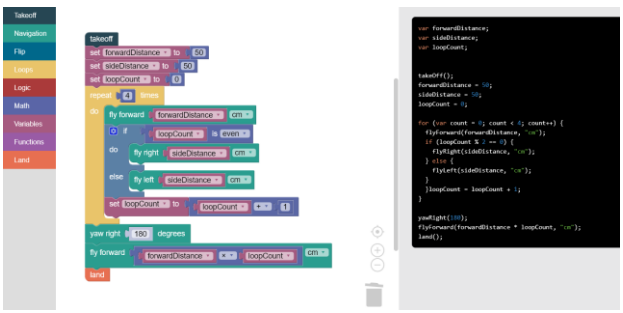

Figure 4. Interface of Drone Blocks and Drone Blocks Code applications [3]

III. PROGRAMMING LANGUAGES FOR DRONE PROGRAMMING

Analogously to the applications mentioned in the previous chapter, the Tello drone can be programmed in Scratch, Python and JavaScript programming languages. The mentioned programming languages are analyzed in more detail in the following subsections.

A. *Scratch*

Scratch is a high-level programming language. It is a visual programming language that contains elements of object-oriented programming. It enables easy sequence creation, synchronization of their work and mutual communication. It is intended primarily for children and students, but also for others who want to use programming as a way of creative expression. It is applied in education in the field of multimedia and programming [4].
Scratch is essentially a visual programming language, consisting of blocks of commands. Block programming significantly reduces the possibility of syntax errors in the program. Sets of block commands differ from each other in color, and the blocks themselves within the same set of commands differ in their shape [5]. Online and offline editors are used for programming in Scratch. Drone programming is only possible in the offline editor.

B. *Java Script*

Java Script is a dynamic, high-level programming language. It represents one of the leading technologies for defining content on the Internet. It is based on prototypes with first-order functions, which makes it a multi-paradigm language, as it supports multiple ways of programming. It is significantly different from the Java language, although it has certain similarities, such as syntax and standard libraries [6].
Java Script is the most popular scripting language on the Internet, and is supported by all major web browsers. It is also used for the development of video games, desktop and mobile applications as well as in server-side web programming with runtime environments such as Node.js.

C. *Python*

Python is one of the most widely used programming languages among programmers, designers, engineers, teachers and students. Python is also a good programming language for initial learning of programming. Its syntax is simple and it is widely distributed in educational systems around the world [7]. It is essentially an object-oriented programming language, which is written dynamically. It uses the Python interpreter environment and the Idle development environment. Both of these environments are provided on your computer after installation. Simpler programs are written in the Python interpreter, where feedback is immediately received on the execution of a line of code. IDLE (Integrated Development and Learning Environment) is used for creating, saving and executing more complex program structures [5].

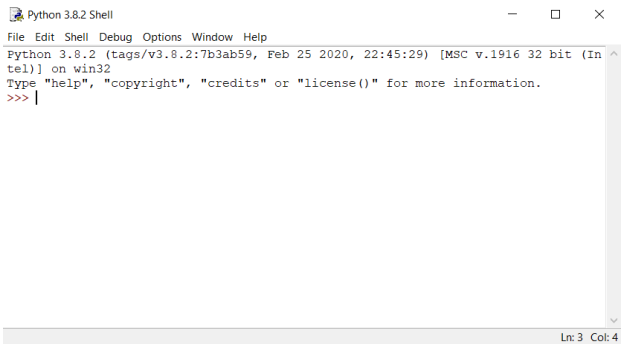

Figure 5. Appearance of the Python IDLE development environment

IV. DRONE PROGRAMMING

In this chapter, the ways of programming the Tello drone in the previously given programming languages, using the appropriate applications, are covered. Also, the necessary software preparation and installation, which must be done before programming itself, is presented.

A. *Programming in Scratch*

For programming in Scratch, in addition to the basic software (Scratch 2.0), it is necessary to install certain add-ons. The first plugin is node.js, which is downloaded from nodejs.org/en. It is an open source cross-platform Java Script environment. After that, you need to download the files Tello.js and Tello.s2e from the repository *dl-cdn.ryzerobotics.com/downloads/tello/20180222/Scratch.zip*. Tello.s2e is an experimental file with additional blocks used to program the drone. The

file is imported into Scratch via the file menu, holding down the shift key on the keyboard.
After that, it is necessary to open the location where the Tello.js file is saved in the Command prompt. The mentioned action is performed by typing "cd" in the command line, and after the space, the address of the folder where the file is located is copied. After confirming with the enter key, enter node - space - Tello.js in the next command line. After all the aforementioned actions have been successfully completed, you can start programming the drone in the Scratch program.

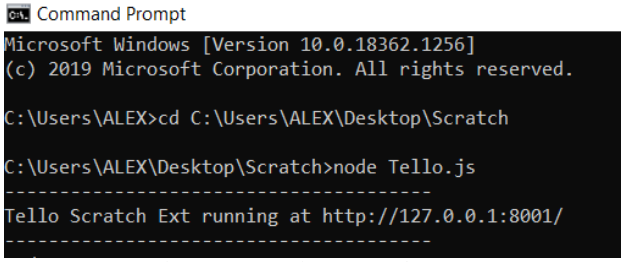

Figure 6. Setup via Command prompt

Scratch was not originally written for programming drones. Its main role is for students to acquire the basics of visual block programming. By combining additional blocks and blocks that the Scratch program already contains, it is possible to create specific programs. Below is an example of a program that controls the drone using a computer keyboard.

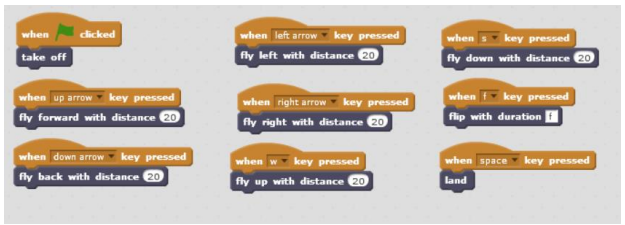

Figure 7. Control the drone using keyboard commands

B. Programming in Java Script

Programming drones in JavaScript can be done in two ways. The first method is visual block programming using the Drone Blocks application, and the second method is text programming using the Drone Blocks Code application. The Drone Blocks Code application can be installed on a smartphone or tablet, while the Drone Blocks application can be installed on a laptop or desktop computer through the MS Store in addition to the above mentioned devices. This function is very useful in teaching programming, because it allows students to work comfortably in computer cabinets. Also, applications installed on smart devices have their advantages, because they can be used directly in an open space, where a practical drone flight is demonstrated.

The Drone Blocks app has nine sets of block commands used to program the Tello drone. The variety of offered blocks allows the creation of different types of programs, from the basic level, through intermediate, and even advanced.

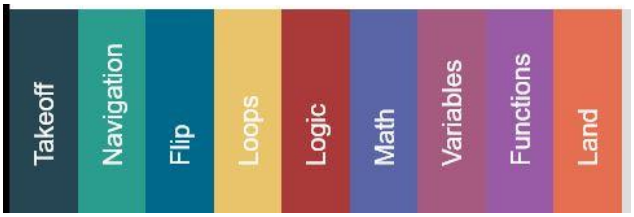

Figure 8. Command sets in the Drone Blocks app

From Figure 8, it can be seen that in the Drone Blocks application, in addition to the commands for taking off, moving, turning and landing the drone, it is also possible to use loops, mathematical and logical operators, variables and functions. All of the above makes this application an extremely powerful tool for developing student competencies in the field of visual block programming. Also, the Show Java Script Code option enables the direct conversion of blocks into text commands, which allows students to easily see the correlation between block and text programming.

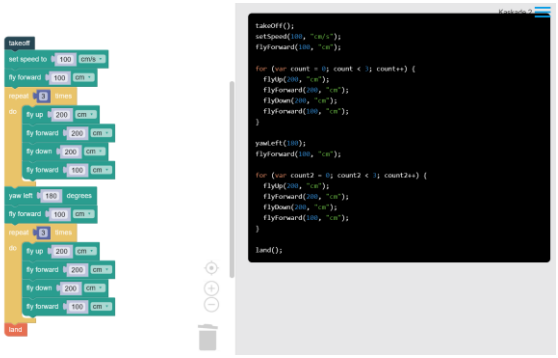

Figure 9. Conversion of blocks to text Java Script commands

C. Programming in Python

To program drones in Python, the PyCharm integrated development environment is used. However, as is the case with the Scratch programming language, it is also necessary to install certain plugins, which are required for programming drones, in Python. In addition to the PyCharm integrated development environment, Tello drone programming requires the djitellopy and opencv-python libraries, which can be downloaded from the

GitHub repository. After that, it is necessary to introduce the time library, which defines the waiting intervals between the execution of commands. Before starting to write the program itself, it is necessary to create the Tello object and connect it. The previous steps are shown in the image below.

Figure 10. Necessary steps before writing a program

The created object allows giving commands to the drone and reading the set value from the drone. For example, the get_battery () method is used to display the battery status. By clicking on the written method while holding down the CTRL key, it is possible to see all the available functions for programming a drone in Python, as shown in the image below.

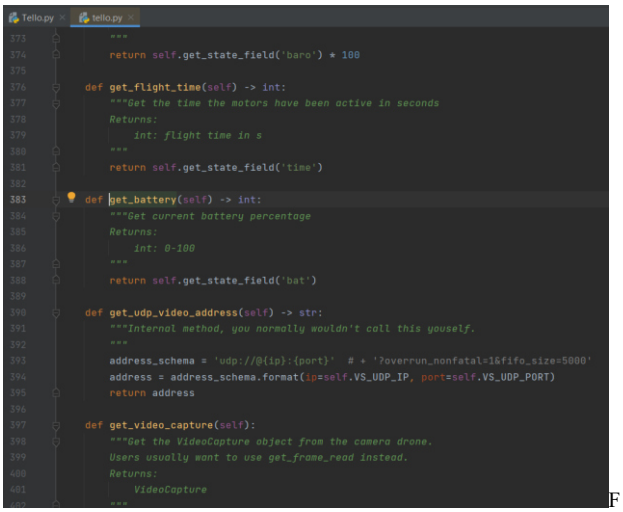

Figure 11. Part of the available programming features

Figure 12. An example of a written program

V. COMPARATIVE ANALYSIS OF DRONE PROGRAMMING APPLICATIONS

This chapter provides a comparative analysis of previously presented applications and programming languages. The analysis was performed according to the following criteria:

- Ease of installation
- Intuitiveness of the user interface
- Ability to use on different devices
- Connectivity with the drone
- Representation of visual block and text programming

Table II. Analysis of programming in Scratch

Criterion	Comment
Ease of installation	The software is downloaded from the official website, after which needs to be installed on the computer. Additional files are downloaded from the open repository. After importing the files, it is necessary to make a connection in the Command prompt so that the program has a connection with the drone.
Intuitive user interface	Additional imported blocks specific to drone flight programming are located in the more blocks group. Other blocks such as operators, loops, and variables are found in the basic program groups.
Possibility of use on different devices	The program can be used on laptops and desktop computers. Smartphones and tablets are not supported.
Connectivity with the drone	Errors often occur when connecting to the drone.
Representation of visual block and text programming	There is no possibility to convert to text programming code.

Table III. Analysis of programming in PyCharm/Python

Criterion	Comment
Ease of installation	The software is downloaded from the official website, after which it needs to be installed on the computer. Additional files are downloaded from

	the open repository. After importing the files, it is necessary to make a connection in the Command prompt so that the program has a connection with the drone.
Intuitive user interface	Intuitiveness is appropriate for a text-based programming environment. The list of available functions for drone programming is easily reached.
Possibility of use on different devices	The program can be used on laptops and desktop computers. Smartphones and tablets are not supported.
Connectivity with the drone	Connectivity with the drone is excellent. The settings are saved even after exiting the program and turning off the computer.
Representation of visual block and text programming	There is no possibility of conversion to a visual program block.

Table IV. Analysis of the programming in the Drone Blocks application

Criterion	Comment
Ease of installation	The application is installed from the Play Store or App Store on a smartphone or tablet. An application from the MS Store is intended for a laptop or desktop computer.
Intuitive user interface	The interface is extremely intuitive. Contains only blocks intended for drone programming.
Possibility of use on different devices	The application can be used on a smartphone, tablet, laptop and desktop computer.
Connectivity with the drone	Connectivity is excellent. It is established by clicking the appropriate button.
Representation of visual block and text programming	Visual blocks can be converted into text commands by selecting the appropriate option. On that occasion, an additional window is opened that remains open and on it it is possible to dynamically monitor changes in the code during changes in the blocks themselves.

Table V. Analysis of the programming in Drone Blocks Code application /Java Script

Criterion	Comment
Ease of installation	The application is installed from the Play Store or App Store on a smartphone or tablet.
Intuitive user interface	Intuitiveness is correct.
Possibility of use on different devices	The application is intended for smart devices only.
Connectivity with the drone	The connection is established automatically after connecting to the drone using the Wi-Fi network.
Representation of visual block and text programming	There is no possibility of conversion to a visual program block.

From the previous four tables, it can be seen that the most suitable application for programming drones is Drone Blocks. Installation is simple and no additional files are required to import. It can be used on different devices, such as laptop and desktop computers, smartphones and tablets. The intuitiveness of the user interface is at a high level because it only has commands adapted to drone programming. Connecting to the drone is done without any problems, and the ability to convert visual blocks into text commands and their comparative review is of great importance when working with students.

However, as the teaching and learning plan for the subject of informatics and computer science stipulates that the sixth and seventh grade of elementary school learn the programming language Python, programming in the Drone Blocks application alone is not enough to achieve the prescribed outcomes in these grades. Considering the above, it is expedient to use the PyCharm application. In addition to the slightly more demanding installation, it has a good intuitive user interface, as well as a connection with the drone. Once set connection parameters are permanently saved, and it contains a large number of functions for programming drones.

VI. CONCLUSION

Programming drones is an interesting approach, with the help of which students can acquire competencies in the field of programming. The Tello model is flexible, programmable and adapted to educational processes, so it is recommended to use it for these purposes.

Also, the wide range of applications and programming languages that can be used to program the Tello drone makes it even more user-friendly. Of all the presented applications, the analysis showed that DroneBlocks and PyCharm applications are the most useful for programming drones.

The DronBlocks app makes drone programming accessible to students through visual block programming with a very simple interface. After connecting to the Wi-Fi of a laptop, tablet or smartphone, students can start their current or already formed flight missions directly on the drone. Also, its dynamic connection with the Java Script language, which is one of the most powerful and flexible programming languages on the web, will enable students to master the fundamental steps in object-oriented programming [8].

The PyCharm application, on the other hand, enables students to acquire knowledge from the textual way of programming in the Python programming language. In this way, competences from object-oriented programming are developed at a higher level.

Regardless of the fact that drone programming is a very attractive and useful activity, its

implementation in the classroom is accompanied by numerous difficulties. Namely, since there is no special subject of programming in elementary school, it is studied within the subject of Informatics and Computer Science, the space for the realization of teaching content from programming drones is very narrow. In the implementation itself, teachers have difficulty in including drone programming in the annual fund of 36 hours in the subject of Informatics and computing, of which only 50-60% are related to the field of programming [5]. Therefore, they are forced to perform this activity often within various sections and free teaching activities.

Due to all of the above, the logical question arises whether it is necessary to reform the curriculum of the second cycle of basic education and upbringing, by introducing a new subject of programming. In this way, teachers would be able to implement all standard and innovative teaching content in a comfortable way, not only related to programming drones, but also microbit devices, Mbot robots, etc. As the mentioned problem is in the domain of a higher (strategic) level of consideration, there is an inevitable need for the relevant ministry (of education, science and technological development) within the framework of the Strategy for the Development of Education and Training in the Republic of Serbia until 2030 [9] to comprehensively analyze this issue as well . Further research by the author of this paper will move in the direction of applying artificial intelligence in drones.

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Statistical Analysis of Knowledge for Topic Complex Numbers of Students From the First Academic Year

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Abstract - Students who decide to study at a technical faculty must be well prepared for all mathematical topics. Many of the students, at the beginning of their studies when they encounter math problems with complex numbers, face difficulties in solving them, even though they have already studied complex numbers in high school. In this paper an analysis of the knowledge of the topic complex numbers, of the newly enrolled students at the technical faculties at University Goce Delchev Shtip, is made. The need for such an analysis was realized a few years ago when it was observed how first year students had problems when complex numbers were mentioned. With an appropriate statistical analysis, we wanted to assess how well the students know how to solve problems with complex numbers, what they find most problematic when learning the subject of complex numbers and what difficulties they face. Based on the results of the analysis, we will offer a solution to overcome the problems that students face when solving problems with complex numbers.

I. INTRODUCTION

Every year at the technical faculties, it can be observed that enrolled students are with different knowledge about the topics they studied in the subject of mathematics. We concluded that every new year are coming students who, when complex numbers are mentioned, get confused, do not remember what they did in high school and encounter a problem when solving tasks. Complex numbers are a mathematical topic that students are introduced to for the first time in high school. This topic is quite abstract for students, because complex numbers are not the kind of numbers that students face in their daily life. Our experience with new students at the technical faculties at University Goce Delchev Shtip, led to the conclusion that students have a hard time learning the lessons of this topic. In order to change that, we got the idea to complement the classic approach to learning this topic with the mathematical software GeoGebra. The software is useful for visualization of the concept of a complex number, to find the module, power of a complex number, to present operations over the field of complex numbers, etc. GeoGebra is simple to use, free and supports solving problems with complex numbers. Software-assisted learning during mathematics teaching can be very useful in explanation of abstract terms. GeoGebra can be installed on a computer or can be used a web application. More about GeoGebra we can find in [1] and [2]. GeoGebra software is very popular in teaching mathematics [4]-[8]. The effect of use GeoGebra software in the achievement of students has been considered in [3]. About the importance of introducing new methods in learning, the importance of visualizing problems using software and the results of the same can be found in [9]-[12].

The main objective of this paper is to compare the knowledge that new students of technical faculties have about complex numbers before the beginning of their studies and after the lessons dedicated to this topic, during which the teaching is held with the application of software. We formed a group of students from the Technical Faculty of Goce Delchev University, with which we determined the knowledge of complex numbers through two tests, one before the beginning and one after the teaching on the subject of complex numbers in the beginning of academic year. In this paper we will present the results of the two tests and their statistical analysis. Finally, we will present the conclusions of this analysis.

II. MAIN RESULTS

Complex numbers are topic that students of technical faculties must know, which is why it is included in the subject Mathematics 1 in the first academic year. On the one hand, the importance of its application in most areas of technology and engineering, as well as other disciplines of mathematics, and on the other hand, the increasing tendency of difficulties in solving problems with

complex numbers from year to year, were the reason to make a statistical analysis. Because of that we decided, along with the standard materials, to include GeoGebra in the study of this topic. The educational software which we decided to use was GeoGebra, primarily because it is free and on the other hand it is easy to use.

First, after studying the topic of complex number in secondary school and before the new students start with the lessons at faculty, we did a test on a group of 19 voluntarily enrolled students to see if the results were satisfactory for the topic of complex numbers. Basic information about the students in the group is given in the following table.

TABLE I. PRELIMINARY INFORMATION ABOUT THE STUDENTS

Group structure		***Number of students***
Age	18-21	14
	other	5
Gender	F	11
	M	8
Total number of students in the group:		**19**

For assessing of the student's knowledge, we've designed a test consisted of 10 tasks. Below is given a sample of the test.

Test sample

1. Write down the opposite and conjugate complex number of $z_1 = 2+3i$. **/5 points**
2. For $z_1 = 2+i$, $z_2 = 3-2i$ find z_1+z_2, z_1-z_2, $z_1 z_2$ and $\frac{z_1}{z_2}$. **/10 points**
3. Calculate i^{-125}. **/10 points**
4. Find the power $(1-i)^{10}$ **/10 points**
5. Represent the complex number $\frac{3-4i}{7+3i}$ in algebraic form. **/10 points**
6. Write the complex numbers $z = -1-\sqrt{3}i$ in trigonometric form. **/10 points**
7. Find the modulus of the complex number $z = (-1+i)^4$. **/10 points**
8. Calculate $\left(\frac{1-i}{-1-i}\right)^{1087}$. **/15 points**
9. Simplify the expression $3\bar{z}-2z+1$ if $z = -\frac{1}{2}+i$. **/10 points**
10. Represent the following complex numbers in the complex plane: $z = 3+4i$, $z = -3+4i$, $z = -3-4i$, $z = 3-4i$. **/10 points**

Except the first one, which carries 5 points and the eighth, which carries 15 points, the other tasks are 10 points. Total number of points from all test tasks are 100. Students had 60 minutes to solve the test.

The results of the testing with which we wanted to assess the students' knowledge of the topic of complex numbers from secondary school are shown in the column "Points from first testing" of Table II.

Since the results were not the satisfactory, we decided, before starting with the intended content of the subject Mathematics 1, to hold extra classes in which we will solve tasks from topic complex numbers using the GeoGebra software. Additionally, we decided to restudy the topic with the application of ICT.

Fig. 1 trough Fig. 10 show how GeoGebra can be used for solving the tasks from the Test sample.

To get the solution of the first task in GeoGebra, we created complex number z_1 directly in Graphics, with the Complex Number Tool. Then we use the command *conjugate* (z_1) which we enter in Input bar to get z_2. Finally, we make a Check box with the Check Box tool for z_1 and z_2 (Fig. 1).

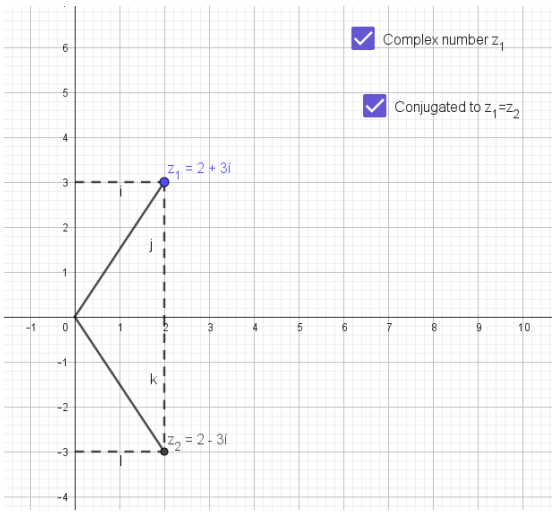

Figure 1. Solution of the Task no.1 with GeoGebra

For the second task we enter the complex number in Graphics and then in Input bar we enter $z_1 + z_2$, $z_1 - z_2$, $z_1 z_2$ and $\frac{z_1}{z_2}$. As a result we get the complex numbers z_3, z_4, z_5 and z_6 shown in Fig.2.

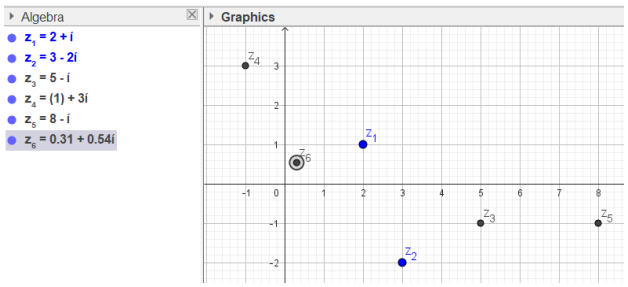

Figure 2. Solution of the Task no.2 with GeoGebra

For the third task we enter first the complex number z_1 and then in Input bar we enter z_1^{-125} and we get z_2. Check box for showing and hiding of z_2 is also made (Fig. 3).

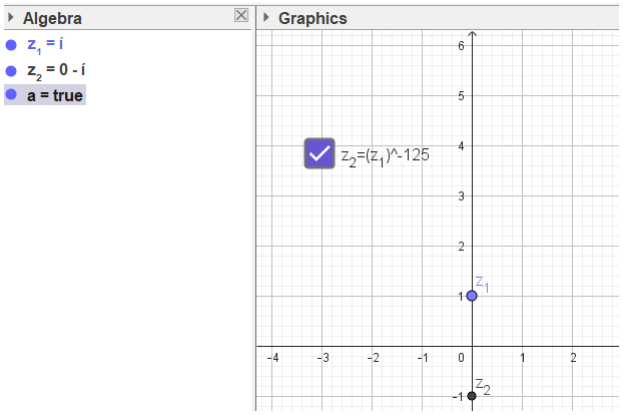

Figure 3. Solution of the Task no.3 with GeoGebra

For the fourth tasks we input complex number z_1 in the Graphics and then we got z_2 when in the Input bar we enter z_1^{10}. Check box for showing and hiding of z_2 is also made (as in Fig. 4).

In the fifth task, the complex numbers z_1, z_2 and z_4 are entered first in Graphics and then in the Input bar we enter z_1 z_2 and z_4 z_2 to get z_3 and z_5 respectively. In the end we enter z_3 / z_5 in the Input bar to get algebraic form of given number, z_6 (Fig. 5).

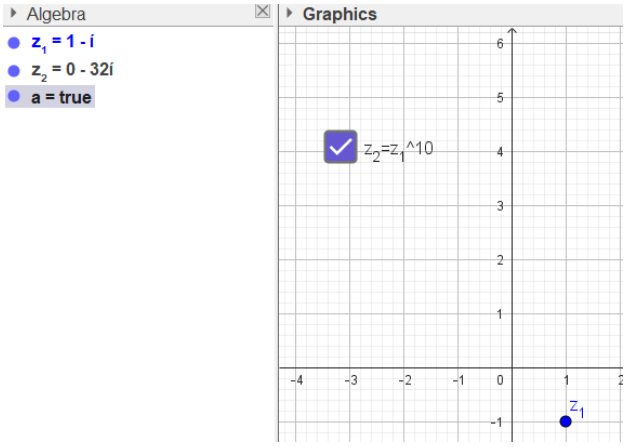

Figure 4. Solution of the Task no.4 with GeoGebra

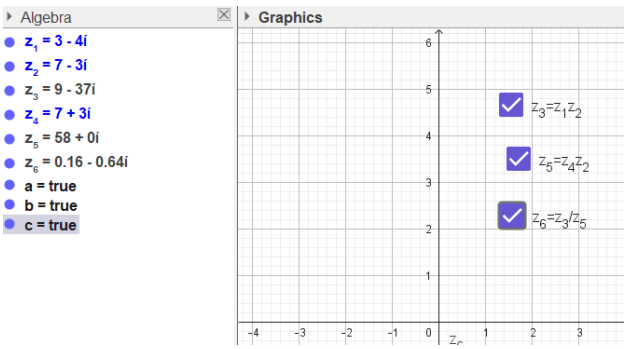

Figure 5. Solution of the Task no.5 with GeoGebra

In the sixth task we first find the modulus ρ. Then we find argument θ of z and we write the trigonometric form of z, by following the instruction are given in the static text in Graphics (as shown in Fig. 6).

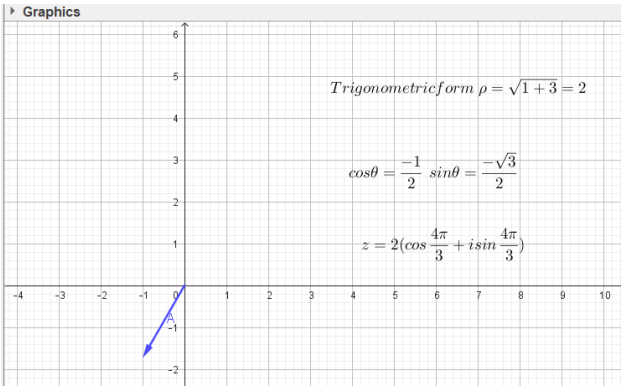

Figure 6. Solution of the Task no.6 with GeoGebra

In the next task 7 we enter complex number z_1 in Graphics and then we get z_2 after entering in Input

bar z_1^4. From z_2 it easy to get the modulus of z. (Fig. 7).

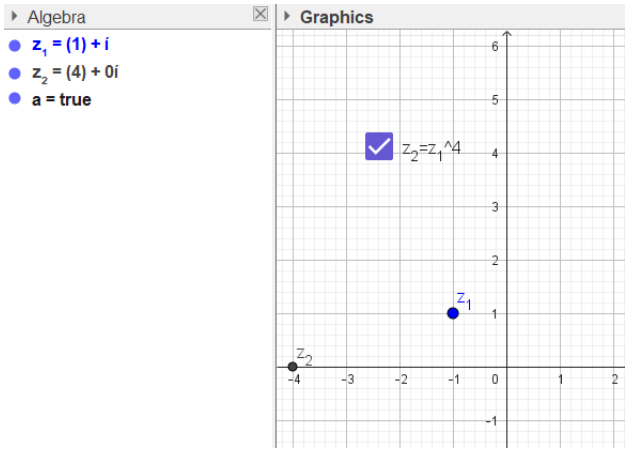

Figure 7. Solution of the Task no.7 with GeoGebra

For task 8 we enter the complex numbers z_1 and z_2 in Graphics. Then in Input bar we enter $(z_1 z_2)^{1087}$ to get z_3 which give us the solution of task (Fig.8).

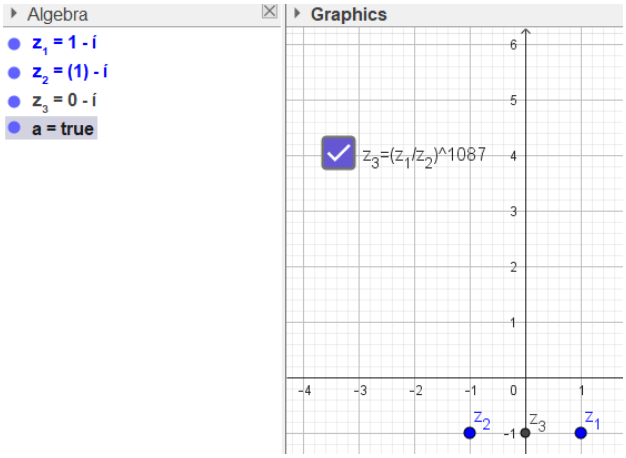

Figure 8. Solution of the Task no.8 with GeoGebra

In task 9 we enter the complex number z_1 in Graphics which is appropriate to z. Then we use the command *conjugate* (z_1) which we enter in Input bar to get the conjugate of z and we get z_2. In the end in the Input bar we enter $3z_2 - 2z_1 + 1$ and we get the solution of task (Fig. 9).

In task 10, the complex numbers z_1, z_2, z_3 and z_4 were created directly in Graphics, with the Complex Number Tool (Fig. 10).

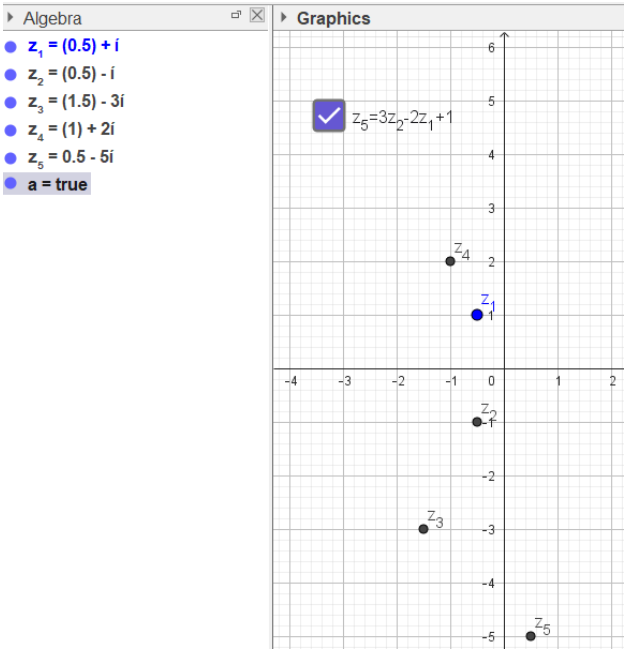

Figure 9. Solution of the Task no.9 with GeoGebra

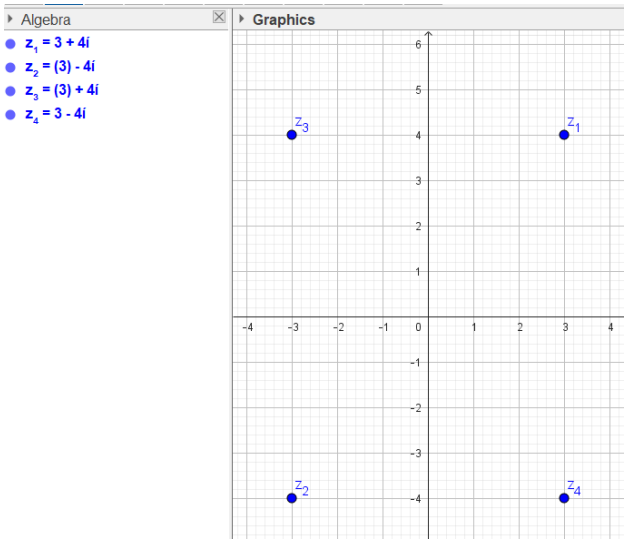

Figure 10. Solution of the Task no.10 with GeoGebra

After the classes in which tasks were solved with the help of Geogebra, as the examples listed above, we again conducted testing on the same group of 19 students. In the new test, the students had to solve the similar tasks as in the first test but now they had followed additional classes where they worked on tasks from the given topic using GeoGebra. When preparing for the new test at home, students could use the software to check the results they got when manually solving problems with complex numbers, and thus get motivation to work and solve a large number of problems. Solving time in the second test was also 60 minutes and the working conditions were the same as in the first test. Results of the second test with the same tasks with the first are

given in table 2 in the column "Points from second testing".

TABLE II. STUDENTS' ACHIEVMENTS ON TESTINGS

Student	*Student achievements*	
	Points from first testing	*Points from second testing*
1	100	100
2	71	96
3	79	92
4	100	100
5	55	90
6	65	68
7	89	100
8	65	75
9	91	93
10	100	100
11	38	59
12	65	65
13	34	41
14	30	33
15	62	78
16	70	92
17	43	51
18	100	100
19	27	44

From Table II it is obvious that the results after second testing is much better. It shows that the extra classes for the topic complex number in which tasks were solved with GeoGebra software helped the students to overcome the ambiguities and to improve knowledge about given topic.

To determine whether students' knowledge of the given topic can be improved if students are advised to use GeoGebra software when learning complex numbers, the following hypotheses were analyzed:

- **Null hypothesis**: There is no statistically significant difference between the achievements of students for the topic complex number in the beginning of their study in technical faculty so that they taught it in secondary education and the achievements of students after lessons for that topic in which are solved tasks with GeoGebra software in the beginning of study.
- **Alternative hypothesis**: There is a statistically significant difference between the achievements of students for the topic complex number in the beginning of their study in technical faculty so that they taught it in secondary education and the achievements of students after lessons for that topic in which are solved tasks with GeoGebra software in the beginning in study.

We performed a t-Test to test these hypotheses using the SPSS' Paired Samples T-Test for means comparison. The results are given in Table III.

TABLE III. PAIRED SAMPLES T-TEST

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	FirstTesting – SecondTesting	–10.15789	10.23210	2.34741	–15.08961	–5.22618	– 4.327	18	<0.01

Since the significance level Sig. (2-tailed) is less than 0.05, we have to reject the null hypothesis and we can say that there is statistically significant difference between achievements of students before and after the lessons in faculty in which the examples were solved with software.

Considering the results of both testing we can conclude that the extra lessons are very important and that it is good to advise students in learning the topic of complex number with the use GeoGebra. The t-Test shows that there was significant difference in the results of the students in the two testing before and after the lessons in faculty in which the examples were solved with software.

III. DISCUSION

Our research and its results gave valuable insights about the impact of the use of GeoGebra on the students' success and confirmed our opinion that

the impact will be positive. However, as any other similar research, it has certain limitations which should be acknowleged .

The study was conducted with a relatively small group of voluntarily registered students which may impact the generalizability of the findings to a broader student population. A larger group could provide a more comprehensive understanding of the effects of the use of GeoGebra on the students' success.

The participants in the study were from one academic year and one university. In order to obtain more relevant analysis, the study should be extended over a longer period, with students from other universities with similar syllabi. Proper control groups, a more diverse resources, alternative ways of implementation of GeoGebra into the teaching methods and different types of tests for the measurement of the student success, should also be utilized in the future studies of the impact.

IV. CONCLUSION

From Table II and Table III we can see that the application of ICT in the teaching of complex number is very important. The results confirm the general opinion that it is very important for students to have help in learning (in this case from the software). This is the only way they will get a greater desire to work, a greater interest in solving problems and thus achieve better results. The more thorough the students' knowledge is, the greater are the chances that they will apply it in practice successfully. Our research has also shown that it is good to use GeoGebra to improve knowledge and results on topic of complex number, and the t-Test showed that there was significant difference in students results in the two testings. The benefits and advantages of GeoGebra are enormous. Critical thinking, understanding and interest are much greater when working with this software compared to not using it, more knowledge is gained, tasks are solved more quickly and easily and excellent exam results are achieved.

With the help of GeoGebra, more students were motivated to study mathematics. The inclusion of GeoGebra, or any similar educational software in the teaching process brings many benefits such as facilitating learning, easier mastering of the material and achieving better results. Therefore, it is important to highlight the advantages of the use of educational software and its capacity to enrich the traditional teaching.

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Formative Assessment in Distance Education - Examples from the Primary School Practice of Technics and Technology

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Abstract - This paper aims to present the selected methods in formative assessment in the online learning process. The school subject can be any of the ones being taught in the primary school. The selected formative techniques are derived from learning outcomes based on Bloom's taxonomy. Teachers are constantly encouraged to improve their digital competencies to make the learning process easier, more memorable and more interesting for their students. This paper shows how any teacher can use ICT tools to achieve outcomes and improve students' performance and competencies.

I. DISTANCE EDUCATION IN TEACHING TODAY

Distance education has been around for more than two decades now all around the world. It encompasses many levels and forms, from the lower primary school to postgraduate courses. Students, as well as their parents, may choose distance learning for many different reasons. Schools, on the other hand, offer a wide variety of content, student support and types of examinations.

All school subjects can be taught through distance learning. In more communicative ones, however, like languages, both native and foreign, the physical separation of the teacher and students may present more of a challenge. The reasons for this are language-specific contents like fluency, intonation, listening and speaking practice, and the basic need for communicating a message. In subjects in which kinesthetic skills are the focus, like physical education, technics and technology, or art, where the physical presence and guidance of a teacher have a crucial role, distance learning has to be of such form and quality to replace that moment when touch and movement play the role in the learning process in students. To monitor their student's progress in these reciprocal activities, teachers are required to make an additional stretch and effort to make their learning activities brain-teasing and pleasing to students. This is true for all proficiency levels and ages, but especially more so for primary students. The reason is that in the traditional classroom, all four types of learners (visual, auditory, kinesthetic, tactile) [1] can be catered for. In distance learning, on the other hand, kinesthetic and tactile are, naturally, in the background, while visual and auditory take precedence. Cooperation, peer learning, pair work, small groups and short project-based tasks are a true dare both for teachers and students in distance learning circumstances. Due to all the above-mentioned reasons, students are much more dependent on their competencies and efforts. That is why it is a teacher's mission to make the learning process more interesting and enjoyable, as well as to encourage self-confidence and student autonomy. Assessment, as part of that process, in these circumstances should be an integral part of the process of learning, with precise rules of grading known to students. In this way, students are used to being assessed, but in a relaxed manner and grading serves its purpose - to motivate and direct students towards the desired goal. It should also not be too time-consuming for both sides, since the organization of time is a relevant issue in distance learning. This type of assessment should provide instant feedback and be repeated a necessary number of times. In distance learning, a good choice of a tool may successfully complement the teacher's role. One of the best methods for any type of learning is still through trial and error, only now we can have it digitized and enjoy it.

II. THE PURPOSE OF FORMATIVE ASSESSMENT

Assessment is a continuous pedagogical activity that positively determines the attitude towards learning and knowledge and encourages motivation to learn [2]. This implies that assessment of students' achievement and effort should be done regularly. The positive component of assessment suggests that the activity should come naturally and not be stressful to students and that they should regard it as a positive direction towards better academic results and self-confidence. Thus, assessment is an excellent way to build self-confidence and internal motivation in students, which are both a much-needed basis for success in any type of learning.

Formative assessment is a part of that process. It refers to a wide variety of methods and techniques that teachers use to assess the comprehension of their students on a topic or unit, to better understand their learning needs and to make future planning easier and more student-centered. It may vary from asking a simple question to check understanding of a general point to a short quiz to an elaborated self-assessed essay against a defined set of criteria. While formative assessments help teachers identify learning needs and problems, in many cases the assessments also help students develop a stronger understanding of their academic strengths and weaknesses. When students know what they do well and what they need to work harder on, it can help them take greater responsibility for their own learning and academic progress [3]. In traditional classrooms, these techniques are somewhat dependent on the physical presence of teachers and students. In distant learning, however, where physical presence is not a must, ICT tools are a very powerful means to achieve the same goal. Many ICT tools are, of course, used in traditional classrooms, but in distant learning, they hit the bull's eye - they are visually attractive, easy to replicate, time-efficient, and provide instant feedback.

III. BLOOM'S TAXONOMY IN A CLASSROOM

Bloom's taxonomy is a system that classifies cognitive skills and educational learning objectives. Created by psychologist Benjamin Bloom in 1956, this model arranges six levels of thinking into a hierarchy, from the lowest to the highest level [4]. The lower-order thinking skills are remembering (recalling facts and basic concepts), understanding (explaining ideas and concepts), and application (use of information in new contexts), while higher-order thinking skills would be analysis (drawing connections among ideas), evaluation (justifying an opinion) and creation (producing new or original work). Bloom's taxonomy can be used to plan new or revise existing curricula; test the relevance of course goals and objectives; design instruction, assignments, and activities; and develop authentic assessments [4]. The goal in any classroom is to develop higher-order thinking skills as much as possible and to master communication, whether oral or written.

IV. LAURILLARD'S COMMUNICATIVE FRAMEWORK

Professor Diana Laurilard of University College London developed six learning types. They are widely used in language learning, as they offer teachers a variety of different activities, i.e., cater for different needs of learning types. The framework comprises learning through the following: acquisition; investigation; discussion; practice; production and collaboration [5]. The essence of the framework is the attribute 'communicative', which makes it very practical and useful in foreign language classrooms, but also in any other as well.

V. EXAMPLES FROM THE PRACTICE IN PRIMARY SCHOOL

The age of the students in primary school can vary, but here we shall present the practice from the range of 10- to 14-year-old. We shall tackle various phases of a lesson, from the beginning to the end, as formative assessment may be part of any phase of a lesson.

Generally, in the introductory phase, a teacher would want to activate prior knowledge needed to understand a new point (Bloom's lower-order skill - recalling basic facts and concepts, or Laurillard's acquisition phase). Then, he would want the students to understand some new concepts so that they could explain them (Laurillard's investigation phase) and apply the knowledge in new situations (Laurillard's practice). Further on, higher-order skills come into the scene: the teacher expects students to connect ideas, justify their opinion on a matter and produce a new, original piece of work (which, in Laurillard, would involve investigation, discussion, collaboration and production).

In the context of the school subject Technics and Technology, which operates with a very true-to-life content, the aforementioned process would look like this, for example: a teacher activates prior knowledge on what a machine is. Then he revises types of machines. He wants the students to be able to explain the principles of their operation. Now the teacher would expect the students to connect the existing ideas and form and justify an opinion about what some machines new to students do and how, when,

where and why people use them. In the finals, students would design a new machine, individually or in groups.

Ideally, this lesson would be done online in real-time, on a platform which enables the teacher to present the lesson material visually and students to follow it. Another option is for the teacher to upload the material on a platform or some kind of classroom or online bulletin board (e.g., Edmodo, Google Classroom, ClassDojo, etc.). In this case, students review the material when they find it suitable and do the assessment tasks either in a defined time frame or according to the agreement with the teacher. Both options will be presented here.

VI. PRACTICE - BRING INTO ACTION PREVIOUS KNOWLEDGE

The teacher aims to activate students' prior knowledge of what a machine is. Students are expected to show practically that they can discern visually what a machine is.

Before the lesson, the teacher sets up a formative assessment task online. In the lesson, he asks the students to think about what a machine is and what it is not. After a minute or so of recalling, he sends the online task to the students to assess whether they can recall the information correctly.

Students are sent an online task to the designated place, e.g., Google Classroom. After that, students do the assessment task and show feedback to the teacher by presenting the results on their screens.

The formative assessment technique used in this activity is the online task that has self-assessment built into the exercise (https://learningapps.org). The students are shown ten photos, most of which are machines. Some of the pictures that are not machines contain an element of a machine, and only a few are not machines. In a situation when this is not done in real time, students can repeat the exercise as many times as needed until they have got a maximum score. Only then do they send the teacher their feedback. The teacher congratulates students who did well and suggests others revise the information from the working material presented before this lesson and do the task again.

VII. REMEMBER - RECALL FACTS OR BASIC CONCEPTS

Before the lesson, the teacher had already found an appropriate video online which explained the types of machines. Along with the video, the teacher has put several multiple-choice comprehension questions for students to answer. It can be a link to a Google form or similar. In a lesson that is not done in real time, the students can watch the video as many times as needed in their own free time. After that, they do the self-assessment task and send feedback to the teacher (a screenshot, e.g.).

To boost student autonomy, the teacher also asks several questions which should guide students toward self-assessment of their learning process: If you do not hesitate when you give answers, you have mastered the introduction. If you need to think a bit – watch the video again. If you are not sure about one or more answers – watch the video several times until you do not hesitate when you answer the questions. Next to the questions, write your process of giving answers according to the given criteria.

The teacher congratulates students who did well and suggests others watch the video again until they have the impression that they have mastered the presentation.

VIII. PRACTICE - BRING INTO ACTION WHAT YOU HAVE LEARNED

In a real-time lesson, a teacher would use a photo of a machine and explain how it works. In a lesson which is not real-time, before the lesson, the teacher had already created a short (1- or 2-minute) video in which he explained how a machine of his choice works and uploaded it in the Google Classroom, for example. In a real-time lesson, the teacher can ask orally several true/false questions. In a lesson which is not real-time, students are sent the questions in the form of a quiz. The quiz has the Submit or Check button which shows the correct and incorrect answers after being clicked. A good example is ww.flexiquiz.com. Again, the students send feedback to the teacher, by presenting it on the screen.

This is the level of the application of the newly acquired knowledge about how a machine works. Questions for self-assessment: How well did you do? Criteria: 10, 11, 12 correct answers – excellent; 8, 9 – very good; 7, 6 – pass; 5 or less – needs improvement. If you are not satisfied with your result, answer the question: What do you still need to know to score better?

The teacher commends students who did well. The teacher will re-teach crucial points, if necessary (50% of students or more did not pass), preferably in the following lesson.

IX. NVESTIGATE - COMPARE CONCEPTS

The teacher presents several new machines to the students. One of the ways is to show them a short

video (up to 5 minutes in length, because keeping the concentration in students is one of the key challenges in real-time teaching), pause at key moments and ask students to answer their questions orally. The questions concern what some machines new to students do and how, when, where and why people use them. Next, he would ask them to compare two machines used for the same type of activity, e.g., lifting packages of different weights and consistency. In a real-time lesson, he may pair the students and give them five minutes to agree on this point - which machine they would use in a specific situation and why. The students can use Google Meet or Viber video call and discuss the point. This requires collaboration, efficiency, knowledge, and justification. When the time is up, the students go back to the lesson and discuss the answers with other pairs and the teacher. The formative assessment technique here is discussion, which is an excellent way to boost communication and collaboration even in the situation of physical distance. In a lesson which is not real-time, students can pair up in the same way, type the answer (2-3 sentences) and send it to the teacher.

The self-assessment technique which can be used after this activity is Traffic light: Answer the question: Was the exercise difficult? Criteria: red – yes; yellow – not much; green – no. Think and answer the question: What can you do to improve?

The teacher congratulates students who did well and suggests others revise and do the exercise again until they are satisfied with their results. The teacher will analyze the feedback and re-teach only the points which are not clear, if necessary.

X. CONSTRUCT

This is a higher-order thinking skill, which requires the students to use all the previous knowledge and, depending on the student's abilities, creativity and entrepreneurship skills.

During the real-time lesson, the teacher explains the tasks. There are three tasks: an easy one, one that is of medium difficulty and a hard one. The teacher forms groups of three students, based on the principle of their knowledge and skills in that particular school subject (so that they are not homogenous groups according to that criteria). An easy task would be to create a quiz (an online one, preferably) for other students about the key points during the lesson. Before sending it to their classmates, the group would send the quiz to the teacher for review. A task of average difficulty would be to improve the possibilities of an existing machine (draw it and explain upgrades). A hard one would be to design a new machine for a specific purpose, e.g., planting trees (draw it and explain what its functions are). This would require a greater amount of time, e.g., 20 minutes during a real-time lesson. In a lesson which is not real-time, the teacher can define a deadline of several days for students to come up with their answers, draw designs, create videos with explanations, etc. This would be a project work in an online educational setting.

A very important point here is peer learning, which is much needed in an online educational setting. Children need children to thrive and fulfil their potential in a familiar environment, i.e., their friends.

The formative assessment here is the presentation itself. It will show all the accumulated knowledge and skills.

The self-assessment technique which can be used after this activity is: How difficult this was: thumb up, thumb down or smiley with a flat mouth. Analyze in your group what your greatest problem was. Ask the teacher for additional explanations.

The teacher congratulates students who did well, answers the questions and analyzes the feedback. At this point not many revisions are expected.

If a lesson and exercises are sent to the students via a platform, the formative assessment feedback that students receive from the websites can be collected into one post or email for easier organization of communication and for the sake of time-effectiveness.

CONCLUSION

Online tools in formative assessment are widely used, practical and interesting for students. In online education, they are essential. For that reason, the forms of assessment should be various, to cater for the needs of all types of learners. Polls and quizzes created with Quizizz, Socrative, Gimkit, and Google Forms are user-friendly and not too time-consuming for both teachers and students. In primary school, where learning techniques are still being developed, it is advisable to have a range of different techniques and keep the assessment interesting, short and to the point.

The presented techniques for formative assessment in online education settings are suggestions from the practice of the subject Technics and Technology in the seventh grade of a primary school. The methodology behind them is Bloom's taxonomy, which has been in use since the mid-fifties,

and Laurillard's communicative framework, which was developed in 2002.

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Some Information Communication Technologies in Logistics and Supply Chains

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Abstract. The digitization process, imposed by the rapid development of electronics, the Internet, the availability of IT, new software, devices, networks and platforms, is gaining an almost unlimited reach. The concept of process visualisation initially appeared as a comprehensive term for obtaining and using data and information with the application of new information and communication technologies (ICT) in the economy and beyond, intending to fully characterise the process with specific key performance indicators (KPI), which would enable its users to better insight into the state of their processes, vehicles, devices, people, at any time, from any place, according to the principle of "each and everyone". The paper presents systematized communication technologies and services in the cloud that are in use or under development. The division into groups of technologies was made according to the functions that are important in logistics and/or SC. Some of the analyzed technologies are briefly described. The work aims to point out to businessmen and other interested researchers that they should focus their activities on some of the new technologies that are significant for their areas of business and interest.

I. INTRODUCTION

The term Industry 4.0 was first published in 2011 in Germany. It is a term that interprets the vision of the future "Smart factory". It can be defined as the embedding of sensors into smart devices, integrating them into digital and physical processes for direct communication. The essence is in the application of IoT, which represents the comprehensive connection of machines, products, systems and people for mutual communication in the virtual market, managing each other, creating a continuous connection between the virtual and physical world regardless of geographical and organizational boundaries. In parallel with the development of I 4.0, the complexity of logistics also developed. Today, Logistics 4.0 is in development, which aims to become "Smart logistics", which means "Smart product" and "Smart service", and requires the application of automatic storage and sorting systems with new software for managing warehouses, intelligent containers, greater use of self-propelled vehicles (AGV), the application of Robot-as-a-Service (RaS) robots, drones for monitoring inventory status with faster scanning of bar codes from cargo, etc., which will fully support intelligent production. Work technology in SC is being developed in parallel with logistics. Now, SC 4.0 requires the application of IoT/IIoT, the use of robotics, the use of Smart Environment Sensor (SenS) and SenS+, which are special stereoscopic cameras for detecting obstacles during the operation of machinery and vehicles in intralogistics, machines and devices in production, the application of predictive analytics with the possibility of processing a large amount of data from all SC processes and for all users, the application of as much automation as possible, AI/ML, Blockchain and others.

Digital transformation is the most important business trend of our time and includes: digital transformation within a company through the digitalization of its business functions (bookkeeping, finance, TPS processes, digital self-driving vehicles...), between the company and its users (customers) through the digitalization and transformation of relationship management to customers, marketing automation, electronic commercial business (E-com), through electronic ordering and payment, electronic data processing and exchange, electronic catalogs, etc.) and the third category is digital transformation through the entire value chain of business networks, from suppliers of materials and finished products, procurement processes, distribution partners, banks, end users and everyone participating in the global SC.

II. COMMUNICATION TECHNOLOGIES IN LOGISTICS AND SUPPLY CHAINS

As a concept, network technology IoV (Internet of Vehicles), is part of IoT/IIoT and represents the fastest-growing technology today, it is realized in most cases by wireless transmission for analysis and processing of data between different devices via communication networks (GSM, UMTS, HSPA, HSDPA and LTE), hosting units for data processing, user interface for data access, their processing and analysis. A significant number of communication technologies have been developed or are being developed for the one-way or two-way exchange of data and information under the general name of

Vehicle-to-Anything/Everything (V2X/C2X) and Cellular Vehicle-of-Everything (C-V2X) radio technologies between vehicles and other entities that can affect the movement of the vehicle or vice versa. Depending on the language, two terms with the same meaning V (Vehicle, in the USA, in further notation) and C (Car, in Europe) are used. A whole series of specific communication technologies have been developed or are being developed, such as [7]:

Vehicle-to-Vehicle (V2V), direct vehicle-to-vehicle communication, with the exchange of data and information in real time with vehicles from the immediate environment at distances of up to 300m. The technology is used to transmit and receive data about current vehicle locations, speed between vehicles and safe traffic communication, according to the ISO/TS 19091:2019 standard.

Vehicle-to-Infrastructure (V2I)/I2V or Vehicle-to-Roadside (V2R) communication with the infrastructure elements of the road (light signaling, line markers, parking space restrictions, etc.).

Vehicle-to-Pedestrian (V2P), communication with pedestrians and cyclists.

Vehicle-to-Network (V2N), the technology enables communication between cars, trucks, buses, traffic signals and lanes, unexpected events on the road with obtaining directions for further movement using mobile wireless networks such as Long-Term Evolution (LTE), 3G but above all 4G) or C-V2X communication based on cellular network (5GTN-5G Test Network)/IEEE 802.11p.

Vehicle-to-Grid (V2G), technology is still being developed, with the idea of using batteries in electric cars and trucks more efficiently as power sources in the electrical grid based on real-time power requirements. Energy exchange between electric vehicles (EVs and V2G batteries) with the public electricity grid is required through the positional coordinates of the vehicle with communications: Vehicle-to-Building (V2B) energy exchange during the movement of the vehicle to the workplace (business building), Vehicle-to-Home (V2H) at home (apartment) when parking and Vehicle-to-Load (V2L), exchange at transshipment, loading and/or unloading points in warehouses and terminals. V2B and V2H support energy use in private homes and commercial buildings, while V2G responds to network conditions and thus supports the network. The application of these technologies increases energy efficiency and the total capacity of electricity production improves the stability, reliability and efficiency of the network. Bidirectional electronic converters, namely AC–DC (BADC) and DC–DC (BDC) are commonly used for easier G2V and V2G power transfer between the grid and EV battery. Bi-directional converters have been successfully developed and implemented in V2G systems, they help to achieve very efficient energy conversion, and with the growth of such converters and charging stations, they will help in the transition from conventional to electric vehicles, and ultimately lead to a green environment. Infrastructure-to-Infrastructure (I2I), communication between infrastructural elements that are in contact with each other, placed on the road and through which information is exchanged about traffic situation control, traffic jams and traffic accidents.

Brain-to-Vehicle (B2V), a technology pioneered by Nissan that connects the driver's brain to his car, is currently not in use. This technology could radically change the future of driving and traffic safety.

Platooning, the technology will connect two or more goods vehicles in a caravan to reduce fuel consumption and CO2 emissions, improve safety with automatic braking and increase efficiency.

Vehicle-to-Device (V2D), talking from vehicle to device via Bluetooth/WiFi-Direct, Apple's CarPlay and Google's Android Auto applications,

Vehicle-to-Cloud(V2C), communication in the cloud about vehicle diagnostics and maintenance via electronic control units Diagnostics over Internet Protocol (DiIP).

Infrastructure-to-Infrastructure(I2I), communication between infrastructural elements that are in contact with each other, placed on the road and through which information is exchanged about traffic situation control, traffic jams and traffic accidents.

In SC, the situation is somewhat more complicated because there are several subjects in the business organization, the cargo owner as the sender or his forwarder, the consumer as the end user of the goods (cargo), state authorities, customs, control, and insurance companies, etc.) and logistics providers providing different services from 1PL-5PL,Figure 1.

Business-to-Business (B2B), technology refers to trade between two companies, on a wholesale basis and is sometimes called Business-to-Employee (B2E), when the traffic is focused on managing activities within its company. If the business is carried out between the company and the retailer, then it is called Business-to-Customer (B2C), or company-retail technology.

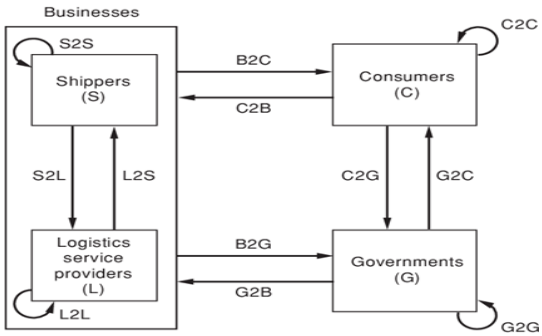

Figure 1. Possible forms of communication in Logistics and Supply chains [9]

If it is a transaction between the company and the end user, in the Direct-to-consumer (D2C) notation, or Direct2Consumer, the transaction is carried out without intermediaries, where the companies will build, market, sell and deliver the product directly to the customer at lower prices than the intermediaries who use traditional retail business models and maintain end-to-end control of business operations. In commercial business, it is often necessary to provide the necessary documentation accompanying the goods from state authorities, such as transit permits, quality certificates, insurance of goods, etc., whereby companies communicate with state authorities that issue certain permits, and vice versa. Such technologies are Business-to-Government (B2G), Customer-to-Government (C2G), Government-to-Customer (G2C) and (Government-to-Government (G2G). Consumer-to-Consumer (C2C) technology), achieved when wholesalers directly sell goods or services to end consumers online and/or perform consulting services, various auctions and transactions, personal services, etc., and all in accordance with the Law on Electronic Commerce. The mentioned communication technologies are implemented in both directions, directly P2P (Peer-to-Peer), and online via the Internet.

III. SERVICE APPLICATIONS IN THE CLOUD

Recently, the integration of computing into Cloud Computing Services (CCS) has been increasing, which achieves elasticity in the use of services, based on the "Pay-per-Use" principle, low financial inputs, shorter service time, change of responsibility in risk management, easy accessibility, complex and large calculations are shortened, storage space is reduced, management without expensive hardware infrastructure, expensive software systems, etc. The paradigm "The Everything-as-a-Service" (XaaS) implies computing in the "cloud" in which the services of various business functions are provided with the use of certain tools, software, infrastructure, databases, etc., which will be performed by the Application Service Provider (ASP), Cloud Service Provider (CSP), Complete Solutions Provider or Communication Service Provider (CSP) [10]. It is very important to choose a quality CSP provider that has: the ability to adapt and manage existing and develop new "cloud" and general business applications, IIoT, batch processing (Batch computing/processing). According to [5], a CNNC classification based on the intuitiveness of the scientific approach was proposed, where two types of service applications are considered: The first group contains the term "cloud" in its name (Cloud, NNClouda), and the second does not have the word "cloud" in its name (NN-No Name). In relation to Big data in the cloud, the following technologies are listed in the first type of applications: CloudKit, Cloud Datastore, Light Cloud, Cloudera and others. In the second type, the following are listed: 1010Data System, Algeraix System, Azure Document DB, Datameer and others.

From the perspective of logistics and SC, it is acceptable to view cloud services through several functions:

A. **Surveillance Security Service (SSS)**, as: Device-to-Device (D2D), Device-to-Cloud (D2), Device-to-Gateway (D2G), Security-as-a-Service (SecuaaS/SaaS), Identity and Policy, Management-as-a-Service(IPMaaS), Cybersecurity-as-a-Service (CaaS) and/or Crimeware-as-a-Service (CaaS).

B. Services of using networks, devices, sensors with data collection and their processing in a multi-cloud environment, as: Infrastructure-as-a-Service (IaaS), Things-as-a-Service (ThingS), Storage-as-a-Service (StaaS/SaaS), PaaS (Platform-as-a-Service), Software-as-a-Service (SaaS), Sensing-as-a-Service (S2aaS), Hardware-as-a-Service (HaaS), Sensor-as-a-Service (SenaaS), Desktop-as-a-Service (DaaS), Network-as-a-Service (NaaS), Telematics-as-a-Service (TaaS), Quantum as a Service (QaaS), Workspace-as-a-Service (WaaS), Ethernet-as-a-Service (EaaS), Failure-as-a-Service (FaaS), Sensor Event-as-a-Service (SEaaS), Testing-as-a-Service (TaaS), Application-as-a-Service (AaaS), Laboratories-as-a-Service (LaaS).

C. Services of unified (joint) communication management of companies with different functions, as: Supply Chain-as-a-Service (SCaaS), Logistics-as-a-Service (LaaS), Accounting-as-a-Service (AaaS), Object-as-a-Service (ObaAS), Mobility-as-a-Service (MaaS), Business-Process-as-a-Service(BPaaS), Integration-as-a-service(IaaS),

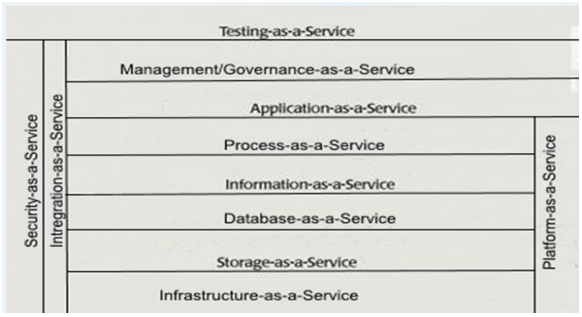

Figure 2. Interdependence of basic cloud technologies [2]

Business Integration-as-a-Service (BIaaS/BIaS), BI/BIaaS (Business Intelligence-as-a-Service), Business Framework-as-a-Service (BFaaS), Unified-Communications-as-a-Service (UCaaS), Cloud-Based Analytics-as-a-Service (CLAaaS), Mobility-as-a-Service (MaaS) and/or Mobility-as-a-Service (MobiaaS), Forensics-as-a-Service (FEaaS) and/or Digital Forensics-as-a-Service (DFaaS), Sensing and Actuation-as-a-Service (SAaaS), Surveillance-as-a-Service (VSaaS), Information-as-a-Service (IaaS).

D. Database Services, Data-as-a-Service (DaaS), Data Integrity-as-a-Service (DIaaS), Database-as-a-Service (DBaaS/DaaS), Continuous Analytics-as-a -Service (CaaaS) Data Mining-as-a-Service (DMAS/DMaaS), Management/ Governance-as-a-Service (MaaS and GaaS), Cloud-Based Analytics-as-a-Service (CLAaaS).

E. Backend as a Service, Backend as a Service (BaaS), Mobile-backend-as-a-Service (MbaAS).

From the IT aspect, the development of services in the "Internet base" practically has no capacity limitations [8]. In the following text, the characteristics of the basic technologies and their interdependence are given, in Figure 2.

Testing-as-a-Service (TaaS), technology enables the collection, updating and evaluation of data for specific processes or products performed by consultants or service providers, with the fulfilment of objectives set in test objectives.

Management/Governance-as-a-Service (MaaS and GaaS), MaaS enables start-up companies to solve certain development problems. GaaS enables the transition from traditional, paper-based government systems to a digital, centralized service delivery model in partnership with industry, citizens and other stakeholders.

Application-as-a-Service (AaaS) enables the use of computer software applications, as a remote service at the request of the user, via the Internet by the ASP as a service provider.

Process-as-a-Service, Business-Process-as-a-Service (BPaaS) refer to a specific type of service that is leased through cloud technologies and a global IP network. It includes combining several service options to fully automate the business process, which helps companies plan for greater efficiency, and comprehensiveness in their operations and achieve business goals.

Information-as-a-Service (IaaS), information as a service is any combination of the exchange of certain data and the activities of people who use the obtained information to effectively support operations, management and decision-making, in real time, according to an entity (customer, product, etc.).

Database-as-a-Service (DBaaS/DaaS) is one of the most sought-after cloud services due to the huge amount of data from IoT/IIoT and other sources. The technology does not require your own physical hardware setup, software installation, or database configuration, which allows users to scale, perform, perform backups, and more without their database, reducing overall business costs.

Storage-as-a-Service (SaaS/StaaS), data storage is a technology where a company rents someone else's or rents its infrastructure to store someone's data. StaaS can be used to provide storage of blocks, files and other types of data.

Infrastructure-as-a-Service (IaaS) represents the technology of renting other people's Cloud Data Centers (CDCs) and the complete infrastructure, through CSP. With direct access via the Internet, users are enabled to design and create a physical IT infrastructure in a virtual environment, which can use any application and run it without modifications to the hardware owner's infrastructure, which means that it has full control over all resources, virtual networks, warehouses, vehicles.

Security-as-a-Service (SaaS/SECaaS), cyber-security services include cloud and database protection, VoIP security and general network security. The responsibility for this service belongs to the relationship between CSPs and the Communication Service Customer (CSC).

Integration-as-a-service (IaaS), in B2B relationships, requires connecting on-premise data with data residing in cloud-based applications, with which businesses develop, maintain and manage custom integrations for various cloud systems and applications.

Platform-as-a-Service (PaaS) service represents the use of leased platforms located somewhere on a remote server with direct access through a browser.

Users do not need to have an operating system and specific tools installed on their local computer, which significantly reduces capital investments.The technology uses Blockchain [1].

From the aspect of logistics and SC, in addition to the mentioned technologies, the following are significant: Logistics-as-a-Service (LaaS), based on integrated business models with a complete logistics service. Supply Chain-as-a-Service (SCaaS) is a marketing service that helps to create a campaign for a supplier to customers. Accounting-as-a-Service (AaaS) provides accounting services using cloud services. Mobility-as-a-Service (MaaS) technology enables the connection of services by transport and mobility technologies in a package, which ensures adaptability to the needs of end users. Telematics-as-a-Service (TaaS) allows companies to pay only for the actual use of the used equipment without the initial investment in telematics equipment. Surveillance and security technologies D2D, D2C, D2G, play a significant role in traffic in the exchange of data between vehicles, vehicles and clouds, vehicles and gateways [6].

The mentioned technologies include a wide range of different standards, such as architecture standards, sensors, communication protocols, application requirements, identification standards, security and data processing standards, standards of various platforms, etc. The importance of standardization is great because of its advantages. According to [3], protocols are very important. The best examples are Java Message Service (JMS), Message Oriented Middleware (MOM) protocol for sending messages between two or more users, Transport Layer Security (TLS), Secure Sockets Layer (SSL), OSI Model and many others.

CONCLUSION

Managing and mining large amounts of data, especially from sensor systems, pose major challenges to traditional approaches. The concept of cloud computing has emerged as the most sought-after destination that promises to effectively solve many problems in the cloud environment by sharing IT resources and services. The paper provides an overview of communication technologies and new services based on the cloud, which are under development or have been created in the last decade of ICT development. Some important and useful services are briefly explained according to their applicability in the IoT paradigm. A large number of data management technologies are observed and are still increasing. Each of the technologies is specific in terms of its software, data storage and processing, and cloud computing mechanism. New ICTs, in IoT/IIoT, lead to numerous advantages in business and thus to better services, receiving and processing data and information in real time, reducing the impact on the environment, enabling the application of new approaches and methods with easier real-time management, more efficient use of data is enabled, processes have become visible, complete integrations in business are realized, safety, security and efficiency of business have increased, etc. The new vision of ICT is realized through IoS (Internet of Services), which provides a network platform for providing support to services, which makes it possible to combine different services and providers (ASP, CSP, ISP). The essence is in a completely decentralized way of exchanging online services and digital products, on P2P networks, which allows programmers to develop large-scale dApps with the possibility of supporting a large number of users, with a series of innovations for special measurement and interaction between instruments and measurement techniques. Future work includes further expanding the discussion on new services and analytics from the perspectives of integrating new technologies in different domains based on the idea of hybridization of both static and dynamic schemes.

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Augmented Reality Learning Environment for Mathematics and Sciences in GeoGebra 3D

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Abstract - Augmented reality represents advanced digital technology able to provide a learning environment for a better understanding of space, mathematical objects, and relationships among them. This paper will present in detail some of the features of augmented reality with the implications for their application in mathematics and science classrooms. GeoGebra 3D module will be explained as one of the tools for the implementation and realization of the augmented reality environment.

I. INTRODUCTION

The immersion of computer technologies in science and education is more than evident in recent decades. However, even though they have been used for a long time, new applications are always appearing and existing ones are being improved.

Augmented reality (AR) is one of the newest possibilities that can be used in mathematics and science education. It represents more than just a 3D tool because it can represent 3D objects in a real environment. AR is an interactive technology that offers a combination of real and virtual worlds.

The hybrid nature of this technology enables more than working with 3D geometry, it gives the opportunity to explore it, manipulate it, and observe it in different kinds of ways. Such multifaceted possibilities make it a great candidate for application in education, especially in mathematics, physics, chemistry, biology, etc. The benefits of using AR have been confirmed multiple times in science and mathematics education [1], [2].

Concerning the many fields of implementation of AR such as medicine, engineering, gaming, etc., the speed and variety of AR apps are significantly increased. There are many specialized apps for AR, depending on what it will be applied for. One of them is GeoGebra, the software which is mostly used for educational purposes, and has an AR module [3].

In this paper, the basic elements of AR will be shown, concerning educational application.

Section II deals with the multiple fields of the application of AR, and education is also one of them. In particular, the teachers' attitudes toward the implementation of AR are discussed.

In section III the GeoGebra 3D Calculator module for AR is presented with all its features and following examples.

Section IV contains conclusions and future remarks.

II. APPLICATIONS OF THE AUGMENTED REALITY

The applications of AR are very wide because it can be used in various fields. Nowadays it is common to find AR as a tool in medicine, in engineering for design but also for remote assistance in maintenance. The gaming industry cannot be imagined without AR.

Depending on the field and purpose of use of AR, there are different apps for it.

A. Platforms and apps for augmented reality

AR applications are designed to work on different platforms, such are Windows, Mac, Android, and iOS.

The apps are customized for the purpose of their application. For example, in medical sciences, AR is used by doctors for complex operations and also as a great tool for medical education because it allows students to see and manipulate the precise 3D display of the human body [4].

The application of AR is even more common in engineering. There are apps specially adapted for the purpose of use. Some companies make special AR-integrated training apps for their workers. Others use AR apps to allow technicians to have a direct view of the key procedures, often assisted by virtual reality glasses, Figure 1.

Figure 1. Application of AR in engineering

Finally, the apps for AR are constantly developed and perfected, and new fields of application of this technology are being found.

B. Application of augmented reality in education

The recent educational trends include computer technologies as mandatory tools for teaching and learning. The learning process has been reoriented from textbooks to visual representations. It is shown that the learning outcomes are better when AR is used. The motivation for learning, interactions between students, and improvement of cognitive possibilities are some of the benefits of the application of AR for educational purposes [5].

In science and mathematics education, the application of AR can bring new insights into abstract concepts. It allows the interaction between the real-world and virtual objects which helps students to adopt and understand some topics they find complicated.

Also, AR enables the exploration of phenomena that cannot be easily examined in classroom conditions. It is reported that this kind of learning is more effective than traditional ones [6].

C. Augmented reality teachers' perspectives

Teachers' perspectives are something that is of great importance when speaking of education, but often they are neglected in favor of students' perspectives. However, concerning the implementation of the AR, there is some related work that deals with teachers' attitudes [7].

As expected, there are pros and contras concerning AR, from teachers' point of view. Results of the research indicate that teachers find AR very useful for visualization, understanding, and exploring. In that way, teachers believe that students get more motivated to learn and develop interactions which all lead to good learning results and positive attitudes toward learning.

On the other hand, teachers complain about the lack of experience in AR. They report that their skills do not meet the requirements of modern 3D software and development of the teaching materials. The lack of appropriate technical support in schools for AR is also one of the negative sides.

However, teachers do believe that the future of education needs new technologies and that their influence can contribute to increasing the quality of education outcomes.

III. GEOGEBRA 3D MODULE AND AUGMENTED REALITY

Recently, there are many devices such as mobile phones and tablets that are equipped with AR features. In that way, AR is becoming accessible to a wide range of users.

Applications for AR are diverse and work on different platforms. For the purpose of mathematical and science education, we have chosen GeoGebra application for AR, *GeoGebra 3D Calculator*.

When considering GeoGebra and working with AR, it is possible to use it in two ways. First, ready-made materials can be used which can be found on the official GeoGebra website www.geogebra.org. There are many AR resources that can be searched depending on the need for certain content. These resources can be used directly online [8]. When using ready-made GeoGebra AR resources online, they are usually in the form of video material, Figure 2. It is important to remark that AR video materials cannot be manipulated, only recorded video content can be observed.

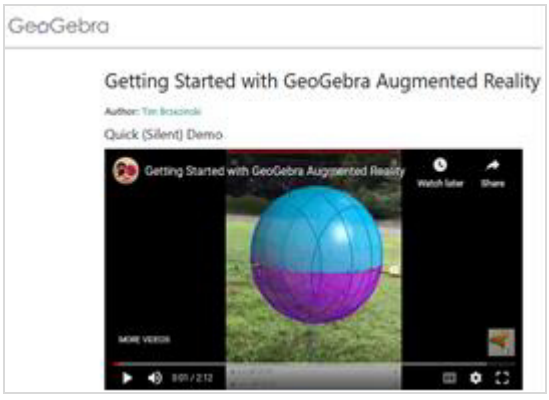

Figure 2. AR resources in form of the video material

On the other hand, sometimes ready-made material can be used with the application GeoGebra 3D Calculator. In that case, the 3D Calculator is started on the mobile phone or tablet, and the AR resources are uploaded directly on it. By activating the AR button, the object can be observed in the

real-world environment on the screen of the mobile phone, or tablet. This kind of AR resources can be manipulated and can be imported into real surroundings, Figure 3.

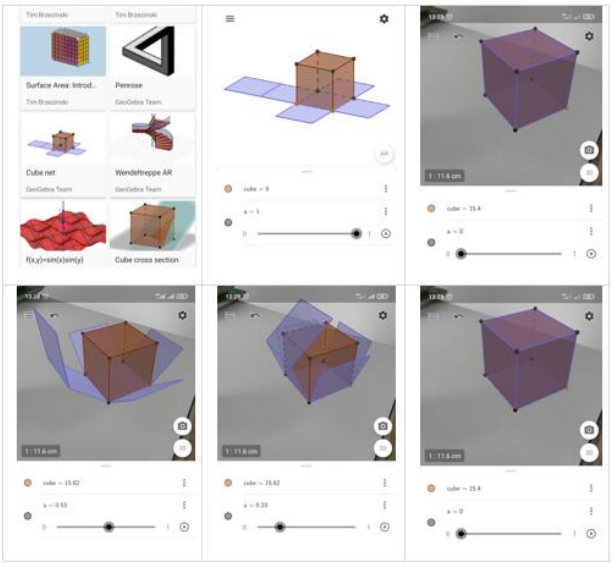

Figure 3. GeoGebra AR resources manipulation within the 3D Calculator application

This kind of use of ready-made materials in combination with the GeoGebra 3D Calculator can be very good for teachers who are not so familiar with the creation of digital teaching and learning materials. They are not obliged to master their skills in programming or using specific applications (which is identified as one of their major fears) but still, they can apply some very serious techniques in their classrooms. GeoGebra 3D Calculator and ready-made materials bring the possibility for teachers (no matter the level of their digital/computer skills) to create inspiring and supportive environments in mathematics or science classrooms and to deliver and explain to their students some very advanced concepts.

Also, it is important to mention, that the possibility for teachers to have access to and use some advanced digital materials strongly works towards improving their attitudes and motivation to use computer technologies and embrace their benefits.

A. Platforms and installation

The selection of GeoGebra 3D Calculator was based on its features for the possibility of working on different platforms (Android, iOS, etc.) and because is free download software.

For the purpose of this paper, we have used the Android platform, and mobile phone as a device.

The application 3D Calculator can be downloaded to mobile phones by using the Play Store. Once downloaded, it can be activated and is ready to use.

The starting screen of GeoGebra 3D Calculator has the space for drawings and all the tools which are usually available as original GeoGebra tools. The new features are the buttons for 3D and AR.

When the user chooses the 3D environment, it can use the GeoGebra 3D Calculator for the creation of 3D materials, as usual. But, by choosing the AR button, the environment changes, and the real surrounding is integrated via the back camera of the mobile phone, Figure 4.

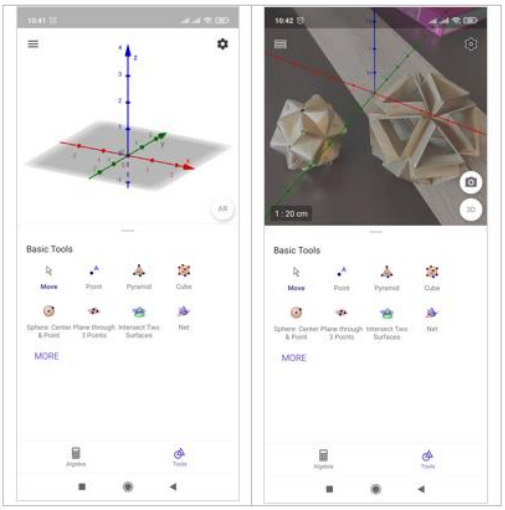

Figure 4. GeoGebra 3D Calculator 3D environment (on the left) and AR environment (on the right)

All the created materials can be saved in three ways: as GeoGebra file which can be used, upgraded, and later modified, as photographies of the screen with geometric shapes placed in the real environment, and finally, as a video material where the geometric shape can be observed in the real environment, but from the different points of view by changing the position of the mobile phone.

The next sections will show how can be used the GeoGebra 3D Calculator and its AR module.

B. Example 1 – Creating 3D geometrical shapes in AR

The work with the GeoGebra 3D Calculator in AR conditions does not differ from the regular one. First, the user should choose the AR button, for work in the real environment. All the next steps are similar, if not the same, as when working in a regular 3D GeoGebra application.

The tools for creating 3D objects such as cubes, prisms, pyramids, and cones are the same and the button is placed in the right bottom corner of the screen. By clicking on it, all the tools for creating 3D geometric shapes become visible, Figure 5.

Figure 5.Tools for creating 3D geometric shapes in GeoGebra 3D Calculator

By clicking on the specific tool, the 3D geometrical shape is created. It is only needed to import the corresponding points and parameters. In this example, we used the tools for creating a cube, a pyramid, and a sphere.

When created, 3D geometrical objects are placed in the real environment and can be observed from different positions on the mobile phone screen, Figure 6.

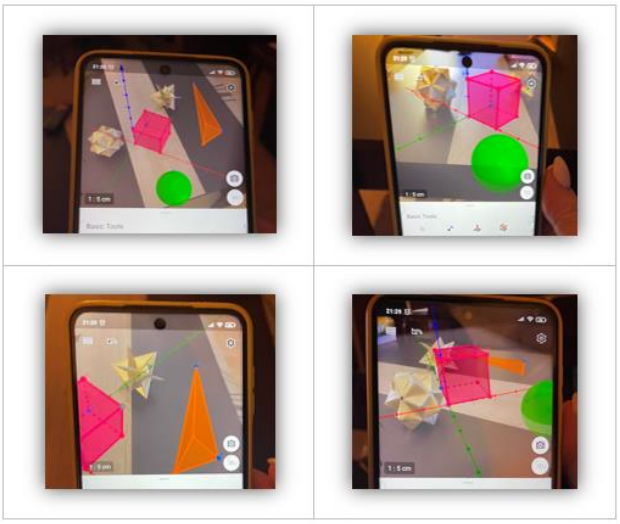

Figure 6. Different positions of the 3D geometrical objects, mobile phone screen view

This kind of simple material can be used for teaching geometry in mathematics, but can also be useful in sciences, especially in chemistry, for presentation of molecule forms, etc.

C. *Example II*

The GeoGebra 3D Calculator also supports the creation of more complicated shapes and forms [9]. Also, the AR module of the 3D Calculator enables modeling of the specific objects which is particularly useful when mathematical representation of an object is needed. In that way, AR can be used as a virtual laboratory for exploring natural phenomena, understanding the relations among them, and their scientific representation. For the needs of mathematical and science education, AR can meet requirements on all levels of education.

For example, it is possible to combine multiple shapes and observe their spatial relations such as intersections. A similar can be done using only GeoGebra 3D environment and 3D glasses [10]. However, the 3D display even with the 3D glasses, does not offer so much convenience for work as AR.

Let us create one example of the intersection of the cube and a plane through three vertices of the cube, Figure 7.

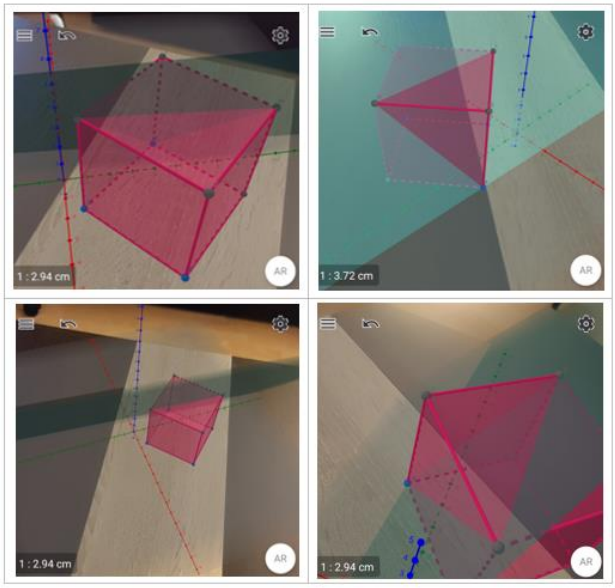

Figure 7. Intersection of the cube and plane through three vertices, different positions view

It is important to emphasize that this kind of representation of geometrical objects can enable deeper insight into relations among objects. The AR represents objects as they are “real” and gives the opportunity to be seen from the side, from below, from above, etc.

Using 3D representation and 3D glasses, the intersection could only be seen from limited positions. But, by using the AR module, the intersection can be observed from any position. Every position can be photographed or recorded and

by that, the students can be given the opportunity to learn in a real environment and explore and understand many science and mathematics concepts.

IV. CONCLUSION

The benefits of integrating AR into the educational process are multiple. First, it is a technology that is now available to both, students and teachers. There are many applications, such as GeoGebra 3D Calculator which have AR modules and can be obtained and used for free on mobile phones and tablets.

The application of AR is not limited, it can be applied in sciences, mathematics, engineering, etc. In education, it is confirmed that it has more than positive effects on learning outcomes, motivation of students, and collaboration.

In the future is expected that AR become even more integrated into the teaching and learning process. Improving teaching and learning experiences by AR using innovative teaching materials and creating an inspirational learning environment in the science and mathematics classrooms are some of the tasks yet to come for AR.

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Review of the Usage of Cloud Technologies in Education

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Abstract - Cloud technologies are increasingly used nowadays. A large number of institutions and organizations have already migrated their applications to the cloud. In this way, they use services offered by the service providers instead of using on-premise servers to host their applications. With this, the organizations get a scalable infrastructure, reduction of initial costs that are required to purchase an appropriate IT infrastructure, flexibility, security, automatic updates and disaster recovery. These are just some of the benefits that cloud technologies offer. This confirms the importance of acquiring skills for these technologies through the educational programs. This paper provides a comprehensive review of the usage of cloud technologies in different phases of education, determines the models of cloud services and the most used services in education. In addition, the opportunities offered by cloud providers to educational institutions are presented here in order for students to get a real work environment and acquire cloud computing skills.

I. INTRODUCTION

Cloud technologies are widely used nowadays in different areas and for different purposes [42]. Amato et al. in [1] present a touristic recommendation system that is based on the preferences of the tourists and the user experience. It uses a cloud architecture that can process a huge amount of data. Cloud technologies are often used to perform complex operations. Ekanayake and Fox in [2] emphasize the usage of cloud technologies for performance analysis of high-performance parallel applications. Popel and Shyshkina in [3] provide a discussion about the involvement of cloud-based environment components in augmented reality. They noted that it is much easier for institutions to use augmented reality if they have deployed a cloud environment or use some cloud services. Aziz et al. in [4] present the possibility for adaptation of cloud technologies for improving the e-government services. They highlight a lot of benefits of cloud technology such as costs reduction, lower maintenance of the infrastructure, increased availability and reliability of the services, greater flexibility, energy efficiency, access to public sector information and so on. Some of the challenges for adopting the cloud computing technologies are also depicted here such as standardization, services that can be easily reached by the end users, availability and affordability of the services, customization of services according to the users and the needs and great level of serviceability. Devasena in [5] show the importance of the usage of cloud technologies for business development. This study confirms the benefits of cloud technologies and their positive impact on the business services that are basis for the business development and improvement. Yamamoto et al. in [6] proposed a solution for processing a large-scale house data in a smart city using the cloud technologies. The proposed platform is scalable and can store and process a large-scale and heterogeneous log data. Near and Rahman in [7] present the possibility for the usage of cloud technology for video surveillance applications. They highlight the benefits of the cloud services for the high-resolution video surveillance management systems (VMS). Kumar et al. in [8] discussed the application of cloud technologies and various related services in digital library. According to the study, cloud computing techniques and methods that are applied to digital libraries can improve the utilization of the resources and with that to contribute to the development of a better implementation model.

Cloud technologies are also used in education. They are used for a variety of purposes. The main objective of this paper is to provide a comprehensive overview of the usage and application of cloud technologies in education.

The rest of the paper is structured as follows. Section II presents the specific usage of cloud technologies in education. Section III provides a review of studies. In this section we can see the research questions, the selection of appropriate studies and the research results. The last Section IV is a conclusion of our work. This section also presents the future research directions according to the overview of all studies.

II. USAGE OF CLOUD TECHNOLOGIES IN EDUCATION

There are a lot of use cases of using cloud technologies in education. According to [9], the cloud computing is used by 43% of universities and colleges. The market size of cloud computing in the education sector in 2021 was 23.81 billion USD [9]. It is assumed that the size of the market will reach 173.62 billion USD by 2030. The cloud technologies allow access to resources from anywhere and at any time. This is really important for the educational institutions. The usage of cloud technologies in education can be described by the three basic service models:

- Software as a Service (SaaS) – The educational institutions can use software and applications that are offered by the cloud service providers. Applications are hosted in the cloud and the users access them over the Internet. Students often need to use applications in certain subjects. Instead of installing them separately, they can access them directly through the SaaS model. This provides flexibility and easier access to resources that are needed in the learning process.
- Platform as a Service (PaaS) – Professors in educational institutions can create virtual laboratories for students. In this environment students and educators can have access to tools, services and support for programming languages that can be used for exercising during the classes.
- Infrastructure as a Service (IaaS) – This model provides access to processing, storage and network resources which can be used for hosting applications. This is needed for students to test a real working environment that can be useful for acquiring new skills.

Cloud computing have a lot of benefits that are specific for the education sector [9]. Some of them are:

- Scalability and flexibility – Sometimes the number of users in educational applications increases significantly. All this requires resources with better performance. If we use on-premise infrastructure, in that case it can be difficult to ensure its scalability. This can be done very quickly by using the cloud infrastructure. In this way, we can handle the increasing number of users, requests, data and traffic, but also ensure a good user experience.
- Time and freedom – The professors can upload the learning resources in the cloud. In this way, they would save time instead of printing and distributing them. The professors can also save the assignments for the students and lesson plans in the cloud. All these resources can be shared with other professors and the students. In addition, the resources can be accessed from anywhere just by using the Internet, which allows freedom for the professors and the students.
- Collaboration based on cloud – The cloud allows multiple students to work on the same assignment at the same time. They can also receive a real-time feedback from their educators. This is very important in the process of acquiring new knowledge and skills. The educators can also collaborate with each other.
- Support for students who cannot attend classes – There are students who are not able to attend classes regularly. Sometimes there are students who work in parallel with their studies and cannot attend classes. Cloud technologies and educational e-learning platforms that are often cloud-based can help them to continue with the learning process [43].
- Cost savings – Cloud technologies provide a cost-effective solution for educational institutions. They can use cloud infrastructure without having to make large upfront investments in physical IT infrastructure. In addition, cloud providers also offer the possibility of subscription, which enables a significant reduction in the costs for using the cloud services [10].

III. REVIEW OF STUDIES

A. Research Questions

With this review, we want to explore the usage of cloud technologies by the educational institutions. The main research questions in this review are:

- At which stage of education are the cloud technologies used, i.e. in primary, secondary or higher education?
- Which cloud service models are used or proposed?

- What types of cloud services are used or are proposed to be used by the educational institutions?
- Do educational institutions offer students a real working environment for using cloud services?

B. Selection of Appropriate Studies

The main purpose of this study is to review the latest research papers for the usage of cloud technologies in education in the last 5 years. The studies are selected according to the following criteria:

- They should not be older than 5 years;
- They must include the usage of cloud technologies in education or proposal for their usage;

We excluded studies according to the following criteria:

- They are older than 5 years;
- They are theses, dissertations or review papers;
- Studies that have an informal context;
- Introduction studies to cloud computing and cloud services;

According to the given criteria, we selected a total of 31 research papers. The selected papers can be seen in Appendix A at the end of the paper.

C. Research Results

- At which stage of education are the cloud technologies used, i.e. in primary, secondary or higher education?

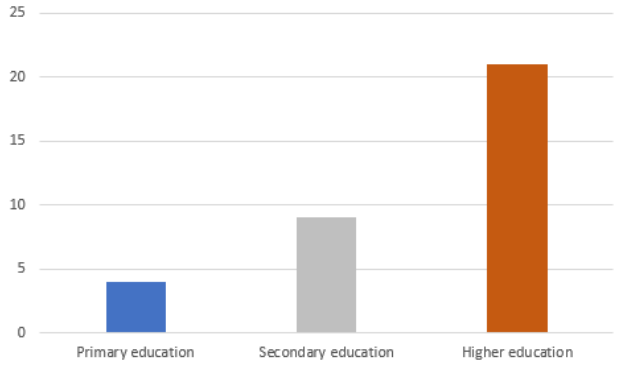

Figure 1. Stages of education in which cloud technologies are used

As can be seen in Figure 1, cloud technologies are mostly used in higher education, while they are least used in primary education. From the total number of studies, 21 studies cover the usage of cloud technologies in higher education, 9 studies in secondary education and 4 studies in primary education. Considering the benefits offered by cloud technologies, our opinion is that they should be taught in secondary and even primary education. In this way, the students will be prepared to apply these technologies in the higher stages of education. In addition, they can contribute to the improvement of the educational process.

- Which cloud service models are used or proposed?

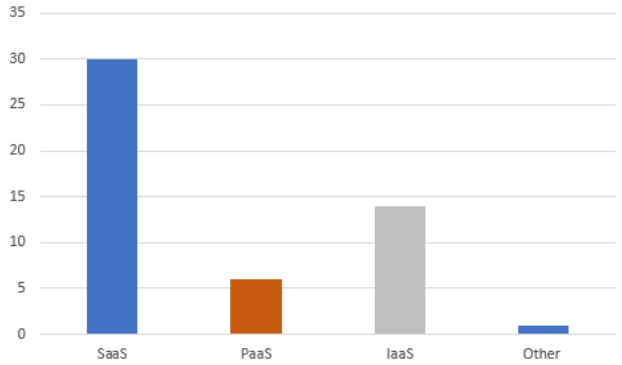

Figure 2. Used cloud service models

The most used or proposed service model is SaaS (Figure 2). It is mentioned in a total of 30 out of 31 studies. This confirms the importance of using SaaS. The next most used model is IaaS, which is used or proposed in 14 studies. PaaS model is mentioned in 6 studies. Only one study [17] includes usage of others non-standard cloud service models such as Desktop as a Service - DaaS and Communications as a Service – CaaS. Our opinion is that the usage of SaaS, PaaS and IaaS models in education can be really important for the students and the educational institution.

- What types of cloud services are used or are proposed to be used by the educational institutions?

From the research of the studies it can be seen that most of them propose cloud services that can be used, i.e. a total of 24, while a smaller part cover the real usage of cloud services, i.e. 8 studies. Most of the studies, i.e. 30, cover SaaS cloud applications (Figure 3). Other types of services that are covered in the studies are:

- Storage Services - 16 studies [11, 14, 15, 17, 18, 19, 21, 22, 23, 26, 27, 28, 33, 35, 37, 39]
- Processing Services - 3 studies [14, 17, 22]

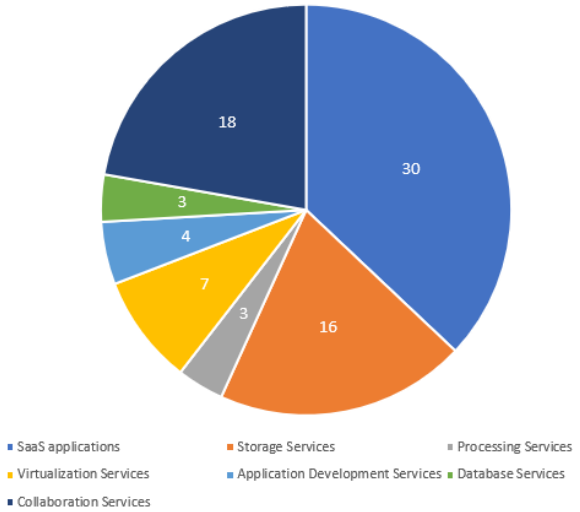

Figure 3. Used or proposed types of cloud services

- Virtualization Services - 7 studies [15, 16, 17, 19, 21, 27, 33]
- Application Development Services - 4 studies [13, 17, 19, 33]
- Database Services - 3 studies [19, 27, 33]
- Collaboration Services – 18 studies [17, 18, 21, 23, 26, 27, 28, 29, 30, 32, 33, 35, 36, 37, 38, 39, 40, 41]

All types of services can contribute to the improvement of the educational process in a different way.

- Do educational institutions offer students a real working environment for using cloud services?

As can be seen from the overview of the studies in Appendix A, a very small number of papers, only 6 [12, 13, 16, 19, 21, 27], cover the usage of real working environment for cloud services in educational institutions.

The institutions must consider the educational programs and benefits offered by cloud providers that provide a real working environment for their cloud services. For example, Amazon Web Services offers the AWS Academy Learner Labs environment which can be very useful for the educators and the students [44]. Microsoft has the Azure for Students program through which the students can earn free credits for using cloud services in the Microsoft Azure cloud platform. Google offers the module Google Cloud Free Tier which also offers free credits for using cloud services in the Google Cloud Platform [46].

IV. CONCLUSION

Cloud technologies can significantly contribute to the improvement of the educational process. According to this research, they are mostly used in higher education. The SaaS model is the most used model of cloud services. Very few educational institutions provide a real working environment for students to use cloud services. In the future, special attention should be paid to providing access to these services.

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APPENDIX A: SUMMARY OF ALL SELECTED PAPERS

NO	YEAR	REFERENCE	TITLE OF THE PAPER	EDUCATION	USED OR PROPOSED MODEL OF CLOUD SERVICES	USED OR PROPOSED SERVICES	PROVIDING A REAL WORKING ENVIRONMENT TO USE CLOUD SERVICES
1	2019	[12]	The use of cloud technologies when studying geography by higher school students	Higher education	SaaS, IaaS	Proposed: - SaaS applications related to geography (Gapminder, DESA Technology, Datawrapper.de, Time.Graphics, HP Reveal (Aurasma), MOZAIK education, Settera Online, Click-that-hood, Canva	Yes
2	2019	[15]	Cloud technologies in art entrepreneurship education	/	SaaS IaaS	Proposed: -Services for virtualization, network resources, memory resources, data resources, storage resources, business continuity, user devices and security -Application packages that are related to art entrepreneurship -Services that offer interactive tools and educational videos	/
3	2019	[19]	Implementation of cloud service models in training of future information technology specialists	Higher education	SaaS, PaaS and IaaS	Proposed: -Access to SaaS mathematical software -Web-SCM Sage software which allows integration of main types of software in a single environment -Online integrated programming environments such as Eclipse, Heroku, Code9 -Virtual Education Laboratory (VEL) Service -Services for creating virtual machines -Database services (Cloud SQL, phpMyAdmin, DB2 DBMS, Azure SQL Database) -Storage Services -Amazon Web Services (Amazon EC2, Amazon SimpleDB, Amazon RDS, Amazon SQS, Amazon FPS, Amazon S3, Amazon CloudFront, Amazon SNS, Amazon VPC, Cloud Watch -Software for creating a virtual	Yes

						laboratory (“Agapa” System) -Parallel programming tools	
4	2019	[21]	Cloud services application ways for preparation of future PhD	Higher education	SaaS, PaaS, IaaS	Proposed: -Tools like G Suite for Education, Microsoft Office 365, ThinkFree Online, Google Cloud Services, Amazon Web Services, Microsoft Azure services -CoCalc cloud service in learning of mathematical disciplines -SAGE Web SCM -Storage services: One Drive, Google Drive -VMware cloud-based virtualized environment -Cloud services for training purposes: -Services such as Maple, MATLAB, MapleNet, MATLAB web-server, WebMathematica, Calculation Laboratory -Cloud based corporate services (Xen, VMWare)	Yes
5	2019	[27]	The group methodology of using cloud technologies in the training of future computer science teachers	Primary and Secondary education	SaaS, PaaS, IaaS	Proposed: - Google Suite, Microsoft Office 365 -Application software of cloud platforms -System virtualization services - Apache CloudStack and Proxmox platform services - Windows Azure Web Sites product - Google Cloud Platform (GLP) cloud services (Google App Engine standard environment, Google Cloud SQL, Google Cloud Datastore, Google Cloud Storage and Google Cloud Pub)	Yes
6	2019	[29]	Practical use of cloud services for organization of future specialists professional training	Higher education	SaaS	Proposed: - Cloud services to create online questionnaires, interactive tasks, and electronic courses	/
7	2020	[13]	Cloud technologies for STEM education.	/	SaaS	Proposed: - SaaS applications related to Robotics - PaaS platforms for programming robotic systems	Yes
8	2020	[17]	Methods of using cloud technologies in Islamic	Higher education	SaaS, PaaS, IaaS Other:	Proposed: - Picasa service for image processing - Cloud services that offer	/

			education institutions		DaaS (Desktop as a Service), CaaS (Communications as a Service)	infrastructure - Storage services - Application development platforms - Hosted applications in the cloud (Microsoft Office, Google Docs, Google Classroom) - Using services like Dropbox, Yandex and Google Drive	
9	2020	[25]	Cloud technologies as a tool of creating Earth Remote Sensing educational resources	Primary and Secondary education	SaaS	Used: - Cloud platform for geospatial analysis: Google Earth Engine, Land Viewer, EOS Platform	/
10	2020	[31]	Learning free software using cloud services	Higher education	SaaS	Proposed: - OffiDocs Cloud services -RollApp Cloud Service	/
11	2020	[32]	Cloud technologies in informational and methodological support of university students' independent study	Higher education	SaaS	Proposed: - Zoho, Microsoft, and Google's cloud services - Google Calendar - Google Drive, OneDrive, Dropbox	/
12	2020	[34]	Cloud security challenges: implication on education	Secondary and Higher education	SaaS, PaaS	Proposed: -Microsoft Office 365 -Services for creating Massive Open Online Courses -Other Microsoft Cloud Services (Office 365 for Education (formerly Microsoft live@edu), Business Productivity Online Suite (BPOS), Exchange Hosted Services, Microsoft Dynamics CRM Online and Office Web Apps)	/
13	2020	[36]	Application of cloud educational technologies for teacher competence development.	Higher education	SaaS	Used: -Google Apps for Education Edition services - OwnCloud service	/
14	2020	[38]	Cloud technologies for enhancing communication of IT-professionals	Higher education	SaaS	Proposed: - synchronous communication tools – iMessage, Facebook Messenger, Firebase Cloud Messaging, Google Cloud Messaging, etc.; - asynchronous communication tools – Office 365, G Suite, Zoho Workplace;	/

						- collaboration tools – ezTalks Cloud Meeting, Yammer, Evernote, Prezi, Office 365. - OneDrive for Business, SharePoint Online, Microsoft Teams, Yammer, Skype for Business, Outlook Online boards	
15	2021	[16]	Some applications of cloud technologies in mathematical calculations	/	SaaS and IaaS	Used: -Web based SaaS tool for organization of servers (Proxmox) -Ulteo OVD for open virtual desktop	Yes
16	2021	[23]	Features of distance learning of cloud technologies for the organization educational process in quarantine	Secondary and Higher education	SaaS, IaaS	Used: - Google services - Cloud storage services - Document management cloud services - Services for creating Internet surveys by cloud-based tools - Services for creating presentations by cloud-based tools -Cloud based mind maps -Tools for creating sites -Cloud based learning management systems (Google Classroom)	/
17	2021	[30]	Implementation of web resources using cloud technologies to demonstrate and organize students' research work	Higher education	SaaS	Proposed: - Google Apps Education Edition -Google Sites	/
18	2021	[39]	Leveraging Cloud Technologies to Enhance Student Academic Performance	Higher education	SaaS	Proposed: -Cloud based tools for data analysis - Cloud based Learning Management Systems (LMS) - Cloud based student assessment software -Cloud storage services -Cloud based collaboration tools -Usage of Artificial Intelligence (AI) and Machine Learning (ML) services to personalize learning experiences for students - Google Drive and Microsoft One Drive	/

19	2021	[40]	Creation of open educational resources during educational practice by means of cloud technologies	Secondary education and Higher education	SaaS	Proposed: -Whiteboard cloud services: Padlet.com Linoit.com Idroo.com Miro.com Whiteboardfox.com Jamboard.google.com NoteBookCast.com free Conceptboard.com freemium Groupboard.com freemium Classroomscreen.com -Infographics cloud services: Easel.ly Infogram.com Canva.com Crello.com Genial.ly Chartblocks.com Piktochart.com Venngage.com Vizzlo.com Adioma.com - Google Docs - Zoho Office Suite - Office Online - ONLYOFFICE	/
20	2021	[41]	Cloud resources use for students' project activities	Primary, Secondary and Higher education	SaaS	Proposed: - Tinkercad cloud platform - Google Classroom -Cloud interaction tools	/
21	2022	[11]	Use of cloud technologies in education	/	SaaS, IaaS	Proposed: - SaaS applications - Storage services	/
22	2022	[14]	Formation of Students' Competence in the Use of Cloud Technologies	/	SaaS, IaaS	Proposed: - SaaS applications - Processing and Data Storage Services	/
23	2022	[20]	Cloud technologies for basics of artificial intelligence study in school	Primary, Secondary and Higher education	SaaS	Proposed: - DALL-E service that create images from text captions - Services for recognition of emotions - Services for images recognition such as Google QuickDraw that are cloud-based - Makeblock(it has five AI	/

						tools: mental services, machine learning, text-to-speech conversion, and translation) - PictoBlox (it has has tools for Computer Vision, Face Recognition, Optical Character Recognition, Language Recognition, Machine Learning, Ethics in AI, Internet of Things) - Teachable Machine (It is a service from Google. It can recognize images, voice commands, human movements) - Kaggle service	
24	2022	[22]	The Problem of Training Future Engineer Personnel on the Basis of Cloud Technology in Technical Specialties of Higher Education	Higher education	IaaS	Proposed: -Services for distributed data storage and processing systems	/
25	2022	[26]	The current level of competence of schoolteachers on how to use cloud technologies in the educational process during COVID-19	Secondary education	SaaS, IaaS	Proposed: - Google Classroom - Cloud storage services - Cloud services for creating documents - Cloud services for creating Internet surveys - Cloud services for creating presentations - Cloud services for creating smart maps - Cloud services for creating websites; - Cloud-based learning management systems	/
26	2022	[28]	The didactic potential of cloud technologies in professional training of future teachers of Ukrainian language and literature	Higher education	SaaS, IaaS	Used: -Data storage services - Google Apps and Dropbox - GoogleWorkspace for Education - Google Classroom e-learning environment Proposed: - Cloud-based services for creating MindMaps (iMindMap Cloud, MindMeister, Mind42 and Goggle) - Prezi cloud-based presentation service - Google Docs - OneDrive - Google Drive	/
27	2022	[33]	Educational Aspects of using	Higher education	SaaS, PaaS, IaaS	Proposed: - Google Doss, Google Apps,	/

			Cloud-Based Network Services in Training Future Engineers			Office Online, Office 365, Zoho Office - Force.com, Salesforce.com, Microsoft Azure, Google Arr Engine, Cloud Foundry, VMWare, Oracle PaaS Platform - Amazon Web Services, Rackspace Cloud Terremark, gandi.net, GoGrid, Scalaxy - Google Apps -Microsoft Office 365 - Programming services, storage services, database services, graphics services, virtual desktop services, cloud-based antivirus software, cloud-based learning management systems - Microsoft Office 365 - G Suite for Education - OneDrive, Google Drive -Other Google and Microsoft cloud applications	
28	2022	[35]	The results of the use of cloud technologies in the educational process of pedagogical universities in a pandemic.	Higher education	SaaS	Proposed: -Microsoft Office Apps -Google Drive -Moodle cloud based LMS -Classroom -iLearn -Flipgrig -Canva -Zoom, Meet -Padlet -Kahoot	/
29	2023	[37]	Developing professional stability of future socionomic specialists using cloud technologies in blended learning	Higher Education	SaaS	Used: - Google Workspace for Education services (Gmail, Classroom, Drive, Calendar, Vault, Docs, Sheets, Forms, Slides, Sites, Meet)	/
30	2023	[18]	Methods and Advantages of Using Cloud Technologies in Practical Lessons	/	SaaS	Used: - Google Drive Proposed: -Dropbox -Google Docs -SalesForce – CRM and ERP systems	/
31	2023	[24]	Cloud technologies of augmented reality as a means of supporting educational and	Secondary education	SaaS	Used: - Cloud services for augmented reality such as A-Frame and AR.js Proposed: -WebAR	/

			research activities in chemistry for 11th grade students				

With an Electronic Store Closer to our Customers

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Abstract - E-commerce (electronic commerce) is the activity of electronic purchase or sale of products on online services or through the Internet, i.e., a channel of goods distribution and services mediated by the Internet. The e-store is a place that connects the suppliers and buyers of certain products and services in one place (website), where the sale and purchase of a product or service is made. In this paper, the goal is to show how e-commerce and e-store can be used to start an online business without any experience, and why an e-store is a great way to build an online business. An e-store for selling watches will be considered and this e-store will be available to customers and buyers from all over the world.

I. INTRODUCTION

Electronic commerce is the process of buying, selling, transferring, or exchanging products, services, or information over computer networks, including the Internet. E-business is a broader definition than electronic commerce, which includes not only buying or selling goods and services, but also customer service, cooperation with business partners, etc. Electronic commerce has three forms, depending on the degree of digitalization: the product, the process, and the supply agent. All three forms can be physical or digital. Depending on that, we have "pure" or "partial" electronic commerce. Physical organizations conduct their business off-line, selling physical products through physical representatives (brick-and-mortar). Organizations that perform their activities exclusively online are also known as virtual organizations (pure play). There are also organizations that perform some e-commerce activities but perform their primary activities in the physical world (click-and-brick). Most electronic commerce is conducted over the Internet, but it can also be conducted over private networks, such as VAN's (value-added networks) and LAN's (local area networks). The skeleton of electronic commerce consists of

1. At the very top are the applications of electronic commerce (direct marketing), job search, online banks, E-government, auctions, consumer services...
2. Support services (people, public policy, marketing and advertising, business partnership).
3. infrastructure

A. Importance and benefits of e-commerce

- E-commerce helps reduce costs.
- E-commerce helps businesses go global.
- E-commerce can be done with less overhead and less risk.
- E-commerce can expand your brand and expand your business.
- E-commerce offers better marketing opportunities.
- Your online store will remain open 24/7/365.
- E-commerce is easier and more convenient.
- Personalization of shopping experience.
- Improving the image of your business.
- Easy to get product feedback.
- Maximum security of transactions.
- Increase sales.

B. Success factors

- High quality products are important to keep customers loyal to your business.
- The price of the product is important, you don't want it to be too low and customers doubt the quality of the products, or it is too high that they can't afford to buy it.
- Make the store accessible on many devices such as mobile devices. There are things you can do to improve your online store's visibility on mobile devices, such as optimizing your images and using responsive design.
- A good website with a nice look and attractive designs.
- Safety is a top priority. It is one of the main concerns about e-commerce for consumers and business owners, as their personal and financial information is handled over the Internet.

C. *E-commerce during COVID-19*

In March 2020, global retail website traffic reached 14.3 billion visits, marking unprecedented growth in e-commerce during the 2020 US lockdown. Meanwhile, as many as 29% of surveyed shoppers said they would never go back to shopping in person again; In the UK, 43% of consumers said they expect to continue shopping the same way even after the pandemic is over.

E-commerce retail sales show that COVID-19 is having a significant impact on e-commerce and its sales are expected to reach $6.5 trillion by 2023.

II. E-STORE

Like normal business transactions, electronic stores are usually operated by a single supplier (dealer or manufacturer). The supplier connects with the individual buyer through this type of store. The contract and the exchange of products/services materialize after the negotiations are carried out. On the WWW, these types of stores are the online places, where you can compare, choose, and of course purchase products. The electronic market is created when multiple electronic stores compete for customers. Companies usually start their web presence by acquiring information about the company and its products, in support of other sales channels. The online store is formed if the order and payment methods are added to this information. The most important advantages of online shopping are that customers no longer travel to buy something, these stores are available 24 hours a day, and an easy comparison can be made. among several offers from the suppliers. Also, the time savings should not be underestimated.

III. MARKET RESEARCH

Before starting e-commerce, or rather starting an e-store or online business, you must first research the market.

Market research is an organized effort to gather information about target markets and customers: by knowing them, starting with who they are. It is a very important component of business strategy and a major factor in maintaining competitiveness. Market research helps to identify and analyze market needs, market size and competition. With the help of the internet and today's technology on the internet there are too many useful applications and platforms where information can be gathered about a particular business model. In our case, this e-shop would be for selling watches, so with the help of the following few platforms we got some information about whether this business would be good to start. For this research we needed the following platforms:

- Statista is an online portal that provides data on the global digital economy, industry sectors, consumer markets, public opinion, media, and macroeconomic trends. Quantitative data from 425 economic sectors in 50 countries is provided with a range of infographic analysis and visualization tools.

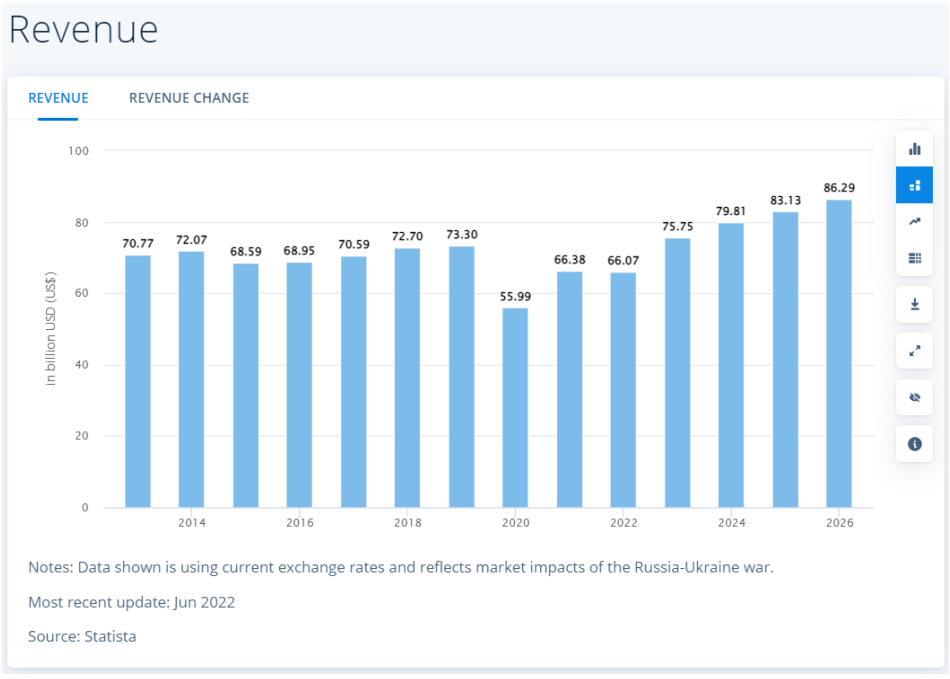

Figure 1. Revenue in Watches Sales Segment (2012-2026)

On this platform, we found interesting information about the revenue in the watch segment

which in 2022 was 66.07, and the market is expected to grow annually by 6.90% (CAGR 2022-2026).

- Similarweb is a digital intelligence provider for enterprise and small and medium business (SMB) customers. The platform provides web analytics services and provides its users with information about the web traffic and performance of their customers and competitors.

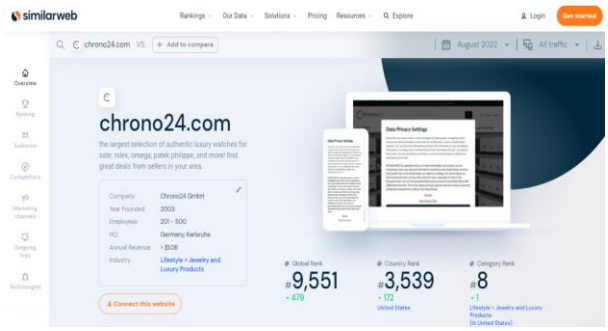

Figure 2. Revenue and ranking statistics of "Chrono24"

Figure 3. "Chrono24" visitation statistics

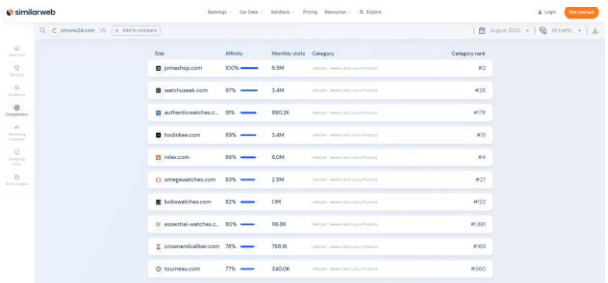

Figure 4. Statistics of the biggest competitors in the watch market

As an example, we researched "Chrono24" - a leading marketplace for the sale of luxury watches. Figures 2 and 3 show information and statistics for the "chrono24.com" website, such as income, attendance, ranking in the world, etc. While on the other hand, figure 4 shows the statistics of other sites that are one of the largest competitors in this area.

A. How big is the watch industry worldwide?

Despite recent developments, such as the economic crisis and COVID-19, the market size of the watch industry has managed to withstand the blow reasonably well. Moreover, it also shows excellent signs of recovery for the coming years, especially if we consider the effect of the increasing expansion of smartwatches.

The latest analysis of the luxury watch industry by Mordor Intelligence tells us that the global watch market (comprising traditional and smartwatches) was valued at USD 61.85 billion in 2020 and will register a CAGR (compound annual growth rate) of 13 % during the forecast period (2021-2025) to reach over USD 100 billion.

- 2020 USD 61.85 billion
- 2025 USD 117.8 billion

IV. E-STORE FOR THE SALE OF WATCHES

The next step after the market research is to start creating an e-shop where we will develop our business for selling watches. We used WordPress to create our website or so-called e-shop.

WordPress is the simplest and most popular way to create your own website or blog. In fact, WordPress powers over 43.3% of all websites on the Internet.

Next, we used WooCommerce to run our business. WooCommerce is an e-commerce plugin for WordPress. It makes creating and managing an online store simple, with reasonable levels of flexibility and several vital features such as inventory and tax management, secure payments, and shipping integration. Other plugins that we needed for the e-shop were:

- CartFlows – allows us to Create checkout pages and sales flows for WooCommerce.
- Checkout Plugins - Stripe for WooCommerce provides a simple, secure way to accept credit card payments on our WooCommerce store.
- Elementor - The Website Builder: drag and drop page builder, pixel perfect design, mobile editing and more.
- Starter Templates – required templates for one page, blocks, and images.
- Variation Swatches for WooCommerce - Provides a super easy shopping experience by displaying beautiful variations on the WooCommerce store and product page.
- WooCommerce - A suite of e-commerce tools that help you sell anything.

- WooCommerce Cart Abandonment Recovery – Recovers lost revenue. It captures the email address of users on the checkout page and sends follow-up emails if they do not complete their purchase.
- WP Affiliate Manager – A plugin for recruiting, managing, tracking, and paying our affiliate partners.
- WPForms Lite - WordPress contact form plugin.

V. MARKETING AND ADVERTISING

After the product is launched on the market, the next step is its sale, so good marketing and advertising is needed. Since, our business is online, digital marketing will be of the greatest benefit for sustainable business growth.

Marketing, in the most general terms, has the task of delivering goods or a service from the point of production to the point of demand for that good or service. The main marketing goal is to increase the volume of sales or expand the market share. To this end, marketers form a marketing mix.

In modern theory and practice, synonyms of the marketing mix are "marketing means", "marketing elements" and "marketing complex". Especially popular is the naming "4P" from the first letters of the English words:

• Product

• Price

• Place

• Promotion

Digital marketing, also called online marketing, is the promotion of brands to connect with potential customers using the Internet and other forms of digital communication. This includes not only email, social media, and web-based advertising, but also text and multimedia messaging as a marketing channel.

SEO marketing is a subset of digital marketing that includes website and website optimization for major search engines like Google. As these search engines have become the dominant way to find almost anything, a variety of practices have emerged to help organizations improve the visibility of their digital assets.

The term "search engine optimization (SEO)" refers to a combination of internal and external tactics. Each of the major search engines has its own formula for ranking pages in search results. Technically called algorithms, these formulas are closely guarded practices that major search engines protect as trade secrets.

Components of SEO:

1. Content

Search engine marketing is highly dependent on producing good content on a regular basis. From this point of view, content must satisfy a need, generally by providing information or answering a question.

2. Keywords

Keywords refer to the subject or topic of the content that is the basis of the search query. Keyword research and selection are closely related to content production and are essential to SEO marketing efforts. To maximize search engine marketing, organizations need to choose the right keywords, both in terms of search frequency and competitiveness.

3. The architecture

Website or page architecture is another important aspect of on-page optimization. When optimizing websites or pages for SEO benefits, the following architectural elements are critical:

• Site map

• Loading speed

• Suitable for mobile phones

• Website security

When it comes to the promotion of the product and how to present it more easily to potential buyers, there are 2 types of promotion:

A. Paid advertising as part of digital marketing

Social media is one of the best places to build awareness of your brand online. That is the main reason why businesses use social media promotion, but some other benefits of social media include that it can lead to:

- Target audience (target group) with exact precision: social media platforms know a lot about their users. If you promote your brand on social media, you can use that information to target your audience based on demographics such as age, location, preferences, behaviors, etc.
- Increase sales and leads: Social media platforms allow you to advertise your products and services. Many platforms even allow you to set up landing pages and stores directly on the platform (Facebook Marketplace) so people can easily convert or buy.
- Help you better understand your audience: With advanced targeting and tracking information

provided by social media platforms, you can more easily analyze data and optimize your social media promotions to match your audience.

- The social nature of social media platforms means that people are eager to communicate and engage with others. Considering that 74% of people follow brands on social media, you have ample opportunity to engage with your audience using social media.
- Social media promotion helps work towards gaining a significant social media presence if you are willing to make consistency an integral part of your social media presence.

Google Ads is Google's online advertising program. Through Google Ads, you can create online ads to reach people exactly when they are interested in the products and services you offer.

- Google Ads is a product that you can use to promote your business, help sell products or services, raise awareness, and increase traffic to your website.
- Google Ads accounts are managed online, so you can create and change your ad campaign at any time, including ad text, settings, and budget.
- There is no minimum spending obligation, and you determine and control your own budget. You choose where your ad will appear, set a budget that's convenient for you, and easily measure the impact of your ad.

B. Free advertising as part of digital marketing

Free advertising is using social media or social media marketing: Instagram, Facebook, TikTok, YouTube, Pinterest, etc., where you present your brand to people from all over the world, by sharing content that will be related to your business/ brand.

Social media is online communication that allows you to communicate with your customers and share information in real time. You can use social media to:

- reach your customers better.
- create online networks.
- market and promote your products and services.

Social media can help you engage with your customers and find out what people are saying about your business.

Social media can help a business to:

- attract customers, get customer feedback, and build customer loyalty.
- increase market reach, including international markets.
- do market research.
- increase revenue by building customer networks.
- analyze competitors.

VI. CONCLUSION

E-commerce (electronic commerce) is the activity of electronic purchase or sale of products on online services or via the Internet, that is, a channel of distribution of goods and services mediated by the Internet. The e-shop is a place that connects the suppliers and buyers of certain products and services in one place (website), where the sale and purchase of a product or service is made. Importance and benefits of e-commerce and online store are:

- E-commerce helps you reduce costs.
- E-commerce helps businesses go global.
- E-commerce can be done with less overhead and less risk.
- E-commerce offers better marketing opportunities.
- Your online store will remain open 24/7/365.
- E-commerce is easier and more convenient.
- Easily get product feedback.
- Maximum security of transactions.
- Increase in sales.

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Development of Digital Literacy and Technological Abilities of Employees

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Abstract - Special attention is paid to employees and technological equipment in the digital age in industries. Contemporary technology is an inevitable integral part of human daily life. Transitions of industrial revolutions up to Industry 5.0 require introducing new technologies. Also, the essential thing is that employees have the necessary knowledge provided with quality training and assured knowledge sharing in organizations. Knowledge management is a crucial factor that leads to achieving the organization's goals and maintaining its place in the market. Emphasis in the paper is placed on the theoretical analysis of the development of digital literacy. The work aims to determine that as technology develops, employees must also develop their knowledge and skills. The subject and problem of research are employees who are ready and able to adapt to technological changes, accept them and simultaneously develop their professional skills and raise their level of knowledge to a much higher level using modern technology.

I. INTRODUCTION

Today, in modern society or the digital age, advanced technology is an inevitable integral part of human daily life. The arrival of the inforamation technology (IT) era and the digitization of everyday life, with the adoption of smart devices and advanced technologies, resulted in an enormous volume of heterogeneous data and digital content, an increase in data sources and various types and forms of data, and structures [1].

Along with the industrial revolutions that followed us, technologies also developed. Today, in Industry 5.0, which is being pursued by many industries and companies, we have incredible technology that makes it easier for employees to do their jobs. The focus is on developing their digital literacy for organizations to achieve desired goals, set goals, and maintain their position in an increasingly large and challenging competitive market. Citizens of the 21st century are offered new opportunities created by the advancement of technology. Thus, individuals need many abilities, competencies and skills to adapt to the technological era [2]. Technological changes happen at an extremely high speed, and it is necessary to keep up with them.

Knowledge management is promoted as an essential and necessary factor for organizational survival and maintaining competitive strength [3]. Knowledge management acquires knowledge inside and outside the organization, turns it into strategies, applies it inside and protects it [4].

Contemporary technology and information technologies (IT) have changed the ways of learning, communicating and working today. Ignorance and improper use of technology can negatively affect employees and even be dangerous. That is why employees in every organization that invests in technology must be appropriately trained and qualified to work with it. The term digital literacy and the use of technology includes basic skills such as using email, using the Internet, using information technology, and working with robots, using robots, artificial intelligence, Internet of things (IoT) and many others.

Through theoretical analysis, this paper aims to determine that as technology develops, employees must also develop their knowledge and digital literacy skills. There is also a significant focus on the importance of knowledge management in organizations that own and invest in contemporary technology.

II. CONTEMPORARY TECHNOLOGY

Considering the transition from industrial revolutions investing in the knowledge of employees in terms of achieving technological capabilities is very important because industries are bringing significant changes in terms of technology. These are technologies such as autonomous vehicles, robots, cobots, artificial intelligence, IoT, big data, information technology, 3D printers and many others [5]. Industry 4.0 was the complete digitization of factories, while 5.0 put man back in focus with cooperation with contemporary technology.

The term Industry 5.0 refers to people working with robots and intelligent machines. These are robots that help people work faster with the help of advanced technology such as big data analytics [6,7].

Humans are required to develop competency skills working with advanced robots, and human workers must acquire knowledge of collaboration with smart machines and robots [8].

It is recognized that in the smart factory, the role of employees will change significantly due to the increased use of technologies. Applying a socio-technical approach to the organization of work will allow the worker to enjoy greater responsibility and improve his personal development [9]. The more organizations invest in learning, the easier it would be for workers to embrace and learn smart factories. A commitment to learning can accelerate adaptation to the smart factory and reduce people resistance. In this sense, organizations with a higher level of commitment to learning can improve employees' and clients' satisfaction [10].

III. DIGITAL LITERACY

The digital age imposes and encourages the need for digital education. Employees must also develop with the increasing demand for digital technology. That is, to improve their knowledge related to technological changes, their way of using it and their management skills must change and adapt.

Digital literacy is the ability and awareness to apply existing digital technology to work with the right attitude towards digital learning [11]. Digital literacy deals with the desire and ability to use contemporary technologies, such as information and communication technologies, to gain access to information. It also refers to how one manages, analyzes and evaluates information, leading to the creation of new knowledge [12].

Many employers organize digital workshops and training to ensure their workforce has the digital competencies needed for a digitized future [13]. The digital literacy of employees and their ability to manage technology is also influenced by age group. Older people can generally retain 25% less information in their working memory that needs to be transferred to a more permanent memory, or long-term memory [14]. That is why there are trainings called cognitive training today. They are used to train well-defined cognitive processes and abilities, which include attention, different types of memory (short-term, working, long-term), executive skills (management of thoughts and actions), speed of problem-solving and speed of information processing [15].

Employees need specific knowledge and a new paradigm of skills resulting from digitalization, which should increase the overall performance of production systems, the effectiveness of operational management, and the efficiency of production and supporting processes [16]. Data literacy refers to skills for working with data, including the ability to read, write, critically evaluate, communicate and derive value from data in different contexts. As such, the so-called data literacy is a crucial competency in the current digital economy, where majority of transactions require handling large amounts and diversity of data [17].

The competencies required for digital transformation can be grouped into four categories [18]:

- Technical competencies related to a specific job - process understanding and knowledge management.
- Methodological competencies that include preventive thinking, research skills, problem-solving ability.
- Communication skills, teamwork, ability to transfer knowledge.
- Flexibility, motivation for continuous training, and ability to work under pressure.

Employees who are ready and able to adapt to technological changes, accept them and compare, and develop themselves, are the ones who have the opportunity to improve themselves. Digital literacy provides opportunities to access many sources of knowledge and a huge amount of data and information.

IV. KNOWLEDGE AND TECHNOLOGY

The challenges of this digital transformation are partly based on technology but, above all, on human resources, with the necessary need to develop skills in many areas [19]. For organizations to have employees with the knowledge essential for using and working with contemporary technology, it is necessary to pay much attention to knowledge management. Organizations must ensure the availability and fluidity of knowledge to all. Knowledge sharing can be defined as "the exchange of knowledge between and among individuals" and aims to combine knowledge sources and manipulate them into new knowledge structures or routines [20].

Two fundamental aspects that influence the view of knowledge management [21]:

- the resource-based view of the firm, which refers to how knowledge contributes to technological change and organizational knowledge,

- the humanistic theory of management, which refers to several important human related topics.

Management plays a vital role in imparting knowledge to its employees, so it must be professional and adequate to provide the necessary training.

Modern training methods include video games, gamification, simulations, virtual reality and social media [22]. Today, virtual training is increasingly common and plays a significant role in improving knowledge. Virtual training is conducted in simulated environments for employees to learn and acquire the necessary skills. There are moments when, during the virtual training, the trainer and the employee are not in the same place but are far away, in entirely different locations.

Virtual training helps employees to have appropriate training without causing any danger and, at the same time, acquire knowledge that they might not be able to achieve in real situations.

With the advent of covid 19, many ways of doing business had to change and adapt to the situations caused by the pandemic. During the coronavirus pandemic, many businesses encourage their workers to do their work from home [23]. For this type of work, it is first necessary that the employees have adequate working conditions and programs on their computers, as well as to know how to handle them. That is why the knowledge related to technology possessed by every organization's employee is essential. Embracing and keeping up with change is critical for those who want to realize the benefits and opportunities offered by contemporary technology. Even some companies require Internet availability with specific capacities and speeds at home. It is vital to ensure smooth communication between employees and the office [24].

Organizations have increasingly used Artificial Intelligence (AI) to manage various tasks in recent years [25], so they have a greater responsibility towards employees. The use, for example, of a robot in cooperation with a human contributes to many reliefs for employees when it comes to complex and dangerous jobs. This leaves room for employees to focus on other, more important tasks, thus encouraging and increasing their creativity, engagement and overall satisfaction. When achieving synergy between man and machine, employees must understand the machine they work with, how it works and what it achieves.

Despite all the advantages provided by information technologies, and especially by artificial intelligence, a certain number of employees resist technological changes. The lack of familiarity with emerging technologies like AI could create fear, and people may feel they are not in control of the technology due to the complexity [25]. However, today, artificial intelligence opens more opportunities than it closes. Jobs evolve, so employees must have the appropriate knowledge to reduce resistance to changes to a minimum level. This is achieved by the gradual introduction of new technology and the gradual habituation of the employee to work with it, adequate training on the machine itself and how to use it and its contributions.

Considering that knowledge can be shared more, significant help of artificial intelligence appears in sharing tacit knowledge. Personal interaction is the most significant indicator of knowledge sharing in the construct of tacit knowledge [26]. Since tacit knowledge is difficult to capture, we looked at artificial intelligence as an alternative to help capture tacit knowledge. In a knowledge management case study, Sanzogni et al. identified artificial intelligence (AI) technologies as collective forms of tacit knowledge [27].

In certain situations, knowledge management can have negative consequences. The use of knowledge management mechanisms based on IT allows not only access to knowledge but also the emergence of risks associated with the creation of counter-knowledge by individuals. Employees can create and disseminate wrong interpretations of facts, unsupported explanations and false beliefs. [27].

V. CONCLUSION

More and more companies, operating for certain periods or new ones, strive to introduce the most contemporary technology. Many organizations lose significant amounts of money and incur unimaginable costs due to inadequate employee training. Organizations must follow the development of digitalization and keep pace with it, provide their employees with training at a severe level, and enable the best way to share knowledge. They need to commit to further investing in technology that they have yet to use so far to make their employees' jobs easier and improve themselves in a business sense.

Further research will be focused on the industries that operate on the territory of Serbia, with the focus on how they invest in technology and the knowledge of their employees. Industries, SMEs and all organizations operating in Serbia need to provide adequate employee training with having the more experienced coaches for employees, seminars, and introduce virtual simulations that will increase the digital literacy and technological skills of employees, which will be further investigated as stated in the previous sentence.

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Advantages of Education and Training of Employees in Modern Business

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Abstract - The key factor in achieving a competitive advantage is no longer material assets, but the knowledge that employees pursue. In order for organizations to be successful, they must invest in the development of their workforce, that is, they must invest in the education and training of their employees. By improving their knowledge and skills, employees are ready to respond to the rapid changes that characterize today's business. This paper will explain the importance of employee education and training, the advantages that organizations achieve by investing in employee development, as well as their impact on the competitiveness of organizations.

I. INTRODUCTION

In conditions of global competition and unpredictable changes, survival and competitiveness of organizations is provided by human capital. Human capital, i.e. man, with his potential, represents a necessary resource of every business process. The potential of employees includes: knowledge, skills, competences, motivation [1]. Education and training are cited as one of the traditional functions of human resource management. Education and training play an important and strategic role in improving work performance, productivity and ensuring the competitiveness of companies [2, 3]. It is very important that organizations invest in the improvement of knowledge and skills, that is, in the education and training of their employees, because the greater the investment, the better the business results.

Education is a goal, but also a consequence of modern society. The knowledge requirements of individuals in modern society are constantly changing, and individuals must constantly deepen and expand their knowledge in order to become part of the workforce [4]. The education of employees is related to the improvement of general knowledge and understanding of the environment in which the organization operates. The level of education of employees should be in accordance with the requirements of the workplace, and the formal knowledge of employees should be adapted to the requirements and responsibilities and areas of work that employees face [5]. The methods of education are different, some of them are: lectures, seminars, manuals, professional conferences, etc. [6]. In order for employees' knowledge to develop and to be able to respond to constant changes, organizations, as well as employees themselves, should improve their knowledge through self-education.

Training is an activity to improve the ability and performance of employees in the performing of their duties, through the improvement of specific skills, attitudes and behavior related to work [7]. Training activities must be well designed in such a way that they really provide benefits in accordance with the goals that employees should achieve. Well-designed job training, as well as its successful implementation, will improve the quality of employees' work [8, 9]. Training methods can be: active learning, simulations, gaining experience at the workplace, professional practice, mentoring, etc.

Education can therefore be said to represent the acquisition and improvement of theoretical knowledge, while training represents the practical application of acquired knowledge and the improvement of skills. Through their policies, practices and human resource management processes, organizations encourage the development of their employees. Education and training are important factors of personal and organizational development [10]. Organizations allocate significant funds for the education and training of their employees, but this also brings them numerous benefits. In addition to increasing employee satisfaction, less turnover, the effectiveness and efficiency of employees increases, productivity is higher and ultimately, organizations are more competitive in today's turbulent market.

II. EMPLOYEE EDUCATION

One of the factors that affects the performance of employees is education. Also, one of the factors taken into account when hiring and/or assigning employees to jobs is education [5]. Therefore, the

education of people is at the same time among the key goals, but also the consequences of modern society. It requires constant deepening, adaptation and development of educational achievements. This means that education should be permanent and reflect all current needs brought about by changes. Employee education can be characterized as a permanent process in which adaptation and change of work behavior, level of knowledge and motivation of employees takes place on the basis of learning based on different methods. This results in a change in the difference between the existing competencies of employees and the demands placed on them [11-14].

The learning cycle is characterized as a continuous sequence of four steps:

- identification of knowledge needs - what changes have occurred in the market and what knowledge and competencies employees need to improve;
- planning the learning process - when and how to implement the learning process, which method to use, when...;
- implementation of the learning process - realization of the planned learning process and
- monitoring and evaluating the effectiveness of education - comparing the acquired knowledge with the previous state, as well as whether certain additions and corrections need to be made.

In order to increase knowledge in the organization more efficiently, it needs to be managed. The area of knowledge management is an area in which organizations are often reluctant to invest, even though employee engagement is known to be their most valuable resource. Knowledge management is the process of improving organizational performance through the creation and application of processes and systems, structures and cultures that support the creation, exchange and use of knowledge [5]. Organizations that successfully manage knowledge strive to be learning organizations. These are organizations that are characterized as a place where people constantly expand their capacity to create the results they really want, where new and expansive thinking patterns are nurtured, where collective aspirations are unleashed and where people are constantly learning to see the larger whole in the future [6, 16]. . The key factors within a learning organization are trust, open communication, a high level of engagement and an environment full of challenges and competition and a creative atmosphere, promote learning and encourage knowledge sharing [6].

Modern business is also characterized by the need of organizations for highly educated employees. The organization's investments in such employees are increasing, because organizations are aware that such employees will more easily respond to the tasks of today's business, they will better recognize the needs of customers, they have more information, which they process better. Also, highly educated employees are more ready to further improve their knowledge and thus respond to changes occurring in the market [17].

Employees must see education as their chance for advancement, better earnings, greater job security, more respect and recognition, and the company greater work efficiency, productivity, employee motivation, as well as better and faster response to changes in the market and environment [18].

III. EMPLOYEE TRAINING

For human resource management in any organization, training is one of the basic and key activities. Training is an activity to improve the ability and performing of employees in the performance of duties through the improvement of specific skills, attitudes and behavior related to work [7]. Training is one of the efforts to improve the ability of employees to perform the tasks given to them so that they are more skilled and able to perform the tasks and responsibilities assigned to them by the organization. It is intended to improve the mastery of various skills and techniques for the implementation of certain tasks, that is, it represents the preparation of employees for the performance of tasks [19, 20]. Therefore, training represents practical improvement and acquisition of new skills of employees.

Training activities must be designed in such a way that they really provide benefits in accordance with the needs and goals of the organization. Good training for the job and improving the skills and abilities of employees in performing work activities, improving the quality of employees' work. Any training attended by employees improves the business performance of employees, because in the training they acquire skills and abilities for their needs and the needs of doing work [5, 8, 9]. Training can be categorized into on-the-job and off-the-job training. Training at a random location is conducted using available instruments, documents, equipment or materials that are needed by the participants during the training. It is universal and effective, because it takes place in the employee's "natural" environment. On the other hand, off-the-job training allows employees to step away from their work and

focus more closely on the training itself. Compared to training at a random location, this type of training is more effective, due to the complete dedication to the training itself [21, 22]. Some of the training methods are [23, 24]:

- individual instructions - performed with the help of an instructor/expert, who trains the employee one-on-one at the workplace, explaining and showing him what and how to do it;
- job rotation – employees gain experience in performing different jobs by changing jobs within a certain period of time;
- professional practice - it is most often related to craft occupations, where practical training is necessary for performing tasks, but also for highly educated employees, after completing schooling;
- mentoring - used for the socialization of new employees, where a more experienced employee advises and helps the new employee to fit into the work environment;
- case studies - the lecturer gives the participants real situations in the organization, which they need to analyze, identify problems and provide possible solutions;
- simulation - the real situation and equipment are simulated and the participants in the training practically solve the set tasks.

Training helps employees develop their skills to perform the job and this directly affects the business. In order for the training to be successful, it is desirable to adhere to the recommendations that maximize the effectiveness of the training, which are shown in Table 1 [25].

Training allows employees to maximize the level of productivity, that is, employees through training become more efficient and productive if they receive effective training [26]. Training affects the results of human resources, which can be measured by both financial and non-financial results. In financial terms, the results are reflected through: return on investment, return on assets, return on capital, improved productivity, sales growth, etc. [10]. Therefore, it can be said that training is one of the key elements for improving organizational performance and improving employee competencies.

TABLE I. RECOMMENDATIONS FOR SUCCESSFUL TRAINING

Before training	During training	After training
Conduct a needs analysis: -analysis of organizational needs -analysis of needs at the task/job level - analysis of needs at individual level	**Form the right thinking at participants:** - build self-efficacy - promote orientation towards skills improvement -encourage motivation for development	**Ensure transfer of learning:** -remove obstacles -provide tools for managers -encourage practice -give instructions and advice for further development
Prepare training requirements: -make a training schedule -inform participants and ensure attendance -prepare superiors and managers	**Follow appropriate training principles:** -use a specific strategy in conducting training -provide conditions for the application of what has been learned -promote self-regulation -spot and correct training errors	**Rate the training:** -clearly state the purpose -think about multi-level evaluation -relate well to training needs

IV. BENEFITS OF EMPLOYEE EDUCATION AND TRAINING

Human capital, i.e. man with his potential as a resource, is a necessary part of every business process. In order for organizations to maintain and increase the value of human, and to the greatest extent, intellectual capital, they must not for a single moment forget about important activities that affect the growth and development of this capital, namely: education and training of employees, i.e. investing in the development of knowledge and skills of employees. People, as the most important potential of the organization, have a decisive role and importance in the production process, they are the bearers of implementing changes, creating additional value, improving business activities, etc. [27].

Training and education brings numerous advantages to employees, but also to the organization, some of these advantages are [28 - 31]:

- improved knowledge and skills influence employees to perform their work tasks more effectively and efficiently than before;
- retention is today a big problem for employees, especially younger, highly educated ones. Organizations that are ready to invest in their employees and in their development are exposed to lower employee turnover;
- employees who have broader knowledge and skills can perform more complex tasks, instead of the same, monotonous ones,

which reduces boredom at the workplace and increases engagement;

- employees who have greater knowledge and better skills will use materials, tools and equipment in a safer and more economical way;
- reducing the need for supervision - training and improvement of employees' knowledge will not completely reduce the need for supervision, but will reduce it to a minimum;
- increased motivation and morale - employees who have undergone development programs will be more confident in themselves and will be more motivated to perform their work tasks;
- better employee relations and greater trust - employees who explore and improve their knowledge and skills are given the opportunity to connect more easily with team members, to communicate more easily and have more trust in each other.

Employee training and education programs are critical to improving employee performance. A 2019 report shows that 90% of surveyed employees agreed that education and training programs had a positive impact on their work performance [32]. Companies that are actively committed and interested in investing in the development of their employees have 41% lower absenteeism rates and even 17% higher productivity. This means that companies that want to emerge from the market competition as winners must invest in employee education and training programs. Likewise, in order to improve their knowledge and skills, employees should undergo certain training and education programs on their own initiative in order to remain competitive for a specific job.

V. CONCLUSION

Global competition and economic uncertainty, which characterize modern business, require organizations that want to remain competitive to have quality human resources. Employees who achieve high business performance, who have developed a wide range of knowledge and skills, are key to success in the market. For this reason, organizations should be the ones to invest in the development of their human resources. Likewise, in order to save more costs, they can create sectors for human resources development in their organization, send employees to courses that are free of charge, etc. On the other hand, employees must be motivated to improve their knowledge and skills, so they need to be rewarded in some way. Unlike the private sector, the public sector needs the state to allocate funds to stimulate employees to improve their knowledge and thus reduce the turnover of employees, as well as the departure of young people from the country. Investment in education and skills development is an investment that always pays back because as Nelson Mandela said "Education is the most powerful weapon you can use to change the world".

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Overview of Studies Regarding Ethical Leadership in Educational Institutions

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Abstract - Ethical leadership is becoming increasingly important in the field of education, as it reflects the moral values and integrity of leaders who shape future generations. The key components of ethical leadership are moral vision, integrity, transparency and accountability and this concept has an impact on the organizational climate, employee satisfaction, student achievement and the development of moral values among students. Continuous education of leaders is necessary in order to support the application of ethical principles in the practice of education, and ethical leadership in the educational sector realizes the potential for the improvement of educational institutions and the moral development of students. This review paper analyzes the key aspects and findings of research devoted to ethical leadership in educational institutions.

Key words: leadership, ethical leadership, education.

I. INTRODUCTION

Leadership as a discipline represents the ability to motivate employees towards common business goal, which is an important factor in managing an organization in modern conditions. Leadership is concerned with the behaviour and atmosphere in the organization and represents a phenomenon that manifests itself at all organizational levels and as such represents a challenge for research. Leadership has a very broad domain of action and its influence on the creativity of employees in the organization is particularly emphasized. With the development of this management discipline, different approaches to leadership have also developed and most modern theories include creative concepts, properties and abilities [1].

Ethical leadership as a concept can be described through two dimensions that include a moral personality and a moral manager. The first dimension refers to the qualities of an ethical leader as a person at work and beyond, such as honesty, reliability, fairness and concern for others. The concept of the moral manager as another dimension refers to how leaders use managerial roles and leadership positions to promote ethics in the workplace such as modeling ethical behavior, setting and communicating ethical standards, and using rewards and punishments to ensure that ethical standards are followed. The social learning approach to ethical leadership proposes that followers will behave similarly to their leader through imitation and learning through observation. Leaders serve as role models and also use reward and punishment to stimulate desired and ethical behavior. Thus, ethical leadership can be defined as "the demonstration of normatively appropriate behavior through personal actions and interpersonal relationships and the promotion of such behavior to followers through two-way communication, reinforcement and decision-making" [2].

Research suggests that ethical leaders are characterized as honest, caring and principled individuals who make fair and balanced decisions. Ethical leaders also frequently communicate with their followers about ethics, set clear ethical standards, and use rewards and punishments to see that those standards are followed. Also, ethical leaders practice proactivity and are role models for ethical behavior. In a corporate environment where ethical messages can get lost amid messages about the bottom line and immediate tasks, ethical leaders also focus attention on ethics by communicating about ethics frequently and making the ethical message salient. They set clear and high ethical standards for others and follow those standards themselves. Three situational factors that influence employees' perception of a leader as an ethical leader are ethical role modeling, the ethical context of the organization, and the moral intensity of the issues the leader faces in his work. From a social learning perspective, each of these factors provides learning opportunities that can contribute to the development of ethical leadership [3]. Ethical leaders are characterized by several key characteristics [4]:

- Moral Vision - ethical leaders have a clear vision of morally responsible behavior and guiding values for the organization. This vision serves as a framework for making decisions and leading the organization.

- Integrity - integrity is a fundamental characteristic of ethical leaders. They adhere to high moral standards and their promises, which creates trust among employees and students.
- Transparency and Accountability - ethical leaders are open in their communications and accountable for their actions. They possess a readiness to take responsibility as well as for continuous learning.

Education today includes various forms and aspects, and the concept of lifelong learning is applied in many business spheres. When it comes to ethical leadership and its application in educational institutions, it is important to consider institutional integrity and legitimacy. According to the evolution model of university ethics, the leadership process changes according to the leader's function, context or structure, and ethical leadership has a positive impact on aspects of job satisfaction, organizational commitment and organizational citizenship behavior of employees in educational institutions. Ethical leadership is an important predictor of ethical climate and normative commitment, which affects overall job satisfaction [5]. Ethical leadership in educational institutions becomes a significant factor in achieving their missions and goals. As education has deep social and moral meaning, leaders in these institutions play a key role in shaping the values, culture and integrity of the organization.

II. METHODOLOGY

A. The subject and the problem of research

This paper will deal with considering etchical leadership in educational institutions as well as in education in general. Also, this paper will present the benefits of ethical leadership. This paper will not be focusing on specific aspect, rather try to observe as many different studies as possible.

B. Research goal

The goal of this paper is to present the role and importance of ethical leadership application in educational institutions.

C. Research question

Based on analyzed theories, we will try to answer the following question:

- What is the role of ethical leadership in educational institutions?

D. Research Method

This is a form of theoretical research in which conclusions are made by studying previous conducted researches. Research will consider different methodologies of other authors and analyze their results in order to make universal conclusions.

III. RESULTS AND DISCUSSION

Over the past few years, there has been an increase in research on ethical leadership in education. Research on the ethical dimension of leadership in education has experienced a significant rise, especially when it comes to moral reasoning based on justice and ethics of care. A multiple ethical approach assumes that leaders of educational institutions can examine and use different ethical perspectives in their work. These ethical perspectives include ethics of care, ethics of justice such as fairness and utilitarianism, ethics of criticism, and ethics of profession. Research shows that it is necessary to look at ethical aspects in education from multiple angles, especially when it comes to the ethical culture of an educational institution. Namely, it was discovered that the leaders of elementary schools are more pronounced in the ethics of criticism than the leaders of secondary schools. Also, higher education institutions are often more organized and controlled than elementary and secondary schools. It is argued that in order to help school leaders become more successful in their educational leadership role, leadership preparation programs should promote issues of ethics, inclusion, democratic schooling, and social justice. Also, informing the actors of educational systems is important for the acquisition of ethical skills, appointment, qualification and development of ethical qualities in educational leadership in order to achieve the promotion of social justice in schools [6].

The application of ethical leadership in education is significantly related to the ethics of education management, because management ethics is defined as the rules of conduct of managers of educational institutions in management in daily activities, taking into account that teachers, professors and managers are obliged to respect the rules and regulations in terms of culture and traditions and ethical principles. Ethical leadership is characterized by ethical values in the management function in terms of decision-making, ethical behavior, communication, coordination, leadership, planning and organizing, so that the values that ethical leadership has in playing a leadership role also have a pronounced importance in educational institutions. The values held by the managers of these institutions are

determined by establishing educational policies and philosophy, by trying to implement these policies through oriented programs, by selecting, developing and evaluating personnel, by rationally using resources and by creating a healthy educational culture [7].

Attributes of ethical leadership such as honesty, respect, fairness and justice are accepted in various educational and national cultures, and ethical leadership of an educational institution is imperative in the context of increasing performance-based accountability [8]. Ethical leadership has the potential to positively influence the performance of employees in educational institutions, which contributes to better results. The effects of ethical leadership can vary depending on context and other factors, and research has shown that organizations with ethical leaders have better business results, including increased productivity and profitability.

Several studies suggest that implementing ethical leadership can lead to improved job satisfaction, increased emotional commitment, and prevent employee burnout. The concept of ethical leadership and its repercussions in the field of education can be viewed through a unifying perspective. Applying ethical leadership in education can focus on the paradigms of ethics of care, justice, and critique that connect to the concept of honest education as a tool to help administrators, faculty, students, and families. Contemporary educational institutions should strive to adopt a unique view of ethical educational leadership in order to obtain ethical educational leadership by exploring the roles of educational leaders through ethics or care, justice and criticism [9].

In addition to the numerous benefits it brings, ethical leadership and its application also face numerous challenges for managers and academics in various fields. The most frequently asked questions are questions about profitability, defining the reasons for the application of ethics in various areas, achieving a balance in the application of ethical leadership, as well as organizational tools and initiatives that would facilitate that application. However, if institutions want to develop more balanced leaders, they need to shift management education from a focus on mastery to an emphasis on discovery. The primacy of solving problems using economic and other technical means is useful, but in modern educational conditions, insufficient [10]. Ethical leadership imposes the need for more coordinated education and training of managers in management and leadership skills, nurturing and investing in employees who have the primary responsibility for implementing the corporate vision and value structure, achieving a greater balance between striving for greater performance and profitability and establishing a code of ethical behavior, as and balanced executive leadership that embraces complexity, diversity and social responsibility.

The role of ethical leadership in educational institutions involves using a just, socially responsible perspective, which means integrating concrete practice with theory and engaging in intentional self-reflection to improve awareness of one's self and values, and then moving on to relationships with others around the world. Creating community in a changing context of increased responsibility relies on reflective ethical leadership. Beyond law, justice, and educational law that guide all administrator and educator practices and decision-making, social justice in ethical leadership decision-making means identifying unjust systems of oppression and replacing them with culturally responsible and just practices to achieve educational excellence. Ethical leadership offers school administrators and other leaders the means to examine their own practices. The practice of ethical leadership in the global society model includes four interactive dimensions [11]:

- Understanding of social justice theory and leadership theory.
- Application of state, national, professional ethical and legal standards.
- Engaging in the practice of ethical leadership and role modeling for culturally responsible leadership (CRL).
- Using personal leadership ethics and core values as a cyclical process of self-reflection and decision-making.

Leadership practice focused on ethical leadership encourages leaders to reflect on their own values, leadership practices, and how their actions can create inclusiveness, and such practice has been recommended in various international educational settings.

The values underlying the transformation of higher education management in the modern changes from the knowledge economy to the economy of creativity, such as transparency, collaboration, meritocracy and self-determination, are considered signs or basic determinants of new approaches to management in higher education institutions, in order to carry out a fundamental transformation in them. management in order to harmonize higher education with the expectations of the world of work. First of all, these expectations are aimed at changes in terms of the importance of

leadership and organizational culture. From the point of view of leadership, changes are expressed in the need for certain abilities, which should be manifested in maintaining a multiple professional and multifunctional status. Modern education requires the ability to meaningfully plan, organize, direct and develop human resources, evaluate objective and subjective resources, in order to more effectively achieve the goals of the educational system and its elements, which requires a highly structured organization that encourages developmental changes. Authentic, ethical leadership is important for institutions of higher education, because changes involve highly professional, authentic followers, who can provide support only to persons with high professional, scientific and professional authority, self-confident, optimistic, moral, future-oriented, who give prioritizing the development of associates in the field for which they are competent, that is, who with their positive psychological characteristics and abilities create an organizational context, which results in greater self-awareness and self-regulated positive behavior among associates, encouraging positive self-development [12].

The key role of teacher leadership in student learning, the effectiveness of the teaching process, innovative and productive approaches to teaching, climate and culture at the school level, school improvement, education policy development and education reform planning have been pointed out by research and practice in different countries. It could be said that teaching effectiveness is only one of the areas in which teacher leadership can help solve the most sensitive and relevant problems in education, and ultimately, and most importantly, initiate students to learn. In recent years, leaders in formal positions have often been included in the analysis, and the heads of schools and other educational institutions have gained importance in such endeavors, while those who directly contribute to the effectiveness of teaching have been put in the background. Precisely due to the lack of initiative and research to include in the framework of the analysis the characteristics of teacher behavior that directly contribute to the effectiveness of teaching, it is necessary to further examine the connections between the leadership style of teachers and the effectiveness of teaching operationalized through indicators of a favorable climate for learning and indicators of student engagement in teaching and learning [13]. Higher education institutions, as equal participants in modern market business, aim to deliver additional value to their users through the improvement of the institution's overall performance. The quality of educational services through the satisfaction and attitudes of students needs to be monitored using different methods. Ethical leadership in education has deep-rooted importance as it shapes future generations and shapes society as a whole. Education is not only the transfer of knowledge, it is also a process of learning about moral values, social responsibility and integrity. Ethical leaders in education not only set the tone for moral behavior in their institutions, but also serve as role models for students and staff, imparting key lessons about responsibility, honesty, and emphaty. In the context of education, ethical leadership also has the ability to overcome challenges that often arise in this sector, including pressure for test results, competition between institutions and changes in educational policies. Ethical leaders are often able to balance those pressures with moral imperatives, prioritizing the long-term education and moral development of students above immediate success.

When it comes to adult education, the power of education lies in the fact that it provides everyone with a chance for constant personal and professional growth and development, while the power of management lies in arranging the changing world, in creating conditions for the realization of desired activities and goals. Combined in the right way, these areas result in synergy in the area of border area - management in adult education, where management principles are applied in an educational context, and managerial and leadership competencies are continuously acquired and systematically developed in numerous educational forms. Only such an approach can provide benefits to both scientific fields, to the benefit of educational and management practice [14].

IV. GUIDELINES AND RECOMMENDATIONS

Based on the research and analysis presented in this paper, the following guidelines and recommendations are offered for educational instutitions seeking to successfully apply ethical leadership into their practise:

- Ethical leaders in education should actively work to develop a clear moral vision for their institution. This vision should be based on universal moral principles and values, such as honesty, integrity and responsibility.
- Regular communication of the leader's moral vision with staff, students, and the wider community is recommended to establish understanding and support for these moral values.

- Leaders should be consistent in the application of moral principles in all aspects of the management of the institution, including recruitment processes, financial management and relations with students and staff.
- Ethical leaders should invest in their own continuous development, including ethics and leadership education. This will enable them to stay informed about the latest trends and issues in the field of ethical leadership.
- The organization of trainings and workshops on ethical leadership for staff and students is recommended in order to raise awareness of moral values and develop skills for ethical thinking and decision-making.
- Leaders should establish monitoring and evaluation systems of ethical leadership in their institutions. This includes gathering feedback from staff and students about their experiences with leaders and ratings of the institution's moral culture.

Through the application of these principles, leaders will be able to create a positive impact on their organizations and contribute to the moral development of students, which will ultimately contribute to better education and society as a whole.

V. CONCLUSION

Ethical leadership is essential for educational institutions because it shapes their culture, integrity and contributes to the achievement of their goals. Ethical leaders play a key role in creating a positive organizational climate, supporting employee satisfaction, improving student achievement and moral development of students (RQ:1). Understanding and promoting ethical leadership should be a priority for educational institutions in order to achieve their mission and contribute to the moral and intellectual development of their members. Ethical leadership in education contributes to a better reputation of the institution, attracting quality students and staff, as well as supporting cooperation with other institutions and communities. This makes educational institutions more attractive and sustainable over time. Ethical leadership in education is not only a moral duty, but also a key factor for achieving high educational standards, moral development of students and long-term sustainability of educational institutions. Ethical leaders in education bear the burden of responsibility for shaping future leaders and citizens, making their role vital to society and community development.

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Improvement of Teaching in the Subject: Enterprises Computer Infrastructure Management

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Abstract – The subject Enterprises Computer Infrastructure Management is studied at the Technical faculty "Mihajlo Pupin" in Zrenjanin in two departments – software engineering and management of information technologies. This paper provides experiences from other faculties and universities in working on similar subjects in order to improve our teaching. Subject goal and content at our faculty was presented. We show teaching improvements made in the last study year with examples of using Unified Modeling Language - component and deployment diagrams for designing organization infrastructure, network, software etc.

I. INTRODUCTION

The development of information and communication technologies enforces an increasing dependence of the enterprises business and work on a successfully developed and built corporate information technologies (IT) infrastructure. The role of the IT team and company management is to achieve desired characteristics of IT infrastructure in the corporate organization. [1]

Students acquire these knowledge and skills, among others, at the subject Enterprises Computer Infrastructure Management, which is studied at the Technical faculty "Mihajlo Pupin" in Zrenjanin, on the following departments: IT - Software Engineering as an elective subject and Information Technologies – IT Management module as mandatory subject. This subject has been in the curricula for almost ten years, and with the change of teacher and associate in the last school year, by insight into the academic content of the subject, the need for improving the teaching content in order to improve the teaching process emerged.

The rest of the paper is divided into the following parts: section 2 provides experiences from other universities and faculties in working on this subject, section 3 shows content of this subject, educational goals, section 4 is the main part of the paper that show teaching improvements at Technical faculty "Mihajlo Pupin", and finally section 5 gives a brief conclusion of the paper.

II. EXPERIENCES FROM OTHER UNIVERSITIES AND FACULTIES

A graduate student of the Enterprise IT Infrastructure Management profile at [2] acquires following knowledge and skills that will allow graduate student to:

- Carry out an analysis of business needs and develop a concept for its development based on information and communication technologies;
- Develop the architecture of the IT infrastructure of the enterprise;
- Carry out systematic planning and development of IT infrastructure;
- Make strategic decisions regarding the selection and implementation of IS and ICT in the enterprise.

As it is stated in [3], IT infrastructure is a strategic part of the organizations. Author has been examined university programs that educate future infrastructure analysts. IT curriculum models are used to survey courses required by telecommunications and IT infrastructure programs in business schools. Around 50 percent of collegiate schools programs have telecommunications and infrastructure-related programs. IT security and infrastructure, networking-advanced are the top three infrastructure-related courses. Therefore, quality is very important issue in this field. Attention in this field has been set to the learning process through several aspects like education in the following: Cyber security, electrical engineering, telecommunication engineering, mechatronics, computer science program, and engineering program.

IT Infrastructure Management subject is examined on university in Ontario, in Canada [4]. It research reporting and presentation approach to examine and critically analyze a combination of the technical and management issues in contemporary IT infrastructure management. IT infrastructure

management evaluates new ICTs in the context of enterprise architecture. It is a combination of IT, business administration and electronic commerce.

Learning outcomes, students should:

- be able to describe the business value and processes of ICT services in an organization;
- be able to investigate, analyze and evaluate the impact of new and current ICT services to an organization;
- be able to describe how effective IT infrastructure management requires strategic planning with alignment from both the IT and business perspectives in an organization;
- be able to demonstrate the technical and communications skills that contribute to the operation of ICT services;
- be able to reflect critically on the role of an enterprise architect;
- be able to synthesize the theoretical, technical and management issues that deliver ICT services to an organization.

This subject will cover the following topics: IT infrastructure and support systems, Enterprise information systems, Data, text, and document management, Network management and mobility, Security, crime, compliance, and continuity, Mobile computing and commerce, Web 2.0 and social media, and Operational planning and control systems.

Information Technology Infrastructure program is designed to help students with an IT background to step into the industry [5]. IT workers need a broad range of practical skills to utilize in their everyday responsibilities. Graduate students will be prepared to enter an exciting career as an IT Infrastructure/Operations manager, IT Infrastructure service manager. Infrastructure Ontario College focuses on the practices and skills used in support of the IT infrastructure. Students will gain knowledge and experience working with various operating systems, server administration, virtualization technologies, and network and security devices.

Article [6] gives a short definition: "IT infrastructure is the digital road your information travels on". IT infrastructure managers require a specific skillsets to understand how to deploy and set up infrastructure components, to understand and direct infrastructure changes; the higher-level staff must understand the budgeting, specifications, architecture, and strategic purpose of infrastructure functions.

Network infrastructure management involves interconnected hardware and internet components that must be configured to transport data and allow access into and out of your infrastructure. Infrastructure is connected to the internet and Wide Area Network through security servers\devices such as firewalls, edge servers, and telecommunication lines. Infrastructure software includes the application and software that runs on servers. There is a need for server operating system and server utility software installation, configuration, upgrade, and maintenance, as well as backup setup, user provisioning and security for system access, services, and some applications. [6]

III. SUBJECT CONTENT AND EDUCATIONAL GOALS

In the following sentences, the educational goals and the content of this subject at our faculty are presented.

Educational goal: the main goal of the course is mastering the knowledge needed for technical planning, design, maintenance and creating documentation for the computer infrastructure and network, servers, communications, data storage, knowledge for working with monitoring software and designing network infrastructure, mastering the basics of server infrastructure of operating systems and virtualization, data storage systems, and cloud technology.

Theoretical teaching content:

- Computer infrastructure of the enterprise - software that include operating systems for servers and workstations, server software, application software.
- Computer infrastructure – hardware, include computers, data storage devices, printers and other peripherals.
- Communication infrastructure - computer networks, communication technologies, network devices.
- Management of data from different sources and formats, storage and backup systems and their integration.
- Computer and communication infrastructure and integration of old and of new software-hardware components of the system.
- Management of network resources and services - accounts and privileges, network file system, remote access.
- Software for planning, designing, documenting and monitoring computer networks and computers.

- Management of Internet services - DNS, e-mail, web, http, ftp, etc.
- Reliability, security and protection of data and computer networks (firewall systems, cryptography).
- Enterprise Virtual Private Networks - creation, management and maintenance.
- Network resources and services, accounts, privileges, network file systems.
- Remote access to computer resources, Planning and monitoring software.
- Archiving systems, cloud.
- Organization of computing centers.
- Information security of computers on the Internet, viruses, threats - threats to information resources, involuntary actions, natural disasters, technical failures, management errors, software attacks, viruses, worms, Trojan horses.

Practical teaching content - Students have to work with software for network monitoring and design, installation operating systems, account opening and privileges, creation of backup and backup copies and archiving. Also, students learn the basics of the "batch" scripting language that is useful on Windows operating systems. They are introduced to basic commands, which are executed as a series of commands.

IV. TEACHING IMPROVEMENTS IN THE SUBJECT

Concepts for describing the relationship between architecture description on the business, application, and technology layers are customized for each architectural domain using standards such as Unified modeling language (UML). [7]

UML enables IT professionals to model computer applications, software and its parts, hardware, networks and similar. The primary authors were Jim Rumbaugh, Ivar Jacobson, and Grady Booch, who originally had their own methods (OMT, OOSE, and Booch). They joined forces and brought about an open standard called UML. Parts of these methods are: use-case, class, object, sequence, state-chart, activity, and component and deployment diagrams. UML has become a standard modeling language because it is programming-language and technology independent. The UML is a language. It does not present a methodology. It can fit into any company's business. [8]

UML diagrams suitable for IT infrastructure design are component and deployment.

A component diagram purpose is to show the dependencies that the software or system has on the other software or system components. The diagram can be shown at a very high level, with components, or it can be shown at the component package level. [8]

A component is a physical part of a system that provides the realization of a set of interfaces. It can be used to model nodes such as programs, executables, libraries, files, components, and documents. Components have names, may realize a set of interfaces, may participate in dependences, generalization, association interactions, and may have instances. [9]

The deployment diagram shows how users access software tools, hardware components, network resources, their connections, nodes, servers, workstations etc. [8]

Basic elements of deployment diagrams are nodes – basic building block of the physical aspects of a system. Node exists at runtime and presents a computational resource that has memory, and often processing capabilities. Every node must have a name, also may participate in dependences, generalization, association interactions, and may have instances like classes and components. [9]

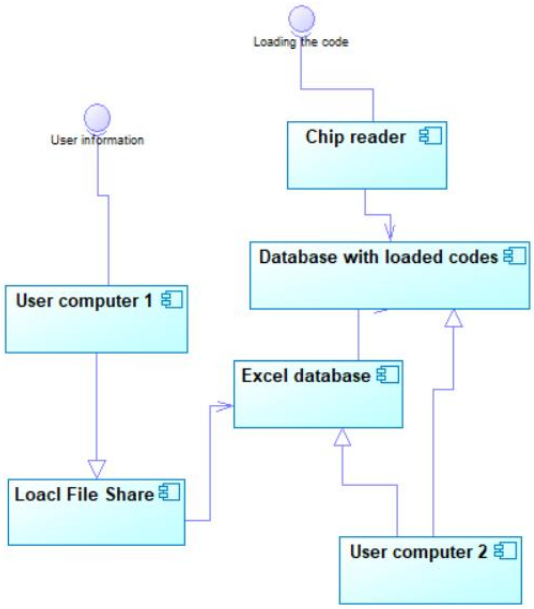

Figure 1. Component UML diagram

From the presented experiences of teaching the subject IT and Computer Infrastructure Management at foreign universities listed in [2], [3], [4], [5], [6], it can be concluded that the content of this subject at the Technical faculty in Zrenjanin match in an extremely high percentage. Topics that are studied

both in the world and at our faculty are: IT infrastructure support, network management, data and document management, system security, operational planning and control systems.

Observing the competences of graduated students listed in [4], [5] and the content of practical classes that were conducted in previous school years at our faculty, it was observed that our students receive too much theoretical content and that was necessary to increase the share of practical classes in software for designing and designing IT infrastructure.

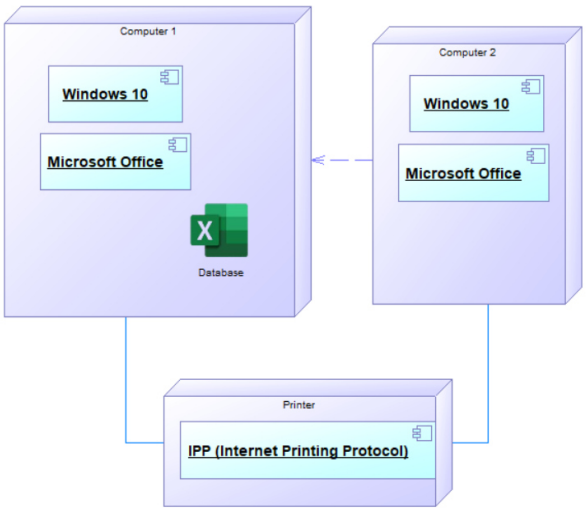

Figure 2. Deploymentent UML diagram

Based on the previously presented subject content and expected skills for which students are trained at foreign universities, we decided to include in the teaching process, in its practical part, work with UML diagrams in exercises performed by students. Example of the system IT infrastructure for animal shelter was developed during practical classes. It is presented at “Fig. 1” and “Fig. 2”. UML diagrams, component and deployment were used for designing organization infrastructure for hardware and software in small enterprise.

In addition to planning the company's hardware and software structure, students are tasked with planning the company's computer network. Understanding the physical and logical topology of the network is essential, as students plan the entire network structure of the enterprise. They become familiar with the operation of a computer network and, based on that, determine the network devices that are needed. Deployment of network components such as: network adapter, routers, hubs, and network printers, and other network devices for a specific company is presented on “Fig. 3”.

Students get acquainted with the computer network through batch files, by calling basic commands for displaying the IP address, DNS server and other commands for manipulating the computer network.

Figure 3. Network infrastucture scheme

The "batch" scripting language is useful on Windows operating systems. Students are introduced to basic commands, which are executed as a series of commands. Automation of repetitive tasks in exercises, such as: working in the console window, starting and executing operating system commands, changing the current folder, creating and deleting folders, working with windows, starting multiple applications, checking network status and recording output to a file, working with connections, variables, working with files - copying, creating, deleting, editing, changing the name of the file and finally user administration.

V. CONCLUSION

From this study it can be concluded that the subject Enterprises Computer Infrastructure Management teaching improvements were made in the last study year at Technical Faculty in Zrenjanin. It can be noted that the teaching content is in accordance with the content studied at foreign universities.

We introduce usage of UML diagrams, component and deployment for designing organization infrastructure for hardware and software in enterprises. Work with network resources and planning was shown in various schemas. Operating system handling was done with executing batch files.

There is still some space for further improvements in this subject in order to achieve better students’ knowledge. Further improvement of practical teaching in the course could move in the

direction of using specific software systems for monitoring and administration of computer networks.

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Synergy Between Marketing Strategies 4.0 and Education in Small and Medium Enterprises

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Abstract - In an era marked by digital transformation, SMEs face the imperative of embracing Marketing Strategies 4.0 to remain competitive and sustainable. This paper, grounded in an extensive literature review, explores the profound impact of Marketing Strategies 4.0 on SMEs. Challenges encountered by SMEs in adopting Marketing Strategies 4.0 are discussed, including financial limitations and resistance to technological change. Ethical considerations surrounding data privacy and consumer trust are also examined. The paper provides practical insights into the tools and technologies available for SMEs to implement these strategies effectively. As we delve into the future, emerging trends and innovations in Marketing Strategies 4.0 are explored, shedding light on how SMEs can position themselves for continued success. In conclusion, this paper underscores the pivotal role of Marketing Strategies 4.0 in the SME landscape and offers guidance for SMEs to navigate the digital marketing terrain, drawing from the wealth of knowledge within the literature. The integration of Marketing 4.0 strategies within SMEs necessitates a comprehensive approach to employee education. Through these educational endeavors, SMEs can empower their workforce with the knowledge and skills necessary to navigate the complex landscape of Marketing 4.0 effectively, fostering innovation, optimizing operations, and enhancing customer engagement for sustainable growth.

I. INTRODUCTION

The advent of Industry 4.0 technologies has revolutionized conventional approaches across multiple fields of study. Through digitalization, these technologies promote sustainability and usher in innovative infrastructures. In today's landscape, it is imperative for every organization to devise a unique marketing strategy to align with the evolving needs of customers and the market, encompassing both products and services.

In the current era of Industry 4.0 and the circular economy, businesses with morally sound and environmentally friendly practices are in high demand. Due to different operational and budgetary restrictions, small and medium-sized enterprises (SMEs) find it difficult to adopt Industry 4.0 technology. In the context of developing nations such as India particularly, the issue is more serious [1]. Companies need to enhance their marketing performance to not only thrive but also to outperform their competition. Enhancing an organization's productivity hinges on several critical factors: customer stratification, customer retention, customer profiling, and customer behavior analysis. In this context, Industry 4.0 technologies like the Internet of Things (IoT), cloud computing, artificial intelligence (AI)/machine learning (ML), big data, blockchain, robots, digital twin, and the metaverse assume pivotal roles. These technologies, as already evidenced in various domains, facilitate real-time monitoring, predictive analytics, intelligent insights, virtual representation, secure transactions, and the development of digital ecosystems.

The implementation of digitalization comprises sociotechnical processes at social and institutional level. Here, we discuss the few studies that present the importance of digitalization to sustainability. Digitalization of any field is driven by Industry 4.0 technologies[2] . Marketing's core activities are understanding customer needs, matching them to products and services, and persuading people to buy— capabilities that AI can dramatically enhance [3].

As the digital realm melds seamlessly with the marketing domain, the significance of tailored strategies becomes apparent, bridging the gap between resource limitations and ambitious aspirations. We delve into the intricacies of these strategies, uncovering their potential to revolutionize SME marketing, bolstering their competitiveness in an ever-evolving marketplace.

As we progress, we unveil the arsenal of tools and technologies at the disposal of SMEs, empowering them to implement Marketing Strategies 4.0 with precision and efficacy. From marketing automation to customer relationship management systems, we decipher the technological enablers that pave the way for success. This paper endeavors to equip SMEs with the knowledge and guidance required to navigate the complex terrain of Marketing Strategies 4.0. Grounded in research and empirical evidence, it serves as a compass for SMEs seeking to not only

survive but thrive in a digital age that demands nothing less than strategic excellence.

II. METHODOLOGY

A. *The subject and the problem of research*

Main focus on this paper will be on how marketing strategies 4.0 in small and medium enterprises impact their competitiveness. This paper will also present how marketing strategies 4.0 in small and medium enterprises benefits them upon implementation.

B. *Research goal*

Goal of this paper is to present importance of implementing marketing strategies 4.0 in order to achieve goals.

C. *Research question*

Main question will be how to best implement marketing strategies 4.0 in order to achieve set goals and raise awareness regarding environmental sustainability.

D. *Research Method*

This is a form of theoretical research in which conclusions are made by studying previous conducted researches. Research will consider different methodologies of other authors and analyze their results in order to make universal conclusions.

III. RESULTS AND DISCUSSION

The term "Industry 4.0" refers to a broad spectrum of contemporary notions whose precise differentiation and clear classification within a discipline are not always attainable [4]. Nonetheless, it can be perceived as a fusion of diverse technologies, including but not limited to IoT, cloud computing, big data, AI/ML, blockchain, digital twin, robots/drones, and the metaverse. Industry 4.0 has ushered in significant advancements across multiple sectors, spanning medicine, management, agriculture, military, construction, and beyond. This fourth-generation industrial revolution has left an indelible mark on the world.

As authors is [5] mention the central idea of Industry 4.0 is the trend of digitization, automation, and increased use of information and communications technology. Some authors noticed that people's lives and workplaces are radically changing as a result of the digital revolution, but the public is nevertheless hopeful about the prospects that Industry 4.0 may present for sustainability [6]. Things we must understand that these authors want us to understand is main objective and idea of Industry 4.0. As we understand there are three main pillars of it. First one would be digitalization, second one would be automation and last one would be increased use of information and communications technology (ICT). It is also important to stress what kind of impact does it have on lives and workplace. They are heavily impacted by it. Individuals live and work is undergoing substantial changes due to the integration of digital technologies. We must pay attention to publics hopefulness for sustainability. Industry 4.0 may disrupt existing norms, it also holds promise for addressing environmental and societal challenges.

As we mentioned before there are quite a few things we must consider under marketing strategies 4.0. Now we are going to list things that we have done literature review about :

- internet of things (IoT)
- cloud computing
- AI
- big data
- blockchain
- digital twin
- metaverse

Implementing the Internet of Things (IoT) in Small and Medium Enterprises (SMEs) can be a transformative process that enhances operational efficiency, customer service, and competitiveness. It's main goal is to gather strategic information for customer satisfaction of targeted audiences. It allows the connection of physical devices, resulting in information exchange that enables organizations to strategically become more efficient in the rising market dynamics, which has resulted in the creation of a long-lasting relationship with the customers [7]. Building long lasting relationships is of utmost importance to SMEs, especially when we compare costs of retaining current customers to cost of acquiring new customers. It is in nature of any SME to strive to get new customers but main foundation is keeping current customers satisfied. To build these long-lasting relationships, IoT technology is used to forecast the demands of customers by analyzing their purchase patterns through the data collected by the organization. IoT has brought about new opportunities and methods for how customers experience shopping. When customers interact with the IoT technology, it culminates in value co-creation, which greatly affects customers' continuance intention and word-of-mouth intention [8]. Many experts assert that word-of-mouth communication

plays a pivotal role in influencing consumers' purchase choices. Additionally, within the realm of the shopping experience, mobile commerce has significantly benefited from the impact of the IoT. IoT has made a lasting imprint in this domain by enabling the seamless integration of data, considering factors like time, location, and context, primarily through the utilization of location-based services. SMEs can leverage the data acquired through IoT to gain valuable insights into customer behavior and product usage patterns. Furthermore, this data can serve as a foundation for designing new products by providing insights into the existing landscape of internet-enabled products in the market and gathering feedback on customer preferences and opinions regarding these products. SMEs longevity can be achieved by enabling IoT devices in the products which are designed for the market.

Cloud computing is a technology employed by SMEs to centralize and integrate a shared pool of resources, resulting in more efficient management and scheduling. E-commerce, in particular, has experienced substantial growth and advancement thanks to the utilization of cloud computing. It is believed that cloud computing utilization (CCU) is beneficial in reducing the various marketing barriers that can be experienced by various SMEs. It can also be used to reduce the international barriers which are encountered by EM-SMEs [9]. Main goal of cloud computing in SMEs is to develop digital infrastructure for accessing essential data at any time and from any location and also be able to receive real time feedback on products and services.

Constructing the right business case is often a critical determinant of a company's success in implementing AI. These solutions ultimately aim to streamline decision-making processes and improve communication as a result of information analysis [10]. From this we can conclude that implementation of artificial intelligence in a SMEs requires the precise establishment of business objectives, as well as access to data and appropriate tools, together with techniques for their analysis. Main goal of implementing AI as part of creating new marketing strategies is developing artificial agents that analyze data regarding customers, focal companies and competitors in order to recommend marketing actions to achieve the best results. Forecasting customers behavior is important because it helps creating marketing plans and adjusting future actions accordingly. AI and ML go hand in hand. ML as part of Industry 4.0 also greatly helps and improves creation of new marketing strategies. AI/ML finds application not only in the B2B sector but also in the B2C domain. Machines endowed with enhanced learning capabilities outperform those lacking such learning abilities, often even surpassing human capabilities.

Big data refers to vast and complex datasets that cannot be easily processed or analyzed using traditional data management tools and methods. Marketing in the contemporary world is largely dependent on big data. Big data is a disruptive technology that has proved to be helpful in decision-making, and may be applied to the various elements of the marketing mix such as product, price, place, promotion, and people [11]. Main goal of big data is to obtain concealed knowledge about consumer behavior. Using business analytics to strengthen the quality of a product or service. Identifying target customers and marketplaces to establish strategies. As marketing shifts from offline to online, there is a greater need to make strong marketing decisions, and one way to do so is by segmenting online customers. The data obtained from these customers is quite exhaustive and it needs advanced technologies such as big data for its analysis [12].

Blockchain is a decentralized and distributed digital ledger technology that records transactions across multiple computers in a way that ensures the security, transparency, and immutability of the data. Blockchain is viewed as a tool that can revolutionize systems in a variety of industries. It is popular right now, due to its strong foundation [13]. Blockchain technology holds the potential to be advantageous for SMEs in marketing, especially in areas such as supply chain management and internal control of marketing operations, enabling professionals to enhance internal management systems and marketing strategies, thereby fortifying the competitive edge of businesses. Goal that blockchain wants to reach is to improve consumer retention, SMEs have begun gathering and retaining customer data systematically, usually through loyalty programs. Consumers can transact directly without going through intermediary layers in unintermediated markets.

A digital twin is a virtual representation or digital replica of a physical object, system, or process, often used for simulation, monitoring, and analysis to improve efficiency, performance, and decision-making in real-world applications. SMEs can create digital twins of their products to simulate and test their designs virtually, reducing the need for physical prototypes, which can be costly and time-consuming. Digital twins generate a wealth of data that can be analyzed to gain insights into product performance, customer behavior, and market trends, helping SMEs make data-driven decisions. They can also can be employed to simulate market scenarios and test new products or strategies before launching them, reducing risks associated with market entry.

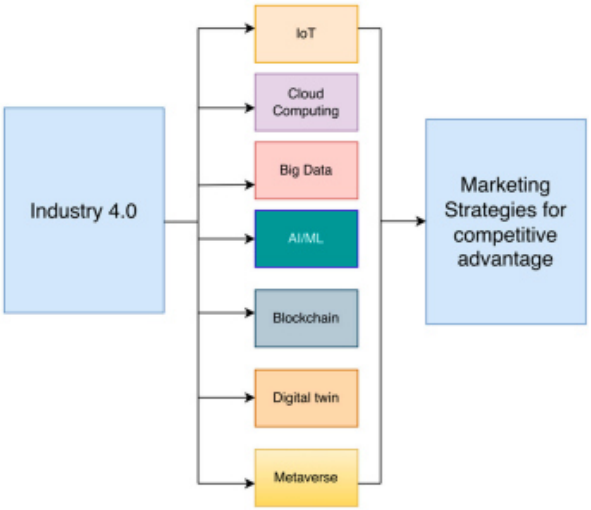

Figure 1 Technologies of Industry 4.0 that affect Marketing Strategies [14].

Integrating AI, ML, IoT, blockchain, big data, the metaverse, and cloud computing into marketing strategies for SMEs can offer several compelling reasons and advantages:

- enhanced customer understanding: AI and ML these technologies can analyze customer data to identify patterns, preferences, and trends, allowing SMEs to tailor marketing efforts more effectively.
- personalization: AI and ML enable personalized marketing campaigns, product recommendations, and content delivery, enhancing customer engagement and satisfaction.
- Efficient data handling: Big Data helps SMEs manage and extract valuable insights from large datasets, enabling data-driven decision-making for marketing strategies.
- real-time insights: IoT provides real-time data on customer behavior and product usage, allowing SMEs to make instant adjustments to marketing tactics.
- security and transparency: Blockchain ensures secure and transparent transactions, which can be particularly valuable in e-commerce and loyalty programs.
- cost efficiency: Cloud Computing: Reduces the need for extensive IT infrastructure investments, enabling SMEs to access scalable resources and solutions on a pay-as-you-go basis.
- innovation and competitive edge: Metaverse offers opportunities for immersive customer experiences, virtual showrooms, and innovative marketing campaigns that can set SMEs apart from competitors.
- supply chain optimization: IoT and Blockchain enable better supply chain visibility and traceability, helping SMEs ensure product quality and authenticity, which can be a valuable marketing point.
- data security and privacy: Blockchain provides enhanced data security and privacy, which is essential for building trust with customers in an era of increasing data concerns.
- improved customer engagement: Metaverse allows SMEs to engage with customers in new and immersive ways, such as virtual events or experiences, strengthening brand loyalty.
- predictive analytics: AI, ML, and Big Data enable SMEs to predict customer behavior, market trends, and inventory needs, optimizing marketing strategies and resource allocation.
- scalability: Cloud Computing offers the flexibility to scale marketing initiatives up or down as needed, accommodating growth or seasonal fluctuations.
- efficient resource allocation: AI and ML helps SMEs allocate marketing resources more efficiently by targeting the right audiences and channels.
- competitive advantage: Implementing these technologies can give SMEs a competitive edge by staying ahead of the curve in marketing innovation.
- adaptation to digital trends: As consumers increasingly engage with digital technologies, incorporating these tools into marketing strategies ensures SMEs stay relevant and accessible.

While implementing advanced marketing strategies involving AI, ML, IoT, blockchain, big data, the metaverse, and cloud computing can offer significant benefits to SMEs, there are also potential drawbacks and challenges to consider:

- costs: high initial investment, implementing these technologies can be expensive, and SMEs may struggle with the initial upfront costs.
- complexity: technical complexity, these technologies often require technical expertise, which SMEs may lack or find challenging to acquire.
- data privacy and security: data risks, collecting and storing customer data can pose

security and privacy risks, and SMEs may not have robust cybersecurity measures in place.

- integration challenges: compatibility issues, integrating various technologies may be challenging, and ensuring they work seamlessly together can be complex.
- resource constraints: lack of resources: SMEs may lack the financial and human resources needed for successful implementation and ongoing management.
- overreliance on technology :loss of personal touch, overreliance on technology can lead to a loss of the personal touch that SMEs are known for, potentially alienating customers.
- data overload: information overload, collecting extensive data can lead to information overload, making it difficult to extract meaningful insights.
- regulatory compliance: compliance challenges, SMEs must navigate complex regulations related to data privacy and consumer rights, which can be time-consuming and costly.
- resistance to change: employee resistance, employees may resist adopting new technologies, causing internal friction and hindering successful implementation.
- customer privacy concerns: privacy worries, customers may be concerned about how their data is being used, potentially damaging trust and reputation.
- technical issues: downtime and glitches, technical issues, downtime, or system glitches can disrupt marketing efforts and customer experiences.
- limited expertise: skill shortage, finding and retaining employees with expertise in these technologies can be challenging, especially in competitive job markets.
- missinterpretation of data: misguided decision-making, misinterpreting data or relying too heavily on algorithms can lead to misguided marketing decisions.

The success of Marketing 4.0 initiatives hinges upon organizations' commitment to empowering their employees through ongoing education and training, enabling them to leverage the transformative potential of emerging technologies. In the era of Marketing 4.0, continuous education and training are paramount to equip professionals with the skills needed to navigate the evolving digital landscape, make informed decisions, and deliver personalized customer experiences

IV. GUIDELINES AND RECOMMENDATIONS

Based on the research and analysis presented in this paper, the following guidelines and recommendations are offered for SMEs that want to base their marketing strategies on Industry 4.0 technologies :

- implementation of marketing strategies 4.0 can lead to many benefits such as efficient data handling, enhanced customer understanding and improved customer engagement just to name a few. They are all absolutely important for SMEs that want to be competitive in the market.
- although marketing strategies 4.0 come with many benefits, they must be implemented in certain way and require certain level on knowledge amongst employees in order to gain benefits from it.
- in order to properly implement marketing strategies 4.0 SMEs need to have certain level of resources in order to make most out of it. If given SME lacks resources or employees who lack knowledge these marketing strategies can't be implemented.
- in some cases implementation of these strategies can raise important questions about breaching data privacy and security or it can lead to data overload and even cause technical issues and glitches that can lead to disruption of marketing efforts.
- The synergy between Marketing 4.0 and comprehensive education and training programs empowers organizations to not only adapt to digital trends but also proactively shape the future of marketing through data-driven insights and customer-centric strategies.

V. CONCLUSION

These technologies offer SMEs the power to unlock deeper customer insights, enhance personalization, optimize operations, and stay competitive in a dynamic marketplace. However, the journey towards harnessing these capabilities is not without its challenges, including costs, technical complexities, and data privacy concerns. Yet, the potential rewards far outweigh the risks. SMEs that embrace these technologies can elevate their customer engagement, adapt to evolving market trends, and make data-driven decisions that fuel innovation. As the digital

landscape continues to evolve, SMEs must embrace the opportunities presented by Industry 4.0 technologies to not only survive but thrive in an increasingly digital world. In conclusion, the fusion of these technologies with marketing strategies is not merely a choice; it is an imperative for SMEs aspiring to carve their niche in the digital age and secure their position as agile, innovative, and customer-centric enterprises. Effective employee education and training in the principles and practices of Marketing 4.0 are indispensable. While challenges and investments accompany the endeavor to educate employees, the rewards are manifold. Well-trained staff can unlock deeper customer insights, enhance personalization, optimize operations, and stay competitive in a dynamic marketplace. As the digital landscape continues to evolve, SMEs that prioritize employee education are better positioned to adapt, innovate, and succeed.

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User Experience Evaluation Metric Model Based on Graphical and Content Elements Estimation

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Abstract – This paper describes aspects of user experience to be included in web applications. It particularly provides elements, characteristics and other considerations that should be addressed in design, in aim to have better results in evaluation of user experience aspect of web site. It also provides a short overview of methods to be used in user experience evaluation. This paper contributes with the proposed method that could be used for numerical expression of the user experience level achieved at a website. The proposed mathematical formula is based on using estimated values regarding existence and the achieved level of quality for particular elements of website. A case study is successfully conducted upon previous official web site of Technical faculty "Mihajlo Pupin" Zrenjanin, Serbia to empirically prove the applicability of the proposed metrical model.

I. INTRODUCTION

Modern websites follow modern building principles with certain personalization options that serve to provide the highest possible quality to users. The most commonly used type of personalization is reflected in the choice between light and dark themes, the choice of font size in the form of support for visually impaired people and the choice of the language that best suits the user.

The user experience of web applications is based on special rules that are applied to make the overall user experience satisfactory. User interface and user experience are united under the term "UI/UX", i.e. "User Interface / User experience", and together they enable a reviewed design of the user interface whose functionality is adapted to the user in such a way that it is easy to understand.

According to [1], the first step towards developing an accessible user experience is based on the attitude that a website is not developed for the "average user". Universal usability refers to users of all ages, experiences including users with physical limitations as well as sensory limitations.

According to [1], the user experience should satisfy the needs of flexibility, user control and keyboard functionality.

In this work, user experience characteristics in web based applications are presented as rules in order to achieve improved user experience. Aim of this paper is to make a short systematization of these rules and methods for evaluation. Particularly, this paper contributes with an evaluation method that focuses on several important elements of a web site related to graphical presentation and content. This method is based on estimation of the element importance and the estimation of the element existence and quality of presentation. This way, the mathematical formula is presented, that is to be used to numerically express the level of user experience achievement.

The rest of this paper is organized as follows: section two presents a short overview of related work, section three presents basic user experience characteristics of web-based applications, section four provides an overview of existing methods for evaluating websites user experience, section five provides particular insight in important user experience considerations within designing user interface. Section six provides contribution of this paper with the proposed model, that could enable quantitative presentation of user experience level achieved at a web site, based on previous estimations of particular elements. Section seven provides an empirical proof of the proposed model applicability, with a short case-study conducted upon previous official web site of Tehnical Faculty "Mihajlo Pupin" Zrenjanin, Serbia. Final section presents conclusions and future work directions.

II. RELATED WORK

One of the most important tools for evaluation of user experience metrics is achieved with web vitals [8]. In order to achieve metric-based score, it is

important to define formulas which will provide metric-based score of different characteristics of the user experience. According to [5], the metric of user experience can be presented trough visual lining of elements and their accumulated height on the left and right side.

According to [8], important factor for evaluation of user experience is achieved with load speed insights, load responsiveness, runtime responsiveness, visual stability and smoothness. Performing a mathematical formalization can be done in order to implement quantitative metrics [6]. With increase of usage of mobile devices, it is important that websites are suitable for users of various mobile device types [14]. According to [10], in order to achieve perfection of user experience, it is required to have various different skills. Capabilities of the user interface and user experience depend on the quality of the designed system [12].

According to [9], measuring the usefulness of the user experience can be realized by observing the success of the implemented task, the user experience:

• The success of the completed task
• User satisfaction
• User interface errors

According to [6], it is possible to perform metrics for different aspects of the user interface that affect the user experience by performing a mathematical formalization in order to transform visual quality techniques in such a way as to realize quantitative metrics.

Based on [9] and [6], it is possible to make a tabular representation of user experience and design characteristics on the basis of which a quantitative metric of the corresponding characteristic can be developed, where each characteristic, depending on its importance and existence, carries an appropriate number of points.

III. USER EXPERIENCE CHARACTERISTICS OF WEB- BASED APPLICATIONS

According to [2], methods (elements) for the development of user experience can be based on the element of task development, which is a method used to analyze the tasks that the user must perform in order to achieve the goal. An element of agile software development is a fast and flexible approach to web application development. The usability element represents the method used to establish the quality of interactive design, which is one of the necessary characteristics of the user experience in modern web application design.

The term user experience in a web application refers to every component of a website including the user-friendly design and the way the user interacts on the visited page. User experience is considered a process in which the user interacts in a particular way through various user interfaces.

According to [3], user experience characteristics can be considered as factors, components and attributes related to user experience needs. The characteristics of the designed system are reflected in complexity, purpose, usefulness and functionality. Usability is a characteristic of a good user experience that contains structure, design and purpose that are made to be easy to understand [4].

According to [4], fairness is a characteristic of the user experience by which it is possible that people with different disabilities, such as low vision, and similar disabilities, can use a website according to their needs. Usefulness represents a characteristic related to the solution of the user's problem. Design overcomes the user's problem that the designer managed to spot, but it does not mean that every useful product is also usable, and vice versa. Satisfaction represents the characteristic according to which users are satisfied when using a website, including the functionality of the website and aspects intended to satisfy all user needs. When designing websites, it is necessary to take care to ensure that the user interface is reviewed and to ensure the use of modern principles and rules for designing websites. The basic rule refers to the color balance, as well as the strictly prohibited use of absolute white and absolute black. Instead, slightly darker shades of white and slightly lighter shades of dark colors are used, so the color saturation is not 100%. When placing the navigation elements, the basic navigation content that is most visited is used, while the deeper structure of the website is found in the drop-down menu that contains many items that the user can search by. Descriptions on buttons should not be verbose, and should aim to accurately describe their functionality.

IV. METHODS FOR EVALUATION OF WEBSITES USER EXPERIENCE

In [6] methodology for metric-based evaluation of the user interface is presented and empirical research upon the proposed methodology is conducted. It is necessary to formulate a hypothesis that can be confirmed empirically, with the application of statistics. Samples are then selected to represent different user interfaces, web pages and applications that differ in their role and intended use. Mathematical formalization is necessary to convert the quality of visual techniques into a metric

equivalent. Then, on the basis of defined formulas, metrics are calculated for each user interface, after which a survey is conducted where users give their opinion for each technique of different user interfaces. After the survey, it is necessary to perform a statistical test to obtain the appropriate results. Finally, it is necessary to analyze the results and see the connection between the results of the metrics and the user's perception of the quality of the user interface.

According to [5], it is possible to apply a formula where the total number of elements, the number of horizontally aligned elements, the accumulated height of the elements on the left side and the accumulated height of the elements on the right side are observed. The metric formula presented in [5] is:

Ba = (nhaw/nw)(1-(|hi-hr|/hi+hr))

wherein:

nhaw – number of horizontally aligned elements

nw – Total number of elements on the entire interface

hi – Accumulated height of elements on the left side

hr – Accumulated height of elements on the right side

According to [5], methods for evaluating user experience and graphical interface can be based on balance, linearity, orthogonality, sequentiality and regularity.

According to [7], the user experience metric for usability characteristics can be realized in the form of a survey, which is scored in the range from 1 to 7, depending on how much the surveyed user agrees with the stated statement. Some of the claims are reflected in the capabilities of the application requirements, the user experience while using the application, and the ease of use of the application.

Methods for evaluating the user experience of websites can be based on the following principles:

- Possibility to select the desired cookies (only necessary cookies or the entire functionality)
- Existence of functionality to change font size (support for the visually impaired)
- Existence of functionality to change the theme (light and dark theme)
- Responsive design (possibility of customized use of the website on mobile devices)
- Minimalist design;
- A clearly structured website without an exaggerated amount of content on the screen
- Functionality of buttons where their role is clearly understood.

Google's Web Vitals became a ranking factor for the first time in 2021, after which it continued with the development of various forms of metrics that Core Web Vitals presents.

According to [8], Web Vitals is a Google initiative that seeks to provide a path to quality that is necessary for the development of a good user experience. The purpose of this initiative is to focus on metrics, using Core Web Vitals. Core Web Vitals consists of experimental metrics that are subject to significant change based on testing and community feedback, pending metrics that consist of metrics that have passed testing and have a defined timeline to become stable metrics, and stable metrics that represent a current set of Core Web Vitals metrics that are considered essential for a great user experience.

According to [8], Core Web Vitals is a subset of the Web Vitals initiative that can be applied to all websites, where metrics can be performed by all website owners using all Google tools. Google Web Vitals provide various developed tools used for user experience metrics. User experience metrics are performed in two different ways:

• Laboratory measurement,
• Measurement in the field.

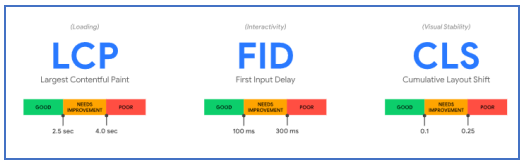

Figure 1 – Types of metrics according to [8]

According to [8], laboratory measurement involves the use of tools that simulate the loading of a web page in a consistent, controlled environment, which is necessary for the development of new web site features. It is impossible to test the performance characteristics on the example of real users, so testing takes place in controlled conditions because this is the best way to prevent performance regression. Field measurement takes place on a real example of a user loading and interacting with a web page, as a result of which performance depends on the capabilities of the user's device and the capabilities of the network the user uses. There are several types of metrics that are relevant to user experience performance:

- Load Speed Insights – how fast the page loads with the visuals on the screen

- Load Responsiveness - how fast the page loads with the execution of the necessary Javascript code to make the components responsive during user interaction
- Runtime responsiveness – after loading the page, how responsive is it during user interaction
- Visual stability - do elements on the page move in a way that the user does not expect, resulting in possible interference during user interaction
- Smoothness – whether animations and transitions render at a consistent number of frames per second and flow fluidly when changing state.

V. USER EXPERIENCE CONSIDERATIONS IN DESIGNING USER INTERFACE

According to [2], user experience design is considered a collection of methods applied to the process of designing an interactive experience. Design as a product is successful if it meets the expectations of clients and provides an adequate user experience. If the design provides a bad user experience, sooner or later it will be replaced by an improved version of the design as a product.
According to [10], a user experience designer needs to have many different skills in order to create a professional user experience. In addition to skills, it is necessary to possess knowledge in various academic disciplines, due to the various activities that a user experience designer may be in charge of.
According to [11], the structure of user experience is reflected in:
• Needs
• Expectation
• Features
• Opportunities.
According to [12], the capabilities of the user interface and user experience depend on the quality of the designed system, which combines the user interface and user experience into one common process.
According to [13], the first step when designing a website is to collect information about the users for whom the website is intended - who are the users, what are their needs and requirements. The information gathering phase requires a certain period of time, but after enough information has been collected, the site can be developed at a high speed.
According to [14], the development of mobile technologies and the increase in sales of mobile devices has led to a much greater demand for the development of user experience and design of websites in such a way as to meet the needs of mobile device users. One type of support is based on the implementation of responsive web design and the improvement of browsers to support devices with different screen sizes.

VI. PROPOSED METRICS MODEL FOR EVALUATION OF THE USER EXPERIENCE OF WEBSITES

In this work, a metric model for evaluating the user experience of a website was developed, which consists of a formula and two tables for calculating the points for the existence of a feature and its importance, including the accompanying system for scoring individual features.
Suggested formula for the total number of website user experience points:

$BBKI=\sum BBki$
• BBKI – Total number of user experience points;
• $\sum$ BBki – Sum of points of user experience characteristics.

Suggested formula: $BBki=Pk*V$
• BBki – Number of points of user experience characteristics;
• Pk – Existence of a characteristic;
• V – Importance.
Based on the existence of user experience characteristics, table 1 is determined. Based on the importance of user experience characteristics, table 2 is determined.

Table 1 Table of existence of characteristics of user experience

Existance of characteristic	Number of points
Exist	1
Exist partially	0.5
Doesn't exist	0

Table 2 Table of importance metrics of user experience

Importance	Number of points
Very important	3
Important	2
Desirable	1

According to [9], user experience metrics are realized differently from standard measurement methods because they represent the personal experience and interaction between the user and the system.

VII. RESULTS AND DISCUSSION

This section presents empirical results in applying the proposed evaluation method to particular website – official web site of Technical Faculty "Mihajlo Pupin" Zrenjanin, Serbia. In this case study, previous web site that was available at www.tfzr.uns.ac.rs is currently moved to IP address: http://147.91.177.109.

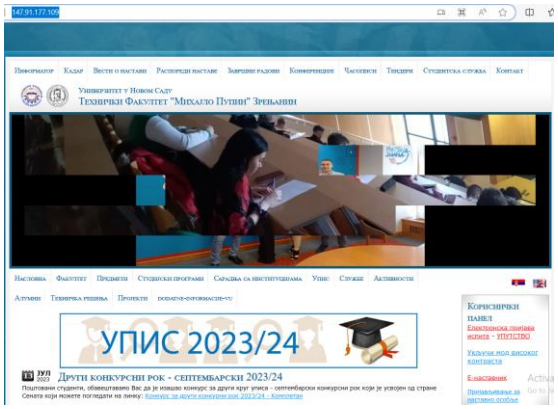

Figure 2. Web site that was evaluated in case study

Based on the proposed formula BBki=Pk*V, content of table 3 is obtained.

Table 3 Table of metrics of points for user experience of old website of Technical Faculty „Mihajlo Pupin" Zrenjanin, Serbia

Characteristic	*Existence of characteristic*	*Importance*	*Number of points*
Responsive design	Doesn't exist	Very important	0
Correctly formed colors	Exist	Important	2
Readable font	Exist	Important	2
Adapted parametrization of user based parameters - cookies	Doesn't exist	Important	0
User based theme	Exist partially	Desirable	0.5
User based font size	Doesn't exist	Desirable	0
Availability of important information	Exist partially	Very important	1.5
Clearly defined navigation	Exist partially	Very important	1.5
Availability of old posts	Exist partially	Important	1
Search	Exist partially	Important	1
		Total number of points	9.5

Each characteristic contains a column for the importance and existence of the characteristic, which is used to determine the number of points of the observed characteristic. Final score for the web site used in this case study achieved total 9.5 points.

VIII. CONCLUSION

User experience is an important aspect of modern technologies because it enables the comfortable use of applications and websites. The way user experience is implemented along with a well-thought-out web design makes it easier for users to search and use, which leads to more interest in using the developed application or website.

With metrics and models for evaluating the user experience, it is possible to show how satisfied users are and how simplified the use of the respective web application / website is. The current proposed model can be improved by adding more features and characteristics for more precise measurement of metric-based evaluation of user experience. The proposed estimation and metrics-based model could be used in comparative analysis of different versions of the same website, in aim to enable tracking progress within development monitoring process.

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Entrepreneurship Education for New Business Conditions in Serbia

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Abstract – Entrepreneurship has been noted as an important influencing factor on economic development. In new business conditions, the development of entrepreneurship education in Serbia can be viewed as a significant strategy that should be supported in multiple ways. This paper analyzes entrepreneurship education for the new business environment that is currently shaping how business is conducted across industries. The paper aims to develop a theoretical model for improving entrepreneurship and competitiveness. The model indicates that businesses should encourage innovation and make it easier for people to get financial resources. This would help create a culture that is open to entrepreneurial efforts. Governments are urged to make regulatory processes easier to understand and to strengthen entrepreneurial ecosystems by combining education and policies that help entrepreneurs. Collaboration between government and business is very important. This model is a starting point for future research into how well different ways of teaching entrepreneurship work, how policies and rules affect entrepreneurship, and how different environments for entrepreneurs affect innovation and competitiveness. Future studies can help improve entrepreneurship and national competitiveness in transitional settings.

Key words: entrepreneurship, education, business, Serbia

I. INTRODUCTION

The modern business environment is primarily shaped by rapid technological advancements and innovations, necessitating businesses to undergo continuous transformation and adaptation. Entrepreneurs are utilizing cutting-edge technologies such as artificial intelligence, machine learning, big data, and the Internet of Things (IoT) to cultivate innovative products and solutions, thereby redefining customer experiences and operational processes [1]. This technological integration represents a fundamental paradigm shift in how businesses operate and provide value to their customers. Beyond technological advancement, sustainability is emerging as a key theme in today's business world [2]. Concerns about environmental impacts, climate change, and resource conservation are driving businesses to incorporate eco-friendly practices and prioritize sustainability. Entrepreneurs are increasingly aligning their ventures with environmental responsibility, focusing on establishing businesses that are both sustainable and environmentally conscious. This emphasis on ecological sustainability is revealing new avenues for innovation and market opportunities, allowing businesses to address environmental challenges while also achieving economic goals [3].

Furthermore, the process of globalization is redefining the scope and reach of businesses, eradicating geographical boundaries and enabling access to global markets. Because of this universal interconnectedness, entrepreneurs must tailor their products and strategies to diverse consumer bases and manage multicultural operational environments. It also increases competition, requiring continuous innovation and improvement to maintain a competitive advantage in the global market. Consumer behavior and preferences have changed dramatically, with a greater emphasis on convenience, customization, and enhanced experiences. In response, entrepreneurs are focusing on the development of customer-oriented solutions and value propositions, striving to meet and exceed consumers' evolving expectations [4]. This consumer-centric approach is important for establishing brand loyalty and ensuring long-term success in today's fiercely competitive business environment.

In this paper entrepreneurship education is analyzed with the goal to develop a theoretical model for improving entrepreneurship and competitiveness. The paper consists of three main sections (excluding the Introduction and Conclusion sections). First, the new business environment and entrepreneurship are analyzed. Next, the importance of entrepreneurship education is discussed. In the same section the theoretical model is also presented. Finally, suggestions and guidelines for improving entrepreneurship and competitiveness are noted.

II. NEW BUSINESS ENVIRONMENT AND ENTREPRENEURSHIP

Entrepreneurship serves as a driver of economic development, innovation, and job creation in this dynamic and multifaceted environment. Entrepreneurs have an impact on societal progress and well-being through innovative solutions and sustainable practices. Exploration of new opportunities, leveraging of emerging technologies, adoption of sustainable practices, and adaptation to continuous changes in the business ecosystem will define the essence of future entrepreneurship [5].

Entrepreneurship is extremely important for economic growth and global development because it serves as the foundation for innovation and job creation [6]. When entrepreneurs start new businesses, they unintentionally contribute to job creation and economic dynamism, both of which are important for any society's development and prosperity. Entrepreneurial ventures, particularly small and medium-sized enterprises (SMEs), are important contributors to employment and are commonly viewed as the engines that power various economies.

Furthermore, entrepreneurship is inextricably linked to innovation. The entrepreneurial spirit drives the creation and implementation of new ideas, products, and technologies, propelling advancements in a variety of industries. Entrepreneurs play an important role in the spread of technology and innovative solutions, which not only raise living standards but also accelerate economic development. Entrepreneurs enable societies to tackle complex problems and address important challenges by using innovative approaches and solutions, improving overall quality of life and paving the way for societal progress. Entrepreneurship boosts market competition while also stimulating innovation and economic growth. The emergence of new entrepreneurial ventures forces existing entities to evolve, fostering an environment in which businesses strive for efficiency, innovation, and customer satisfaction on a continuous basis [7]. This increased competition results in a more diverse and quality-driven market, promoting industry resilience and adaptability while also ensuring that consumer needs and preferences are appropriately met. Entrepreneurship can also be used to spark social change and community development. Entrepreneurs frequently act as change agents, addressing societal needs and disparities through innovative and sustainable business models. Social entrepreneurs, in particular, work to solve social problems by developing long-term solutions that benefit communities [8]. This aspect of entrepreneurship is essential because it helps to improve societies, promotes equitable development, and fosters a sense of community and cooperation. It has a multifaceted impact, is important to the evolution and progress of societies and economies worldwide. It combines economic benefits with societal well-being, resulting in a synergistic effect that propels global development, raises living standards, and creates a more sustainable and equitable future for all.

Entrepreneurship fuels innovation and technological advancement in modern business, allowing companies to develop new products, services, and solutions. This continuous innovation is important because it allows businesses to remain relevant and competitive in ever-changing market landscapes [9]. Entrepreneurial businesses are frequently adaptable and flexible, allowing them to respond quickly to market changes, consumer preferences, and emerging trends. Entrepreneurship propels businesses toward constant improvement and development by fostering a culture of innovation and risk-taking, assisting them in maintaining a competitive edge in their respective industries. Entrepreneurship is also important in increasing national competitiveness. The establishment of new businesses helps to diversify and strengthen the economy by reducing reliance on specific industries and mitigating the risks associated with economic downturns [10]. Countries with a thriving entrepreneurial ecosystem have strong economic growth, higher employment rates, and high levels of innovation. Entrepreneurial activities stimulate investments in R&D, education, and infrastructure, creating an environment favorable to business growth and competitiveness [11].

Furthermore, the impact of entrepreneurship extends to human capital development. Entrepreneurial endeavors frequently necessitate the acquisition of new skills and knowledge, thus encouraging education, learning, and professional development. Accumulation of skills and knowledge improves workforce quality, which boosts national productivity and competitiveness [12]. Finally, by addressing social issues and promoting inclusivity and equality, entrepreneurship has an impact on societal structures and norms. It provides opportunities for economic empowerment and social mobility, allowing people from all walks of life to contribute to economic activity and societal progress. Entrepreneurship can improve a nation's social fabric and cohesiveness by fostering inclusive growth and societal development, which indirectly contributes to national competitiveness by creating a stable and harmonious business environment [13].

III. ENTREPRENEURSHIP EDUCATION IMPORTANCE

Entrepreneurship education is important in shaping future innovators and leaders by instilling the necessary skills, knowledge, and perspectives to navigate the complexities of today's business environment. It serves as the foundation for the development of entrepreneurial mindsets, encouraging learners' creativity, important thinking, and proclivity for risk-taking [14].

Entrepreneurship education is important in providing individuals with the skills needed to identify and capitalize on market opportunities. It equips students with the ability to identify market gaps, develop innovative solutions, and effectively implement strategies to bring their ideas to fruition [15]. Aspiring entrepreneurs can translate their visions into viable business ventures by learning about market research, opportunity analysis, and business model development. Aside from identifying and exploiting opportunities, entrepreneurship education instills a diverse set of skills that are invaluable in today's workplace. Problem-solving, financial literacy, negotiation, and leadership abilities are examples of these. Entrepreneurship education prepares individuals to navigate business challenges, make informed decisions, manage resources efficiently, and lead teams effectively by fostering such competencies, all of which are important for entrepreneurial success and career advancement [16].

Furthermore, entrepreneurship education fosters a resilient and adaptable mindset. Learning to deal with failure, adapt to changing circumstances, and persevere in the face of adversity are all important aspects of entrepreneurial education. This resilience and adaptability are not only necessary for entrepreneurship, but they are also valuable life skills that allow people to thrive in various aspects of their lives. Entrepreneurship education is also important for economic development and innovation [17]. It contributes to the creation of new businesses, job opportunities, and innovative solutions to societal problems by cultivating entrepreneurial talents and skills. Entrepreneurial activity generates economic dynamism, which leads to increased productivity, wealth creation, and higher living standards, all of which are important for long-term economic development.

In a broader sense, entrepreneurship education encourages social responsibility and ethical awareness. It encourages students to think about the societal and environmental consequences of their actions and to pursue ventures that are both sustainable and beneficial to the community [18]. This emphasis on social responsibility and ethics is important in developing a generation of entrepreneurs who understand their societal roles and are committed to making a positive impact. Furthermore, entrepreneurship education is important for instilling in students a sense of self-efficacy and empowerment. It gives people the confidence and motivation to pursue their entrepreneurial dreams, overcome obstacles, and realize their full potential [19]. This sense of empowerment is important for personal development and the pursuit of meaningful careers [20].

Based on the analyzed literature, a theoretical model was developed. The model is presented on Figure 1.

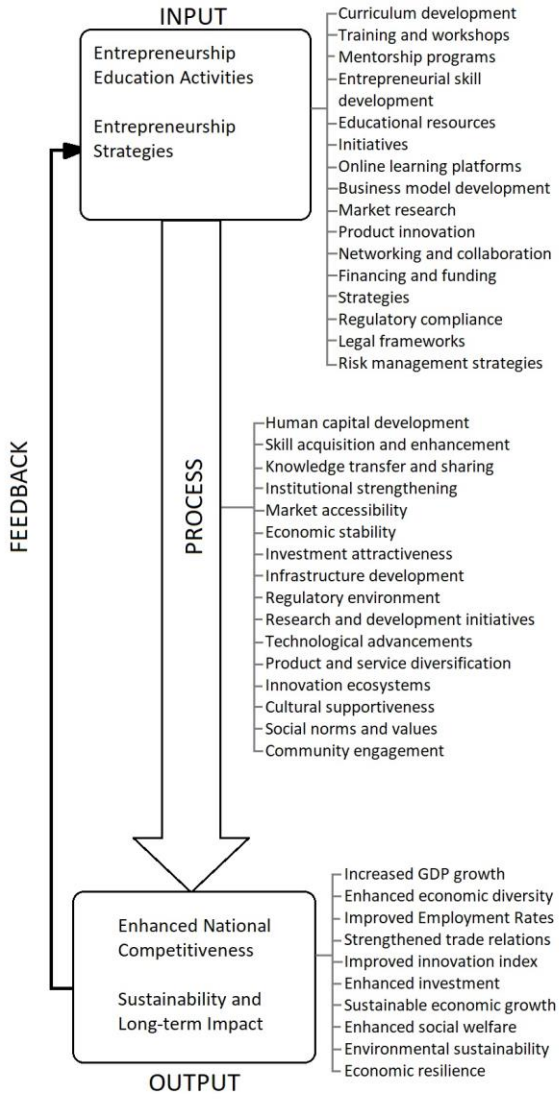

Figure 1. Model for improving entrepreneurship, and sustainable competitiveness.

The model on Figure 1. includes the main input elements, output elements (expected improvements),

the process component. All of these create concisely presented but complex integration. The feedback loop enables the evaluation and analysis of outputs, based on which improvement in the input are conducted. The process elements are also taken into consideration when optimization and improvements are conducted.

IV. SUGGESTIONS AND GUIDELINES

Based on the developed model and the analyzed literature, the following suggestions and guidelines for improving entrepreneurship and sustainable competitiveness are noted:

- Provide Training Programs: Businesses should provide entrepreneurship education and training programs to help employees develop entrepreneurial skills and knowledge.
- Collaborate with Educational Institutions: Businesses should collaborate with schools, colleges, and universities to offer entrepreneurship courses, workshops, and seminars.
- Mentorship Programs: Create programs in which experienced entrepreneurs can guide and support new and aspiring entrepreneurs.
- Establish Innovation Hubs: Create spaces for people to collaborate, innovate, and develop new ideas and solutions.
- Support R&D: Allocate resources to R&D activities that can result in new products, services, and business models.
- Funding Facilitation: Create platforms and networks that connect entrepreneurs with potential investors and financiers.
- Financial Literacy: Provide training and resources to help entrepreneurs improve their financial literacy and management skills.
- Promote Risk-Taking: Foster an environment in which calculated risks are encouraged and failure is viewed as a learning opportunity.
- Commemorate Entrepreneurial Success: Recognize and reward successful entrepreneurs in order to inspire others.
- Simplify Business Registration: Reduce red tape and streamline the process of establishing a new company.
- Create Clear and Supportive Policies: Create policies that support and protect entrepreneurs, such as tax breaks and intellectual property protection.
- Include Entrepreneurship Education in the Curriculum: Entrepreneurship education should be included in the national curriculum at all levels of education.

- Support Vocational and Technical Training: Provide funding for programs that provide practical skills and entrepreneurship training.
- Establish and support incubators, accelerators, and innovation hubs where entrepreneurs can collaborate, learn, and grow.
- Improve Market Access: Facilitate access to local and international markets for entrepreneurs' products and services.
- Underrepresented Groups Support: Implement programs and policies to encourage entrepreneurship among women, minorities, and other underrepresented groups.
- Promote Social Entrepreneurship: Support initiatives that address social, cultural, or environmental concerns.
- Collaborate on Entrepreneurship Programs: Both sectors should collaborate to develop and implement entrepreneurship programs.
- Collaborative Research and Development: Foster collaboration between private businesses and public institutions for collaborative research and innovation.
- Promote Sustainable Business Practices: Adopt policies and programs that encourage environmental sustainability and social responsibility in businesses.
- Support for Sustainable Startups: Provide incentives and assistance to startups that address environmental and social issues.
- Promote International Collaborations: Create platforms and networks that connect local entrepreneurs with international partners, mentors, and investors.
- Encourage Cross-Border Trade: Enact policies that encourage and facilitate trade and collaboration between domestic and international businesses.

In sum, there has to be synergetic collaboration between enterprises and the government in order to positively affect the entrepreneurial climate and increase competitiveness in a sustainable way.

V. CONCLUSION

Transitional-country enterprises and governments play an important role in creating a nurturing and conducive entrepreneurial ecosystem. They can significantly improve the national entrepreneurial climate and overall competitiveness by providing

foundational support through education and proactive strategies, fostering innovation, and initiating reformative policies.

The incorporation of entrepreneurship education into the educational system, the simplification of business registration processes, the development of supportive and clear entrepreneurial policies, and the creation of inclusive and diverse entrepreneurial ecosystems are all important steps toward this goal. To ensure the holistic development of the entrepreneurial landscape, both private enterprises and government bodies must actively engage in public-private partnerships, promoting international collaborations and sustainability.
For future research the efficacy and impact of various entrepreneurship education models and teaching methodologies in transitional economies could be analyzed. In addition, strategies for fostering a culture of entrepreneurship and innovation in various societal settings could be investigated.

VI. ACKNOWLEDGEMENT

This paper has been supported by the Provincial Secretariat for Higher Education and Scientific Research of the Autonomous Province of Vojvodina, number: 142-451-2963/2022-03.

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Variable Duration Melody Generation Using LTSM Encoder-Decoder Architecture

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Abstract - Music is an arrangement of sounds created using methods and concepts of musical theories, where it often has deterministic components. Automatic melody generation has been utilised in many fields such as movies, games, and sports events. The key novelty presented in this paper is the deep learning approach to generation of new musical melodies with variable duration. We will present evaluate and discuss the generation of new melodies utilising a double head Long Short-Term Memory (LSTM) encoder-decoder model architecture trained on Chopin's music Musical Instrument Digital Interface (MIDI) dataset. The proposed model will generate original melodies with variable durations by predicting notes based on previous notes or music part structure. Based on the evaluation results, we can affirm that the melodies produced by the proposed model were not dissonant and sounded quite like human-composed ones. Even so, there are still instances where the model falls into a loop, creating a repeating sequence of notes within one melody. Varying durations for notes were successfully generated, giving the melody dynamic feel..

I. INTRODUCTION

Whether composed using different instruments or not, music is a sound that is transmitted to our ears by air oscillations. This sound can be represented as musical notes, with varying pitches and lengths. Hence music has certain arrangements of notes or notes in certain sequences recognized as sounds and melodies that we listen to [1]. Music generation research by Hiller and Isaacson (1979) utilised a high-speed digital computer to determine the "laws" that govern music. The authors use random sequences of integers as notes on the musical scale and passed the notes onto the computer through arithmetic tests which represent the rules/laws of music [2]. Authors stated that despite the governing laws of music, the sequences of choices in musical elements are limitless in its possibilities to create a composition. However, current approaches to automatic music generation mainly rely on deep learning. Where previously all the dependencies/music rules were able to be semi-quantitatively expressed explicitly with mathematic operations, the deep learning approach is able to detect and learn a latent representation of any dependencies found instead.

Thus, learning a vague representation of any possible music and composition rules to generate the next possible sequences. Recurrent Neural Networks (RNNs) are one type of network commonly used in modelling sequences. It can be described as being "fuzzy" [3] due to its ability in interpolating input data based on the network's representation. This ensures that the synthesized and constructed output will rarely generate the exact same results. However, deep neural networks in general require that the dimensionality of both input and output be known and fixed prior to the learning process. This is a problem most frequently encountered when dealing with sequences as the network's input data. Another problem to take note of when modelling sequences is also the ability of a network to retain past information, and/or long-term dependencies. In practice RNNs are not well-equipped in remembering longer sequences, and is why the Long Short-term Memory (LSTM) was proposed as an improved RNN architecture [4]. Unlike a standard recurrent neuron unit, an LSTM unit utilises different "gates" as a means to constantly regulate (deleting, updating) the stored information. Thus LSTMs are generally more suited for sequential inputs, and utilised in this paper.

Meanwhile, the simplest strategy to overcome the problem of fixed dimensionality, proposed by authors Sutskever et al. (2014), is the encoder-decoder structure [5]. The encoder structure maps the initial input sequences to the Recurrent Neural Network (RNN)-LSTM layer then into a fixed-size vector (of target size). Where then the representation contained within the vector is decoded with an RNN/LSTM layer, mapping the representation into the target sequences [6]. As the vector representation is the one being extracted by the decoder structure of the network (non-input LSTM layer), the encoder-

decoder architecture thus allows for a different-sized input-output window. In comparison to normal stacked LSTMs, it does not have the extra step of extracting the input's vector representation and thus only allows for a fixed input-output window. The network structure presented in the work by authors Chandra et al. 2021, with a many-to-one architecture was used in our paper. A parallel neural network was ultimately opted for with the mentioned (many-to-one) architecture in dealing with and simulating the different elements of music.

In this paper we propose a method for predicting notes based on previous notes or part structures in order to construct original melodies. To be able to generate melodies, the model has to be able to process sequential data where temporal dependencies between notes are taken into account. This paper proposes a deep learning model that generates and predicts the next melody sequence. Our model is implemented using the Keras deep learning library [7]. The training and testing datasets are created using 48 of Chopin's music pieces.

The paper is organized into 4 sections including the introduction. Section 2 (data, model, design) is divided into 3 sub-sections. The first sub-section provides the data analysis, data pre-processing and feature extraction approach, the second sub-section discusses the proposed deep learning architecture, and the last sub-section briefly describes model predictions and generation of new melody sequences. Section 3 will discuss results, and the model design. Section 4 thereby provide our findings and conclusions.

II. METHODOLOGY

A. Data Analysis and Data Pre-Processing

This paper used Chopin's music MIDI dataset that contains 48 of Chopin's music pieces. The dataset is parsed, and the MIDI note number is extracted based on the standard MIDI notation; 128 unassigned values representing a note [8]. The start time and end time of each note in seconds is extracted, and note duration is calculated as difference between end time and start time.

Note pitches and note durations are identified and extracted from the 48 MIDI files. These data are used to generate the sequential training dataset of note pitches and note durations. Fig. 1, Fig. 2, and Fig. 3 show both notes and/or overlapping notes (notes that form chords) extracted from MIDI files. The Pretty MIDI library [9] is utilised to parse chords (into its individual notes) by analysing the note start and note end times. The duration of the notes, and the note numbers (represented with a notation of 128 integers) are used as features for our model.

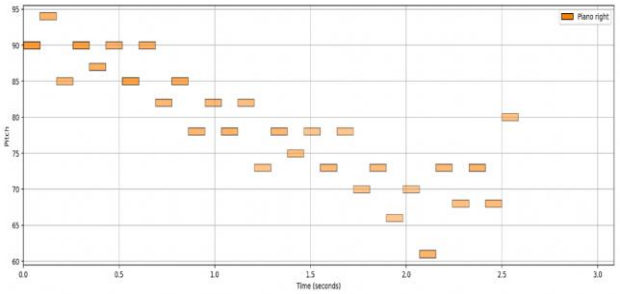

Figure. 1. Visualisation of notes (1)

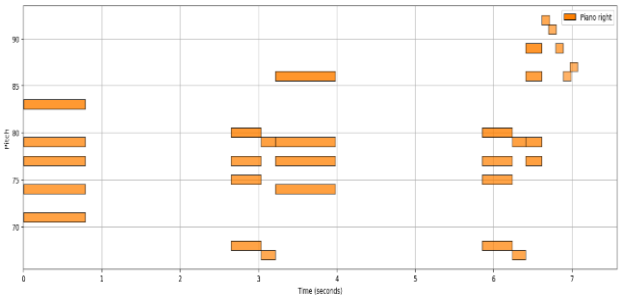

Figure. 2. Visualisation of notes (1)

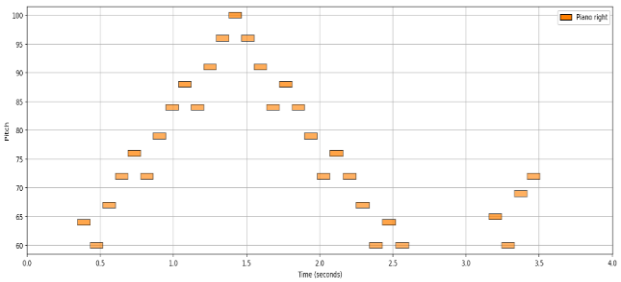

Figure. 3. Visualisation of notes (1)

The distribution of notes for the 48 pieces is then analysed. Bins are divided into 128 and represent all possible classes of notes as shown in Fig. 4. At a threshold of 2000 notes, it can be observed that there are 13 most frequent notes. While at a threshold of 2500, there are 6 most frequent notes. By limiting the lowest threshold as 2000 notes, we decided to use the average of the most frequent notes in our model (10 notes) as lookback.

Fig. 1 and Fig. 3 show individual notes playing at different times, but as is shown in Fig. 2 MIDI chords can contain five notes collectively (first chord seen in Fig. 2), where some chords often have 4 notes. Hence there is a chance that (approximately) five successive notes in the sequence may be part of one singular chord and are played at the same time. Thus, a lookback interval for modelling sequences of less than five is insufficient to ensure the prediction of the note, since at least two previous chords must be

considered to create a prediction. A lookback interval of 10 notes is hence also opted for in consideration of this.

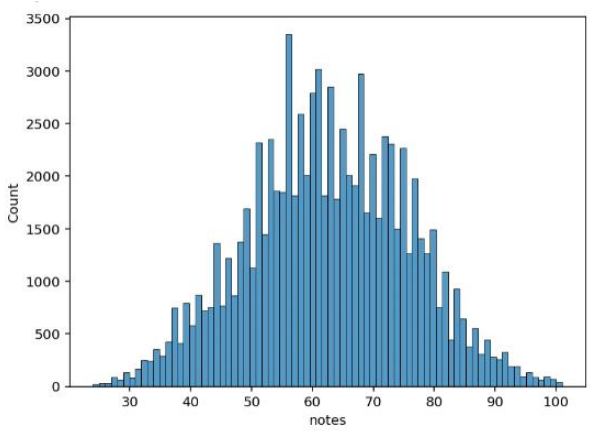

Figure. 4. Distribution of notes

By defining a sequential lookback interval to ten and a step to one, the prediction window will move by one note. Two separate training sequences are prepared, one for the labelled note numbers, and one for the labelled note duration. The generated sequences are then split into training and testing datasets without randomizing.

B. Model Design

In this paper, we propose an LSTM encoder-decoder model architecture shown in Fig. 5. Model is designed not to return cell states in the encoder, and to return cell states in the decoder. Sequences of notes from the encoder with one LSTM layer will be passed to the decoder with one LSTM layer. Notes or durations will be predicted by a Time Distributed dense layer. The Time Distributed dense layer ensures that a dense layer is applied to all temporal slices of the input. A model design is implemented as two parallel models (double head). The first model uses sequences of note numbers as features and predicts the next note. The second model utilises sequences of duration as features and predicts the duration of a note.

As shown in Fig. 5 the model utilises a softmax activation function for the output layer, and a sparse categorical cross-entropy loss. The output layer has 128 nodes, to predict and classify the notes into 128 classes. Sparse categorical cross-entropy loss is used since the target labels are label-encoded and represented by integers [10]. Softmax activation is used to return the probability distributions of the classes: whether the predicted note falls into a particular class based on its probability [11] For the second duration prediction model, we used a linear activation function for the output layer to predict the continuous value of the note duration. Mean squared error loss (MSE) is used to penalize large errors in predictions [12].

Hyperparameters such as the learning rate of the model were tweaked and experimented with. Deep learning models utilise gradient descent algorithms to train and update weights. The error function is minimized as training progresses, but sometimes a loss plateau occurs in descent, which is more common in high-dimensional parameter spaces [13, 14]. A loss plateau is encountered near saddle points (Fig. 6) and is neither a maximum nor a minimum. A local minimum partial derivative is zero in any direction of the x axis, and a local maximum is zero on the y axis. However, at a saddle point orthogonal components of the function's surface are zero on both axes: orthogonal components (x and y direction) will have a value of zero and is thus not a local extremum [15].

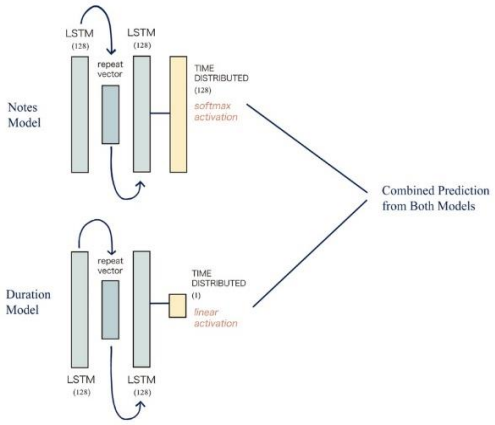

Figure. 5. Model architecture

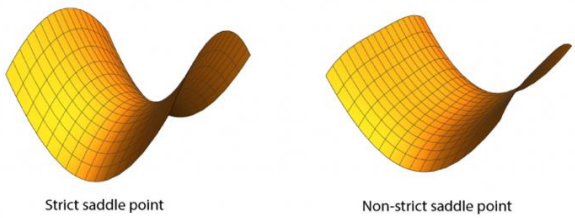

Figure. 6. Model architecture

Deep learning problems often have saddle points as critical points instead of local minimums. Similar to when encountering a local minimum, when training becomes stuck or approaches a saddle point/plateau the gradient values will become really low (very small steepness in the dimensional space), causing the model to think that an optimal solution has been reached. This causes the loss to converge too soon. The learning rate is set to be 0.005 in an

attempt to allow the gradient to traverse faster out of a saddle point.[16]

Convergence is also affected by batch sizes to a degree. The ratio of learning rate to batch size is also a factor in adjusting the dynamics of gradient descent [17]. There is a problem with batch sizes known as the "generalization gap" where sometimes a too large batch size prevents the model from generalizing. For this model the batch size chosen is 512.

Adaptive learning rate gradient descent such as Adam also tries to mitigate the problem by using running averages (moments) of the gradient and considering past gradients [18]. The adaptive learning rate property of Adam means that the learning rate adjusts accordingly to the sparsity of gradients (effective rate is either increased or decreased) on different parameters and is thus only approximately bound to the stated learning rate hyperparameter of 0.005. A variation of Adam [19], based on the infinity norm is AdaMax; which is more suited to sparse parameters and was chosen for our models. After selecting and setting model hyperparameters, both models are then trained for 1000 epochs.

C. *Music/Melody Generation*

To create new melodies, a random sequence of 10 notes is taken from the prepared test dataset for note number and duration. The notes model will then predict the next note (which is the note with the highest probability), and the time model will predict the next duration (a real value) based on the sequences. After one prediction is done, the predicted note number and duration is inserted into the last sequence, where the last 10 notes will then be taken again (including the last prediction made) and fed into the model. This will repeat 30 more times for both notes and duration, thus creating the next 30 notes and duration of notes that will form one melody.

$$(\text{duration}(x)/\text{duration}(\text{max}))*1.0 \qquad (1)$$

Since the duration of the notes is within absolute values (seconds), the predicted duration is scaled in respect to one second (where the longest duration in the prediction is taken to be one second and is shown in Equation 1), representing a quarter note musically. The note numbers are then converted to a piano MIDI file, where the offsets between each note are the predicted note durations.

III. Results and Disussion

The majority of deep learning models for music generation rely on a musical Turing test, in which results are assessed by human listeners rather than by loss/accuracy metrics [20]. In our work we use similar methods to evaluate results. The artificial melodies generated by our model were evaluated by qualified music professionals and differentiated from human-generated melodies. Following the evaluation of the results, we summarise the subjective impressions:

- Melodies produced at random by the model were not dissonant and sounded quite like human-composed ones (visualized in Fig. 7).
- There are still instances where the model falls into a loop, creating a repeat sequence of notes within one melody.

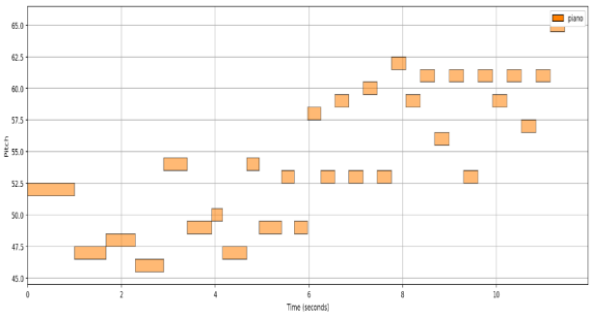

Figure. 7. Visualized created melody

From this it can be concluded that the model was not yet able to fully understand the pattern of some sequences, hence the repetition. Varying durations for notes were also mostly successfully generated, giving the melody a more dynamic feel, rather than having a monotonous beat. Therefore, future work may include other musical aspects such as rests, chords, grace notes to further increase the likeness to a human-composed melody. Future improvements may include and are not limited to: different datasets containing other styles of music which may be used in analysis; an alternative approach in analysis and extraction of the musical elements (chords can be expressed using a custom number notation based on prevailing music theories or discovered analysis results, volume or velocity of notes can also be taken into consideration to further increase realism, etc.); and further experimentation on the currently proposed network model to create an improved internal representation between notes and duration- and to accommodate for new musical elements (if any).

IV. Conclusion

In our study we proposed a deep learning approach to generate new melodies with variable

durations. Using the designed model, subsequent notes and note durations are predicted based on probabilistic distributions of musical sequences. The LSTM encoder-decoder architecture was proposed to generate new melodies based on the Chopin dataset. An evaluation of the generated melodies provides useful directions for future research. In conclusion, further analysis of musical aspects can improve feature selection. This will help us to better understand how notes relate to other components, such as duration type, and musical dynamics. Even so, a larger training data corpus may be beneficial in training the deep learning model presented in this paper.

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Client Side Testing of Web Applications

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Abstract - The focus of this paper represents one way of testing the client-side of web applications. With the increase in internet users, there is a growing number of complex web applications necessary for various tasks. To ensure the quality of these web applications, they need to be checked on different ways, and one of the key methods of quality assurance is automated testing. This paper will explore one solution for testing web applications. It uses the React library, which is popular library in the development of the client-side of web applications, along with the use of the Jest framework and React Testing Library for writing automated tests. This approach enables developers to efficiently and accurately test the functionality of web applications, identifying potential errors and ensuring that the application works correctly in different scenarios.

Key words: Web applications, React, Unit testing, Integration testing

I. INTRODUCTION

The Web has had a significant impact on all aspects of our society. As our society relies more and more on the Web, the dependability of web applications has become increasingly important. The main advantages of adopting the Web for developing software products include no installation costs, automatic upgrade with new features for all users, universal access from any machine connected to the Internet and being independent of the operating system of clients. On the downside, the use of server and browser technologies make web applications particularly error-prone and challenging to test, causing serious dependability threats [1]. This paper focuses on one of the ways to ensure the quality of a client application by writing certain types of automated tests. The paper is divided into 6 logical sections. The first chapter describes the structure of the paper, along with a brief summary of the content of each chapter. Chapter 2 describes the necessary concepts to understand how web applications work. Chapter 3 provides an overview of software testing as a concept. Chapter 4 describes the technologies used for the implementation of the solution. In Chapter 5, examples of implementing certain tests within the web application are provided with detailed explanation. Chapter 6 provides a conclusion.

II. WEB APPLICATIONS

Web applications refer to applications accessed via Web browser over a network and developed using browser-supported languages (e.g., HTML, JavaScript). For execution, Web applications depend on Web browsers and include many familiar applications such as online retail sales, online auctions, and webmail. Web applications are needed in the area of business-to-business interaction over networks, e.g., for overseas companies that outsource projects to each other. The adoption of a Web applications infrastructure can provide vital processes such as transfer of funds and updates of pricing information [2]. Client-server is a system that performs both the functions of client and server so as to promote the sharing of information between them. It allows many users to have access to the same database at the same time, and the database will store much information.

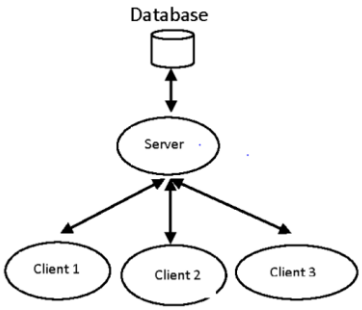

Figure 1. Client-server architecture

In the computing world today, client-server system has become so popular because it is being used virtually every day for different applications. Some of the standardized protocols that client and servers use to communicate with themselves include: File Transfer Protocol (FTP), Simple Mail Transfer Protocol (SMTP) and Hypertext Transfer Protocol (HTTP). Thus, Client-server system can be defined as a software architecture made up of both the client and server, whereby the clients always send requests while the server responds to the requests sent. Client-server provides an inter-process communication

because it involves the exchange of data from both the client and server whereby each of them performs different functions [3]. Fig. 1 presents look of client-server.

III. SOFTWARE TESTING

Software testing is any activity aimed at evaluating an attribute or capability of a program or system and determining that it meets its required results. Although crucial to software quality and widely deployed by programmers and testers, software testing still remains an art, due to limited understanding of the principles of software. The difficulty in software testing stems from the complexity of software: we can not completely test a program with moderate complexity. Testing is more than just debugging. The purpose of testing can be quality assurance, verification and validation, or reliability estimation [4].

It can also be stated as the process of validating and verifying that a software program or application or product [5]:

- Meets the business and technical requirements that guided it's design and development.
- Works as expected.
- Can be implemented with the same characteristic.

There are many types of software tests, each with its specific characteristics and purposes. Here are several key types of software tests with brief descriptions:

- Unit Testing - This tests the smallest functional unit of software, typically individual functions or methods. The goal is to verify that each unit function works correctly in isolation.
- Integration Testing - This checks how multiple units or components of the system behave when integrated together. The aim is to identify errors in their interaction.
- Functional Testing - This type of testing verifies if the software works according to specifications and functional requirements. It focuses on expected outputs for given inputs.
- System Testing- System Testing assesses the entire system as a whole to ensure that all components work together in compliance with requirements and specifications.
- Regression Testing - After each change in the software, this testing ensures that existing functionalities and fixes remain unaffected.
- Automated Testing - It uses automated scripts and tools to execute tests, used to increase speed the testing process.

IV. TECHNOLOGIES

The technologies used for the implementation of the client application include JavaScript together with the React library for rendering UI elements. For the implementation of automated tests, the Jest framework was used with the React Testing Library. For mocking API calls to the server-side, MSW (Mock Service Worker) is used.

JavaScript is an interpreted programming language most often used for enhancing webpage interactivity and functionality. It has powerful capabilities to interact with webpage documents and browser windows [6]. Some of the characteristics JavaScript are that it is a scripting language, which means it runs in a web browser or can also be executed on the server-side using Node.js. With the development of applications and platforms, it can be used to develop various types of applications such as mobile and web apps, etc. It allows the execution of operations without blocking the main execution thread, which is crucial for efficient handling of requests and long-running operations. Due to its popularity, there is a large community and ecosystem for developing additional functionalities.

React tries to solve the problem from the View layer. It can very well be defined and used as the V in any of the MVC frameworks. It's not opinionated about how it should be used. It creates abstract representations of views. It breaks down parts of the view in the Components. These components encompass both the logic to handle the display of view and the view itself. It can contain data that it uses to render the state of the app. To avoid complexity of interactions and subsequent render processing required, React does a full render of the application. It maintains a simple flow of work. React is founded on the idea that DOM manipulation is an expensive operation and should be minimized. It also recognizes that optimizing DOM manipulation by hand will result in a lot of boilerplate code, which is error-prone, boring, and repetitive. React solves this by giving the developer a virtual DOM to render to instead of the actual DOM. It finds difference between the real DOM and virtual DOM and conducts the minimum number of DOM operations required to achieve the new state [7].

Jest is an open-source JavaScript framework for software testing. Developed by Facebook, Jest is

particularly popular in the community for testing React applications, although it can be used to test any JavaScript application or library. Some of Jest characteristics are:

- Automated testing: Jest allows developers to automatically test their JavaScript code to identify errors and ensure that the application functions correctly.
- Easy to use: Jest is easy to install and configure. Its simple syntax makes writing tests intuitive and fast.
- Execution speed: Jest is optimized for fast test execution, which is essential for rapid software development and delivery.
- Support for various types of tests: In addition to unit tests, Jest supports integration testing, asynchronous testing, and other types of tests.

MSW (Mock Service Worker) is library used for intercepting Network requests. It is used to intercept HTTP requests in JavaScript environment. Main purpose of MSW is to provide software engineers easier simulation of HTTP requests and responses in controlled environment through testing. Big advantage is that test in those cases can be isolated from real HTTP requests which is making test more reliable and predictable. In conclusion, MSW simplifies the creation of stable and deterministic tests for web applications by allowing control over HTTP communication in the testing environment.

React Testing Library is JavaScript library used for testing React Components. Purpose of this library is to provide software engineers easier testing of user interactions with React Components, which promotes behavioral testing. It is used a lot with Jest Framework for writing and executing tests. In the moment it's a really popular tool used to provide extra layer of quality that client web application is behaving as it should. Some of main advantages of this library are that is very easy for usage with API and documentation, focus on user experience, simulation of user interactions, selectors used for easy finding of DOM elements and support for asynchronous testing.

V. IMPLEMENTATION

In this chapter, the implemented web application is reviewed. An overview is provided of the appearance of certain parts of the application, along with a review of specific tests written within the application that cover certain functionalities.

Fig. 2 presents one of the application pages. It provides user to look through employees in the company together with functionalities for adding editing and removing employee. Later in the chapter will be covered implementation of integration tests of the page.

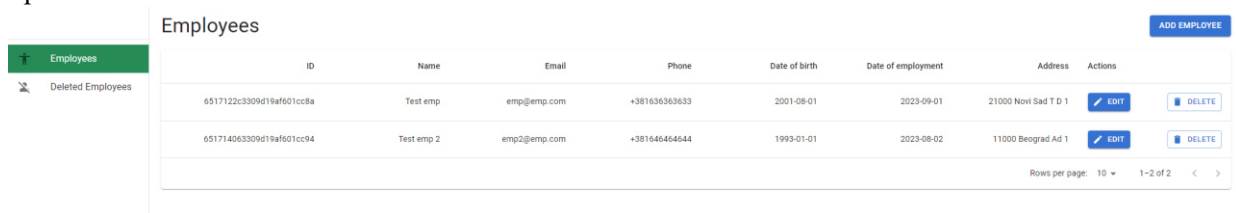

Figure 2. Employees page

```
return (
  <div className={styles.container}>
    <div className={styles['container-header']}>
      <Typography variant="h4">Employees</Typography>
      <Button variant="contained" onClick={() => navigate('/employees/add')}>
        Add employee
      </Button>
    </div>

    <Table columns={_columns} data={data?.employees}>
      <TablePagination
        rowsPerPageOptions={[10, 25, 100]}
        component="div"
        count={data?.count ?? 0}
        rowsPerPage={rowsPerPage}
        page={page}
        onPageChange={handleChangePage}
        onRowsPerPageChange={handleChangeRowsPerPage}
      />
    </Table>
  </div>
```

Figure 3. Implementation of employee page

Fig. 3 presents implementation of possible actions from the employee page. Button for adding employee navigates to modal for adding employee with usage of React Router library. Table component accept columns attributes. Inside those columns are stacked actions for editing or deleting employee.

Edit employee calls a React Router with edit modal, while delete triggers HTTP request on server for removal of employee. Later in chapter will show how is that call mocked with MSW mentioned in the chapter above. Fig. 4 and Fig. 5 represents modals for adding end editing existing employees.

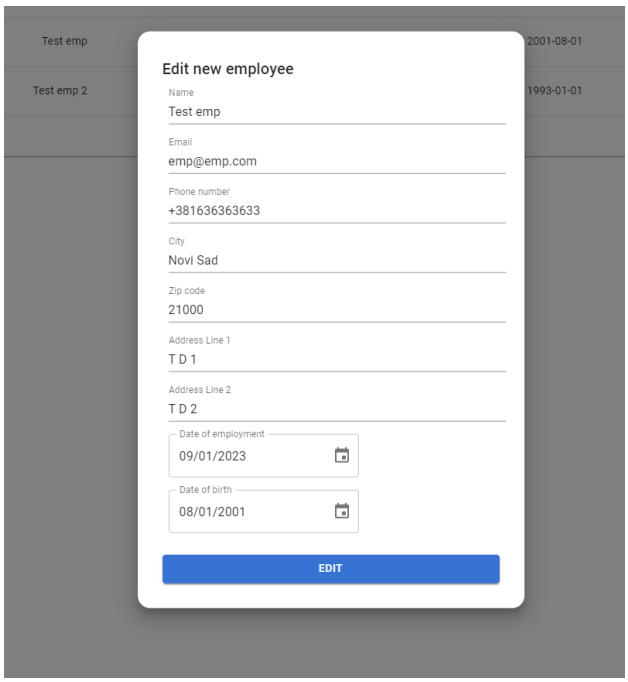

Figure 4. Edit Employee modal

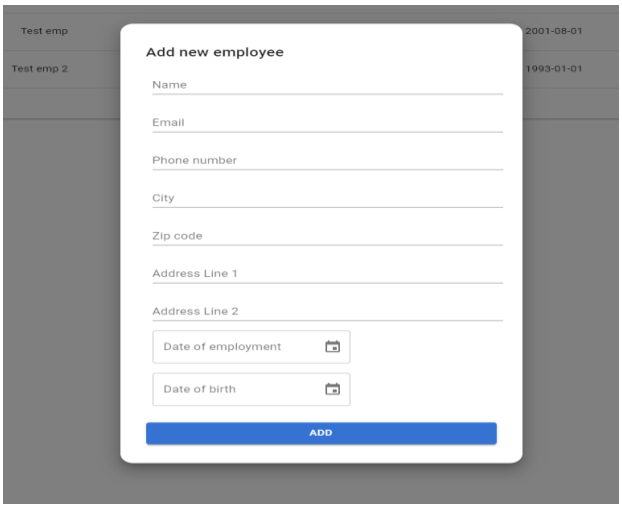

Figure 5. Add Employee modal

```
import '@testing-library/jest-dom';  224.2k (gzipped: 50.7k)

import { server } from './testing/mocks/server';

// Establish API mocking before all tests.
beforeAll(() => server.listen({ onUnhandledRequest: 'warn' }));

// Reset any request handlers that we may add during the tests,
// so they don't affect other tests.
afterEach(() => server.resetHandlers());

// Clean up after the tests are finished.
afterAll(() => server.close());
```

Figure 6. Mock service worker setup

Fig. 6 displays implementation of MSW. Also Jest Framework hooks were used. BeforeAll hook is used to execute code before test execution. AfterEach hook is used to restart mocked server handlers after each test. AfterAll hook is used to close server after all tests are run to avoid memory leaks.

```
export const MOCKED_EMPLOYEES_WITHOUT_REMOVED = {
  employees: MOCKED_EMPLOYEES.employees.slice(1),
  count: 5,
};

export const getEmployeesWithoutRemovedHandler = rest.get(
  `${API_URL}/employees`,
  (req, res, ctx) => {
    return res.once(ctx.json(MOCKED_EMPLOYEES_WITHOUT_REMOVED));
  },
);

export const getEmployeesHandler = rest.get(
  `${API_URL}/employees`,
  (req, res, ctx) => {
    return res(ctx.json(MOCKED_EMPLOYEES));
  },
);
```

Figure 7. MSW handlers

Fig. 7 represents implementation of handlers for specific APIs in the MSW. With this implementation test can be run in isolated environment. Every handler accepts URL and callback function that will return and manipulate with response.

Fig. 8 shows implementation of common used method for rendering employees list. Because Jest is running in terminal and environment that is different from browser environment createMemoryRouter function is used to get different router than browser router. Worth of mentioning is that Jest is using JSDOM to behave with tests as it should be in normal web browser. CreateMemoryRouter is called with routes array which is important to achieve behavior as it is in normal execution of application in browser. Render method comes with React Testing Library which is used to render and with combination of Jest to achieve behavior as it should be in browser. React Testing Library comes with asynchronous locators that are helpful when there are some actions that are waiting for some response from server and similar actions that require some time to be completed.

```
const renderEmployeeList = async () => {
  const routes = [
    {
      path: '/',
      element: <EmployeeList />,
    },
    {
      path: '/employees/add',
      element: <div>Add employee</div>,
    },
    {
      path: '/employees/edit/:id',
      element: <div>Edit employees</div>,
    },
  ];

  const router = createMemoryRouter(routes);

  render(
    <StoreProvider>
      <RouterProvider router={router} />
    </StoreProvider>,
  );

  const header = await screen.findByText('Employees');
  expect(header).toBeInTheDocument();

  return {
    router,
  };
};
```

Figure 8. Render employee list function

```
it('displays fetched items', async () => {
  await renderEmployeeList();

  const ids = MOCKED_EMPLOYEES.employees.map((item) => item._id);

  const firstItem = await screen.findByText(ids[0]);
  expect(firstItem).toBeInTheDocument();

  // assert that items are displayed
  for (const id of ids) {
    expect(screen.getByText(id)).toBeInTheDocument();
  }
});
```

Figure 9. Display employee list test

On Fig. 9 is displayed example of simple test that is asserting that list of employees is displayed as it should and with data that is expecting. Inside test with asynchronous function is waited for employee list to be rendered. Ids array present array of employee ids that should be displayed in the browser. Screen object comes with React Testing Library and provides a lot of selectors and some of selectors are asynchronous. In this example findByText is used to wait for element with first id of mocked data. Asynchronous selectors are way to achieve and wait for some asynchronous action to be completed and then to continue with execution of test. For loop is used to assert that all ids are presented in screen.

```
it('navigates to add employee route', async () => {
  const { router } = await renderEmployeeList();

  userEvent.click(screen.getByText('Add employee'));

  expect(router.state.location.pathname).toBe('/employees/add');
});
```

Figure 10. Test navigation to add employee route

Fig. 10 presents navigation to add employee route. UserEvent object comes with React Testing Library. It is providing a set of API to behave as normal user in the browser. Some of them are click which is used in mentioned test above. It is covering events like drag and drop, click, type, clear, double click and many more. Router object is returned from common method for rendering employee list and assertion is done when pathname of location is changed after click to expected path.

```
it('removes one row after clicking delete', async () => {
  await renderEmployeeList();

  const [id] = MOCKED_EMPLOYEES.employees.map((item) => item._id);

  const [deleteButton] = screen.getAllByText('Delete');

  // after deleting
  // server calls to get newest data
  // intercept call      You, 5 months ago • soft delete employee test
  server.use(getEmployeesWithoutRemovedHandler);

  expect(screen.getByText(id)).toBeInTheDocument();

  userEvent.click(deleteButton);

  await waitFor(() => expect(screen.queryByText(id)).not.toBeInTheDocument());
});
```

Figure 11. Test delete button action

Fig. 11 displays test that is covering removal of employee. DeleteButton object is found in document using selector with a label. Important part of this test is that behavior od application is that when button action is triggered, after successful response it is triggering again endpoint to retreive all employees. That response should return a list without deleted employee. Server object with use method provides overriding of API with response that is different from initial mock. With that test is providing normal behavior of application when everything works as expected. After click asynchronous hook waitFor from React Testing Library is used to wait for specific user to be removed from the page.

VI. CONCLUSION

Testing is crucial for the development of software applications, including web applications. There are different types of software tests, each with its purpose, and the proper choice of tests depends on the specific needs and priorities of the project.

Automated testing, as enabled by tools like the Jest framework and React Testing Library, is becoming increasingly important as it allows developers to quickly identify errors and ensure that the application functions correctly. It's important to note that there are many other tools and techniques for testing, and the choice of the appropriate ones will depend on the specific project requirements. Additionally, testing priorities should be set in a way that the most critical functionalities and parts of the application are tested in detail, while less critical parts can be tested with less detail. In any case, testing is crucial for ensuring the high quality of a software solution and preventing potential errors and issues in production.

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Challenges, Education and Opportunities for Young Digital Entrepreneurs

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Abstract - The greatest challenges for young digital entrepreneurs are the lack of experience, financial resources, and business networks. These challenges are interconnected. A lack of experience can make it difficult to access financial resources and build business contacts, while limited access to finances can prevent young entrepreneurs from gaining the necessary experience and expanding their business network, creating a cycle of challenges for young people to overcome. To create new opportunities for young digital entrepreneurs, it is essential to promote a positive attitude towards entrepreneurship in society, provide young people with access to resources and education to develop skills such as leadership, problem-solving, and project management. Young people are given the opportunity to develop these skills through business incubators, startup competitions, educational programs and courses, mentoring, and financial management education. Social media also assists young people in overcoming these challenges, providing opportunities such as free access to resources, information and education, low marketing and promotion costs, networking and partnership possibilities.

I. INTRODUCTION

Youth is a distinct developmental period that represents the transition from adolescence to adulthood. During this time, young individuals undergo significant changes that enable them to explore themselves, construct their identities and values, all while gaining independence [1]. The process of integration into society continues until young people attain a certain level of social autonomy and self-sufficiency. The transition to adulthood is a complex process in which young individuals gradually assume the responsibilities and roles of adults. This process involves achieving financial, housing, and emotional independence so that young people can take on roles as citizens, partners, parents, and workers [2].

In Serbia, young people or youth are individuals between the ages of 15 and 30 [3].

Young entrepreneurs are often defined by their lack of extensive work experience, as they have recently graduated from college or just entered the job market. These individuals often enter the job market with fresh perspectives, enthusiasm, and the ambition to initiate new business ventures. They often nurture a passion for a specific field and hold unconventional views on business challenges. Their passion, innovativeness, and willingness to take risks make them key initiators of economic change. Their ability to establish companies, create jobs, and implement innovative ideas contributes to the dynamism of the economic landscape [4].

Young people are predominantly users of social media even before they decide to become digital entrepreneurs, so they have experience with posting and creating content. The approach of young individuals often differs from older generations. Young people quickly adopt new social networks and apps that are popular among their age group. For example, Treads, a new app linked to Instagram, is gradually gaining users. Young individuals actively participate in communities, support various campaigns, and use social media as platforms for activism and raising awareness about social issues. They also tend to switch social networks more quickly due to changes in popularity or if a new platform emerges.

There is also a noticeable growth in fields such as artificial intelligence (AI), web development, app development, mobile gaming, digital creativity, virtual reality (VR) development, and robotics. Young people are increasingly inclined to engage in these areas and acquire knowledge about them. They have grown up with the rapid development of digital devices, apps, and platforms, contributing to their high digital literacy and readiness to venture into innovations [5].

II. CHALLENGES OF YOUNG DIGITAL ENTREPRENEURS

When entrepreneurs start their business, they do not expect failure. However, after encountering failure, it becomes a significant learning experience, with high financial and personal/social costs. Emotions play a key role in how entrepreneurs perceive failure. For example, if an entrepreneur

perceives failure as a personal failure and faces low self-esteem and negative emotions, it can hinder their motivation for future entrepreneurial endeavors. Fear usually diminishes entrepreneurial motivation, while joy and anger can enhance it [6].

Some of the challenges faced by digital entrepreneurs through several case studies:

- The study 'Youth Entrepreneurship in Serbia,' funded by the German Ministry for Economic Cooperation and Development through the German-Serbian Initiative for Sustainable Development and Employment in 2019, explores a range of challenges that young entrepreneurs face in Serbia. These challenges include the state's failure to recognize entrepreneurship potential, an overly regulated and unpredictable business environment with frequent legislative changes, unfair competition, grey economy, and corruption, complicated business closures, and a lack of coordination in the support provided by the state to young entrepreneurs. The state often fails to understand the specific needs of young entrepreneurs and struggles to create appropriate measures for support. The biggest challenges for young entrepreneurs in Serbia are access to finances and difficulties in finding capital to start a business, as well as access to information, business networks, and practical skills [7].
- In the interview 'Digital Entrepreneurship in Serbia Lacks Systemic Support for Development,' Andrijana Božić and Vladimir Stanković, young entrepreneurs operating on social media, discuss the challenges they have faced. They emphasize the importance of support and promotion of entrepreneurial thinking among young people. However, they also highlight that this is poorly represented in the society and education. Young people are often not aware of the possibilities and potential that entrepreneurship offers, which can limit their initiative [8].
- The study conducted in Montenegro on the topic of 'Youth Entrepreneurship - Policy Recommendations in Montenegro' examines the barriers that hinder young people from engaging in entrepreneurship. These barriers include a negative attitude towards entrepreneurship, a lack of social support, and the reluctance of young people to pursue entrepreneurship. Young people often believe that formal education does not provide practical knowledge necessary for success in entrepreneurship, leading to a lack of practical and relevant information. Other challenges include a lack of experience, knowledge, and business contacts, a lack of financial resources, regulations, and inadequate institutional support [9].
- The study conducted in Malaysia on the topic of 'Issues and Challenges among Young Entrepreneurs in Malaysia' revealed that many young entrepreneurs have a short-lived business due to a lack of experience and a lack of networking with experts in the same field. The role of a business network in the success of young entrepreneurs is explored, and the authors suggest that a lack of such a network can limit access to the resources and support needed for success [10].

From the mentioned case studies, it can be observed that the main challenges faced by young digital entrepreneurs are a lack of experience, limited access to finances, and networks. The lack of experience can make it difficult to get access to finances, while the lack of finances can slow down the development of necessary skills. A lack of networks can further delay access to experienced individuals and resources that could help overcome the experience and financial constraints.

III. THE IMPORTANCE OF EDUCATION

Digital entrepreneurship operates in a fast and dynamic environment where technology is constantly evolving. Through education, entrepreneurs need to acquire the necessary knowledge and skills to keep up with these changes and how to leverage them, including understanding the latest technologies, digital tools, and online marketing strategies. Digital entrepreneurs often need to make complex decisions related to technology, finance, strategy, marketing, and team management, and education provides them with theoretical and practical foundations for making appropriate decisions [11].

R. L. Katz describes three basic types of entrepreneurial skills that an entrepreneur should possess in order to be successful in running his business [12]:

- Technical skills: Understanding technology/products, organizational skills, technical expertise required for successful management in a specific industry.
- Social skills: Skills that enable effective functioning in a team environment. Social skills can be divided into two categories:

skills related to cooperation within the organization itself and skills related to cooperation with external partners.

- Conceptual skills: These skills include the ability to see the company as a whole. They include administrative skills related to comprehensive and detailed planning, as well as entrepreneurial skills that enable recognition of business opportunities.

Digital entrepreneurship is becoming increasingly important in today's digital age, and as a result, there are numerous organizations, programs, and courses dedicated to this topic. Some examples include Coursera and edX, which offer various courses and specializations in digital entrepreneurship in collaboration with institutions and universities. Startup Grind is a global organization that brings entrepreneurs together and provides resources, education, and networking opportunities. Joining local startup communities and entrepreneurship support centers can be a good way to learn skills and connect with mentors and investors.

In order to create opportunities for young digital entrepreneurs, it is necessary to create a positive attitude of society towards entrepreneurship, young people should also have access to resources and education that will help them develop skills such as leadership, project management and problem solving.

Development of entrepreneurial skills can be achieved through various theoretical and practical experiences. Some of them are [13]:

- Business Incubators: Business incubators are organizations that provide support to startups and small businesses. Through incubation, entrepreneurs can gain access to training, mentoring, and resources such as office space and technology equipment.
- Startup Competitions: Competitions are a great opportunity for developing entrepreneurial skills. Students and young entrepreneurs can participate in such events to work on the development of their business plans and to get the opportunity to present their ideas to investors and experts.
- Educational programs: Schools, universities and online platforms offer various courses and programs dedicated to developing entrepreneurial skills.
- Mentorship: Through experience-sharing within mentorship programs, entrepreneurs can receive advice and support from those who have already been through similar experiences.
- Financial Support: Governments and other organizations can help alleviate the challenges faced by young entrepreneurs through specialized financing agencies, microfinance organizations, and training young entrepreneurs on financial management.

According to the latest data from the Statistical Office of the Republic of Serbia, the unemployment rate of young people aged 15 to 24 is 24.7% for the second quarter of 2023.

Youth entrepreneurship represents a promising alternative for reducing unemployment and can contribute to sustaining growing economies and the overall development of society. While entrepreneurship alone is not a complete solution to the issue of youth unemployment, it plays a significant role in efforts to reduce this problem and is reflected in the following aspects [14]:

- Creating opportunities for self-employment and employment of young people,
- Incorporating marginalized groups of young people into economic currents,
- Impact on socio-psychological issues and delinquency (entrepreneurship provides young people with an opportunity for self-realization and active participation in society),
- Promotion of innovation,
- Revitalization of local economies and communities,
- Sensitivity to new economic opportunities and trends (young people are open to new business opportunities and react faster to trends),
- Helping to develop new skills and experience that can be applied in different aspects of life.

IV. OPPORTUNITIES FOR YOUNG DIGITAL ENTREPRENEURS

The youth unemployment rate represents a challenge for society and the economy but also an opportunity. Young individuals often face difficulties in finding stable employment and realizing their professional ambitions, leading to consideration and the initiation of entrepreneurship development initiatives. Entrepreneurship becomes

an option for young people seeking employment opportunities and starting their businesses. This is particularly significant due to various factors negatively impacting economic development and the overall quality of life in the country. Some of these factors include political instability, a lack of clear long-term plans to support entrepreneurship, as well as various crises that occur. To expand entrepreneurship development initiatives among young people, efforts need to be directed in several areas, such as education, training support, mentoring, and financial support. Promoting entrepreneurial spirit and the benefits of entrepreneurship among young individuals can help create a positive environment for entrepreneurial development. The high youth unemployment rate represents a challenge but also an opportunity for entrepreneurship development as a resource for job creation and economic improvement [15].

In this context, social media provides a platform for information exchange, networking, and idea sharing. Young entrepreneurs can connect with experienced mentors and other entrepreneurs to exchange experiences and ask questions.

Social media makes it easier to monitor the market, research the competition and identify business opportunities. Analyzing trends and user feedback can assist young entrepreneurs in gaining a better understanding of their target audience and adjusting their business and strategy accordingly.

Some of the ways in which social media helps digital entrepreneurs overcome challenges they face include free access to resources, information, and education, low marketing and promotion costs, networking opportunities with other professionals, mentors, investors, and potential partners, feedback and interaction with the audience, access to the global market, and the ability to engage in practical learning and experimentation with various business models, marketing strategies, and innovations.

V. INNOVATION AND DIGITAL TRENDS

Innovations are the essence of entrepreneurship and the creative process. Creativity serves as the starting point, where new ideas and concepts are generated, and innovation transforms these ideas into tangible products, services, or processes. Entrepreneurs should possess a wide range of qualities such as imagination, openness to new ideas, and the ability to think outside conventional boundaries. Innovation consists of three key components: knowledge, creative thinking, and motivation. Knowledge is the fundamental understanding of a problem or market, creative thinking involves generating new ideas and approaches, and motivation is the internal driver that encourages the entrepreneur to implement the idea [16].

Entrepreneurs are continuously searching for new sources of innovation and are not limited to only one form of innovation. Innovation is an essential component of successful entrepreneurship and brings a range of advantages [17]:

- Problem Solving: Innovation enables entrepreneurs to creatively solve problems and find original answers to challenges that arise in business.
- Increasing productivity: Through innovation, entrepreneurs can improve their processes and become more productive in performing business activities.
- Business promotion: Innovative ideas allow entrepreneurs to stand out on the market and attract the attention of customers.
- Competitive advantage: Innovative thinking allows entrepreneurs to outperform the competition by creating better products or services.
- Improving the quality of life: Innovations through entrepreneurship have the potential to improve people's lives by providing them with better products or services.
- It should be noted that innovations through entrepreneurship do not have to be revolutionary, minor changes and improvements are equally important. Entrepreneurs should focus on improving things within their control to achieve a positive impact on their business and community.

To keep up with social media trends in 2023, a digital entrepreneur should use the following strategies [18]:

- TikTok, Instagram, Facebook marketing depending on the target group and interests,
- Interactive content such as polls and comments to collect information,
- Augmented reality (AR) experiences: Use of augmented reality sensor devices, these devices allow users to enter an AR world and interact with things around them in real time [19],

- Artificial intelligence (AI): Using AI and machine learning to improve media services, automate operations, personalize content and generate text or images [20],
- New technologies that are being developed and are starting to be applied in business on social media such as blockchain technology, Internet of Things, chat bots and virtual assistants.

The success of young digital entrepreneurs on social media depends not only on the current platforms and strategies but also on the ability of entrepreneurs to adapt to changes and stay one step ahead of the competition. Social media is a dynamic environment where new platforms and technologies constantly emerge (new social media features like Instagram Stories or Reels, YouTube Shorts, Facebook Stories). Entrepreneurs need to keep up with these changes and adjust their strategy [21].

Some of the advantages of social media include visibility and the potential for funding and investment. Social media provides entrepreneurs with an opportunity to showcase their ideas and reach a wider audience, which can be useful in attracting investors or partners. Creating accounts on social media is free, and posting content is simple. Entrepreneurs should be familiar with social media algorithms and strategies. Algorithms are designed to show users content based on their interests, behavior, and engagement. Algorithms can affect the visibility of content negatively (frequent changes that may lead to reduced reach) and positively (viral content) [22].

VI. CONCLUSION

Young digital entrepreneurs face a multitude of challenges, but they are also presented with numerous opportunities. Education, the development of entrepreneurial skills, and support are essential factors for their success. Young entrepreneurs need to acquire the necessary knowledge and skills, but also adapt to digital trends and be innovative to stand out from the competition, survive in the market, and continue to evolve.

Creating a favorable environment for young digital entrepreneurs requires a combination of a positive social attitude, access to resources, education, and the use of social media to overcome challenges and create new opportunities for growth and success.

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Educational Softwares in the Function of Improving Education of Children with Special Needs

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Abstract - The use of information technologies in educational institutions aims to facilitate the education and development of children. From the very begining this thesis tries to point to effective usage of innovative information technologies and their importance in education of children with special needs. The application of information technologies in work with children with disabilities shows the possibility of using informational technologies as therapeutic method for the development of children's motor skills and perception. The emphasis should be on application and integration of these technologies in everyday education and not on teaching children computer science and this can be accomplished through good menagement of information technologies which aims to improve lectures for children with disabilities. The main advantage of the development of educational softwares is that the education is no longer based on pure naration of the educator but includes active participation of learners which means that besides using hearing and sight senses using softwares children use the sense of touch through interaction of children and softwares (which means that they use computer mouse and keyboard).

I. INTRODUCTION

„Article 23 of the UN convenction of the rights of the child states that „a mentaly or physically disabled child should enjoy a full and decent life, in conditions which ensure dignity, promote self-reliance and facilitate the child's active participation in the communit”.

There is a broad classification of children with special needs which includes different groups of children. In Serbia, the term „children with special needs“ is usually connected to children with mental disorders, however, this term is much broader and also includes children with various types of disabilities, children from less developed social areas, children from high poverty areas, children affected by armed conflict and displacement as well as talented children. Therefore these children require special attention.

Rapid modernization of the world requests the modernization of the methods for working with children with special needs. Unfortunatelly, in Serbia not much attention has been paid to this topic. The Internet, as the global network is the best for this besacuse it enables connections of hundreds millions of users and implementation of specialized computer softwares in education of children with special needs.

The aim of this theses is to explain how educational softwares i.e. the implementation of innovative information technologies can make education of children with specila needs easier where one of the key roles is the menagement of information technologies in the service of children with special needs i.e. children which need more attention.

II. MENAGEMENT OF INFORMATION TECHNOLOGIES IN THE SERVICE OF CHILDREN WITH SPECIAL NEEDS

Menagement of information technologies (IT) in the service of children with special needs refers to the menagement and application of informational technology to support and facilitate learning, development and everyday life of children with special needs. This field combines the principles of menagement and IT to make the environment which will help children with special needs to achieve their full potential. The key aspects of menagement of information technologies in the service of children with special nees are:

1. Accessible technolgoy: Ensure that IT resources are accessible to children with various types of

special needs. That includes development or modification of software, hardware and digital content to enable use by children with disabilities.

2. Educational tools: Implementation of IT for development of educational tools and platforms which meet needs of the children with special needs. This may include educational games, applications for learning languages, maths or something else.

3.Individual approach: IT can enable personalized learning that would suit the needs of each child. Learning Menagement system can follow the progress of each child and to personalize materials and activities to suit the needs of each child.

4. Communication and socialization: IT tools are often used to improve communication of the children with special needs. That could include applications for communication, language applications or tools for impovement of social skills.

5. Data Monitoring and Analisys: Using IT for monitoring children's progress, evaluation of programme efficiency and identification of fields which require additional support and adjustment.

6. Training and Support: Providing training for teachers, parents and experts as well as providing them support for implementation of information technology when working with children with special needs.

In fact, Management of information technologies in the service of children with special needs aims to improve the education, communication, socialization and everyday life of children eith special needs through adjustment of IT resources to particular need of each child in order to increase their independence and successfullness.

III. INTERACTION OF A CHILD WITH SPECIAL NEEDS WITH A COMPUTER

Recent studies show that computers are efficient in education of children with special needs and enable better control, adjustment and manage better teaching and learning through constant feedback link which ensures greater motivation and is essential for evaluation and fair assessment. Computer devices enable a completely new organisation of teaching and educational work appropriate to the individual abilities and interests of students, then ensure faster semission, transmission and absorption of knowledge. Computer based teaching and learning improve development of abstract oppinion and enable planned guidance and individual progress in acquiring knowledge. When using computers in teaching and learning none of the student's characteristics are negated nor are there any signs and elements of suppression of his/her individuality. Communication between student and computer is simple and direct. Computers give students not only lectures and questions but also instructions for solving assigned tasks. Computer based teaching leaves the teacher more time for more creative work, that is, for educational activities, for pedagogical and professional development, for innovating programs etc. It was noticed that computer based teaching enables the development of memory, imagination, independence i learning, raises the educational level, build sensetivity for problems, openness, flexibility, tolerance, independence in work. This was the knowledge is more successfully put into the function of developing human abilities.
Children with disabilities often need different assistive technologies in order to make the use of computer easier. A lot of video games and interesting softwares have been designed to help children eith disabilities which leads to development of their motor skills and logical thinking. There are also different assistive softwares designed according to the requirements of a particular group of students with special needs which makes it easier for them to use the computer.

IV. ASSISTIVE TECHNOLOGY

Assistive Technology consists of services, items and devices that help and enable children with special needs to use the computer, this is esspecially important for children with disabilities. There are thousands of devices and instruments that can be classified as assistive technology, as well as many ways of thinking about it. The most useful way to classify assistive technology is according to the task it helps to be accomplished:

- Stability, seating and mobility
- Working surrounding
- Communications
- Availability of computers
- Motor skills aspect of writing
- Writing
- Learning difficulties, maths
- Vision
- Hearing
- Daily living and the usage of devices
- Recreation nad leisure

V. MEDICAL BENEFITS OF THE INTERACTION BETWEEN CHILDREN WITH SPECIAL NEEDS AND COMPUTER

Nowadays computers are part of the everyday life to almost all people in the world. Besides that they also became part of children's life and are tools which substituted the traditional toys. From the early childhood, children have access to computers and what attract them the most is playing video games. Playing video games, especially excessively, is often portrayed in a negative context. However, the opposite rule applies to children with special needs. In numerous ways, playing video games has positive effect to them. Besides different educational video games and softwares, there are various video games which are recommended to those children. For children with mental disorder various specially designed simple video games are recommended. Apart from occupying attention, these games have positive effect on the development of logical thinking as well as motor skills. Also, for children suffering from serious and chronic diseases it is recommended to play video games that have a great "power" of occupying children's attention. In these cases playing video games presents an escape from reality, that is, a diversion of attention from personal suffering. In practice, in such cases, playing video games in children with serious and chronic diseases has been proven to be beneficial.

VI. COMPUTERS AND SMART DEVICES AS TEACHING AIDS FOR CHILDREN WITH SPECIAL NEEDS

Teachers today are increasingly looking at information technologies as teaching tools that are necessary for their students. The computer can be a useful tool with great potential to provide students with active participation in class. In order to achieve this, it is important that there is a good understanding of how children with special needs should use computers and information technologies. One of the great features of computers is the immediate and constant feedback to the user using text, image and sound. Teachers can predict children's reactions because children do not always give feedback at the same time or in the same way that the teacher expects. For example, autistic children may be confused by inappropriate reactions from humans, while computers always react the same to the user. This can be helpful for autistic children. Multimedia can also offer consistent programs and motivation for children with severe impairments and limited perception that they can use to enable them to be active in their daily lives. There are many programs available that can encourage communication, reading for fun, problem-solving skills, and everyday life skills. It is important that these programs are used well as encouragement for learning and at the same time allow good teachers to use these programs as part of the rich educational opportunities. Children who cannot hold a pencil due to their physical disabilities can write text using a regular or specially designed keyboard. Children can also communicate with others by typing a message and using text-to-speech software applications. What is very useful is the fact that all popular operating systems, both for computers and smart phones, have various types of pre-installed options that make it easier for children with special needs to use computers.

Although smartphones and tablets were not originally intended and designed to serve as educational tools, they quickly found their application in schools. Educators at almost all levels are embracing smart devices and implementing them into teaching. The most interesting of all is that research of the application of smart devices in education is still ongoing, so new ways of applying these technologies in education are often found. These small hand-held devices offer students, both with and without special needs, quick and interactive access to educational opportunities, information, organizational systems, communication and even emotional support.

Everything that ordinary users can use on a daily basis (e.g. interface, portability, accessibility, camera, internet, location services, various applications, etc.) can be used for the purpose of education or improvement of educational abilities. Different properties of smart devices can make them unique compared to other educational devices and methods. Touch screens offer advantages for children with special needs, and in this way access to the device itself is much easier than with a computer. Using touch screens provides immediate feedback in the form of an image or sound. This instant feedback helps students stay focused on the topic they are working on or researching. The two biggest advantages of using smart devices in children with special needs are the improvement of motivation to learn and the fact that they enable personalized learning, which makes it easier to individualize instructions and monitor progress.

VII. RESEARCH METHODOLOGY

A. Research Problems

The application of information technologies in educational institutions has a role to facilitate the education and development of children. From the very beginning, this work tries to point out the effective application of modern information technologies and their importance in the education of children with special needs, but definitely not enough attention is paid to this topic in our country. Special institutions such as schools, which are the subject of our work, partially manage to overcome this problem, but as far as primary and secondary schools are concerned, there is no progress.

B. Subject of Research

The subject of this research is the examination of the impact of educational software on the development of children with special needs.

C. Goal of the Research

The goal of this research is to show whether educational software has a positive effect on children with special needs.

D. Research task

Evaluation of the usefulness of certain educational software for specific types of special needs.

E. The Hypothesis of the Research

- ✓ Using educational softwares in education of children with special needs makes the education more successful.

F. Research methods, techniques and instruments

In this research, the data collection method is used, the technique is surveying, and the questionnaire is the research instrument.

G. Time, place and research sample

The research was conducted in November 2020. The number of respondents is 21.
The respondents are the staff of a special elementary school for children with special needs „Heroj Pinki" from Bačka Palanka.

VIII. THE RESULTS OF THE RESEARCH

The results of the research are presented in a table where the teacher's answers are shown, as well as the percentage of what they think about educational software, to what extent they use it, from which we can later derive the function of what schools and teaching staff need for further work.

Table 1. Obtained results

Question:	Answers of respondents:					
	YES	NO	Analysis:			
1. Does your school use educational softwares in work with students?"	21 100%	0	Based on the answers received, we conclude that the school uses educational software			
2. Do you support innovation in the form of increasing the number of educational softwares in schools for children with special needs?	21 100%	0	Based on the answers received, teachers are ready to expand the capacity of educational softwares, and therefore are ready for their own training.			
3. Do educational software have a calming effect on children?	21 100%	0	All teachers think that educational softwares have calming effect on children with disabilities.			
4. To what extent do educational softwares affect children's concentration?			To a Great extent	To a medium extent	To a less extent	Educational software definitely affects children's concentration, and what is important is that not a single respondent answered with "to a less extent".
			16 76,2%	7 23,8%	0	
5. Do you think that children find educational games are more interesting than educational workshops?	19 90,5%	2 9,5%	Even 90,5% of respondents think that educational games are more interesting than educational workshops.			
6. Do you find educational softwares based on Montessori program more efficient?	21 100%	0	100% responds "YES" confirms the fact that there must be independence in learning, a prepared environment, individuality, freedom of choice and the development of practical skills.			

7. Do you recommend parents to encourage their children to use educational softwares at home (if conditions allow)?	19 90,5%	2 9,5%	Working at home helps children with disabilities, but it is also necessary for parents to have certain knowledge in the field being worked on.			
8. How often do you recommend parents to encourage their children to use educational softwares at home (if conditions allow)?	Teachers very often or often recommend parents to encourage children to use educational sofwares at home.		Very often	Often	Rarely	Never
			14 66,7%	4 19%	2 9,5%	1 4,8%

IX. ANALYSIS OF RESEARCH RESULTS

Analyzing the survey results confirms the main research hypothesis that educational software positively impacts children with special needs in education. Further data description analysis involves examining the distribution of responses to the given questions. Here's an overview of the data analysis based on the provided information:

Does the school use educational software?

100% of respondents (21) answered that the school uses educational software.

Support for innovations in increasing the number of educational software:

Again, 100% of respondents (21) support innovations in increasing the number of educational software in schools for children with special needs.

Impact of educational software on children:

All teachers (21) claim that educational software has a calming effect on children with special needs.

Impact of educational software on children's concentration:

Responses to this question were: To a great extent (16), To some extent (7).

A significant majority, namely 76.2% of respondents, believe that educational software significantly affects the concentration of children.

Interest in educational games compared to educational workshops:

90.5% of respondents believe that educational games are more interesting than educational workshops.

Effectiveness of educational software based on the Montessori program:

100% of respondents confirmed that educational software based on the Montessori program is effective.

Recommendation for using educational software at home:

90.5% of respondents recommend parents to encourage children to use educational software at home, provided that the conditions are adequate.

Frequency of recommending parents to use educational software at home:

The majority of teachers (66.7%) frequently or very frequently recommend parents to encourage children to work with educational software at home.

This analysis demonstrates high support for the use of educational software by respondents and the belief that these tools have a positive impact on children with special needs. Additionally, there is a strong recommendation for using these software tools at home, as well as a perceived effectiveness of software based on the Montessori program.

X. CONCLUSION

The use of modern information technologies in education created necessary condition for improving the teaching process and for more dynamic development of educational institutions because it can and should represent much more than simply combining these technologies with traditional teaching. In order for progress to be continuous, it is necessary to have a good Information technology management that will monitor what will be of use for improving teaching of the children with special needs. Significant roles in this have multimedia technologies, which in the technological sense represent the integration of text, image, sound and speech within one environment (computer). It can be concluded that the implementation of modern multimedia technologies and new software achievements in education achieves what has always been aspired to: personalization, respect for differences between users and the possibility of advancement according to personal affinities and abilities (individualization of teaching). Therefore, education, as an integral part of society, must respond to changes and follow the tendencies of modern society, which is becoming more and more technological. The use of computers in modern teaching is becoming an increasingly common practice, and the use of educational softwares, as well as Internet technology, is of particular importance.

This topic represents a big problem, but also a challenge, which our country should solve in the future and thereby help children with special needs. Investments in this field are getting bigger and more frequent, so it is expected that Serbia will progress in this field in the coming period and that in the future much more attention will be paid to children with special needs.

XI. VISION OF THE FUTURE

The vision of the future for educational softwares in teaching children with special needs can be the creation of a local/regional or national media library to which all schools, organizations, faculties, etc. would have access, because Serbia does not have the means to equip every school with the mentioned educational softwares. The vision of the future can also be the exchange of devices between schools, organizations and faculties, assuming that the software is regularly updated, new ones are acquired and that the personnel who work with them are continuously trained.

Finally, it should be noted that without the promotion of educational software activities in education of children with disabilities as an optimal solution, there is no progress in the mentioned area.

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Enforcing Zero Trust in Distributed Cloud Deployments

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Abstract - Modern software systems are becoming increasingly complex spanning across multiple data centers and geographical boundaries. Incorporating third-party services, APIs, and tools into our software has become the norm. The growing complexity, while providing a greater degree of flexibility and functionality, presents new security and compliance challenges. In this new environment, traditional security paradigms based on closed networks and trusted actors are becoming less adequate. Rather than assuming trustworthiness based on network location or past interactions, zero trust security outlines new practices including continuous validation of both identity and security posture of any request before granting access to resources. In this paper, we'll go into details of zero trust architecture, and how to apply it to the existing distributed cloud platform. As the platform enables clients to form ad hoc clouds for running their workloads and storing data, multiple deployment scenarios emerge. An enterprise may own resources in one or multiple distributed clouds and it may also wish to collaborate with other organizations. We propose a zero-trust-compliant solution for these scenarios, covering the access control model, administrative and operational model configurations, and required architecture extensions.

I. INTRODUCTION

The concept of sharing compute resources accessible via a network isn't anything new. It started in the 1960s when multiple users connected to the same machine using separate terminals in a process called time-sharing [1]. The sharing of computer resources further progressed in the early 2000s when Amazon used virtualization to divide hardware in their data centers into smaller logical units and rent them out to users on a "pay-per-use" basis. Other companies soon followed suit and over time this idea evolved into renting complete platforms (operating systems) or even ready-made services (various databases, Advanced Message Queuing Protocol (AMQP) platforms, etc.) [2]. The entire field of renting computer resources available via the internet was named cloud computing.

To keep the maintenance costs of this computer infrastructure as low as possible, cloud providers are incentivized to run a handful of huge data centers instead of distributing their compute resources "evenly". For example, Amazon Web Services (AWS), the largest cloud provider in the world currently operates only one data center in the entire South America, and only one data center in Africa [3]. Although good for minimizing infrastructure costs, this approach has a few drawbacks. End-users of information systems are often physically distant from the data centers where these systems are launched. This means the performance of these products is degraded due to the time needed for communication via the Internet between the user and the computers hosting the information system. In certain situations, depending on the domain of the information system, sending user data outside the borders of the user's country is not allowed. In these cases, it's not possible to use cloud computing at all, as it implies communication with data centers often located outside the countries where the end users are [4].

A. Distributed cloud model

The paper aims to provide a zero-trust architecture (ZTA) for an existing distributed cloud (DC) platform. In this section, we will describe the above-mentioned platform, which is explained in detail in [5], [6].

Before defining the DC architecture, we will introduce the concept of edge computing: a distributed computing paradigm that expands on concepts of traditional cloud computing. While cloud computing centralizes data processing in large data centers, edge computing pushes some computational tasks closer to the data source. This could be anything from Internet-of-Things (IoT) devices, and smartphones, to sensors in industrial settings. The primary drive behind edge computing is the need for reduced latency (especially in areas with low connectivity) and a decrease in traffic and load on the parts of our system that are running in data

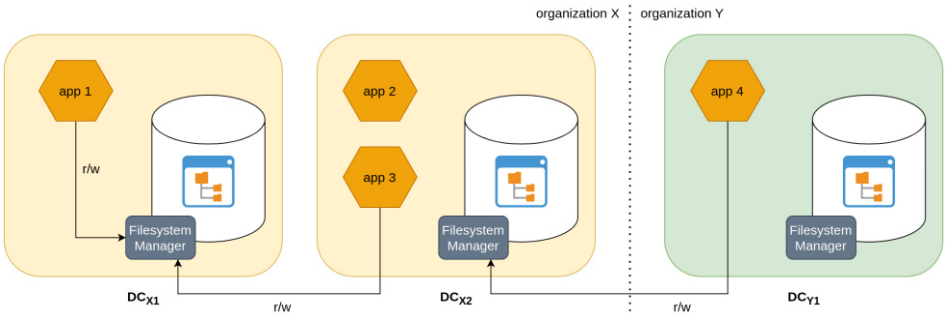

Fig. 1: Deployment scenarios in DCs

centers. In scenarios where immediate data processing is paramount, such as autonomous vehicles or real-time health monitoring, edge computing is proving to be invaluable [7].

The solution Simic et al. proposed in their paper expands on the existing edge computing model, introducing a geo-distributed DC model [5], [6]. This model gives end users the capability to define resources not only within the single compute node or region, but within the region of smaller clusters that are dispersed on the edge of the network. With an entire hierarchy of smaller clusters inside a region, users would be able to define which tasks would be executed on the edge nodes, and which would run on centralized nodes in the cloud. This also gives users control in deciding what data is processed locally, what is being sent to the cloud, and how often.

The smallest unit in this new model would be an DC cluster. It can be compared to the cluster of machines in the traditional cloud, but it would have significantly less hardware and compute resources. The next block in the model would be a region - a dynamic logical grouping of multiple DC clusters spanning across a geographical region, that would be able to accept new clusters or release existing ones based on demand. The last logical unit in the edge layer is called topology, and it consists of one or more regions, also being able to dynamically accept new or release existing regions. Throughout the paper, we refer to one topology as an DC.

B. Zero-trust architecture

In this section, we will outline some key principles of zero-trust (ZT) systems [8], and discuss different deployment scenarios where ZT principles should be applied before proposing our ZTA for the above-explained DC platform.

The foundation of ZTA is built on the idea that all components of an enterprise's network, including identity, credentials, access management, endpoints, operations, hosting environments, and infrastructure, should be considered potentially untrusted. In other words, no entity, whether it's a person or a device, should be given unrestricted access to resources by default. One of the primary goals of ZTA is to minimize the attack surface by restricting resource access to those who genuinely require it to carry out their tasks. This means granting the minimum privileges necessary for a user or system to fulfill their specific role, whether it's reading, writing, or deleting data.

Historically, many organizations relied on perimeter defenses to secure their networks. Authenticated users were often granted access to a wide array of resources once inside the network. However, this approach proved inadequate in preventing insider threats and movement within the network by malicious actors. ZT shifts the focus from perimeter security to a more granular approach. It also recognizes the need to protect resources outside the traditional enterprise networks. This includes remote workers, cloud-based services, edge devices, and more. To achieve this, organizations must adopt ZT principles throughout their network infrastructure and operational policies. In summary, ZT represents a fundamental shift in cybersecurity strategy which aims for protection through continuous evaluation and the principle of least privilege instead of authorization based on network access. By doing so, they aim to create a more resilient and adaptive security framework.

Some of the deployment scenarios where ZTA can be applied are [8]:

Multi-cloud deployments: As organizations increasingly adopt cloud-hosted services, the traditional reliance on the enterprise perimeter for security becomes inadequate. ZTA principles advocate treating all network infrastructure, whether owned by the enterprise or external service providers, with equal skepticism. To implement a ZT approach in a multi-cloud environment, Policy Enforcement Points (PEPs) are placed at the access points of each application and data source. These PEPs can reside in any cloud or even a third-party provider. Users, through a portal or local agent, access these PEPs directly, enabling the enterprise to manage resource access, even when resources are hosted outside their network. This would allow

services hosted in different cloud environments to communicate directly instead of piping all requests through the enterprise network.

Collaboration between enterprises: In traditional setting, Enterprise A could create specialized accounts for Enterprise B's employees to access the required data, but this becomes challenging to manage as the collaboration grows. To streamline this process, both organizations can participate in a federated identity management system. This approach facilitates the quick establishment of relationships, provided that both organizations' PEPs can authenticate subjects within a federated identity system. Unlike relying on complex firewall rules or enterprise-wide access control lists (ACLs), this approach leverages technology such as cloud-hosted policy enforcement and administration services to provide accessibility without the need for VPNs.

Deployment scenarios in the DC platform that will be covered by our solution are:

1. Application running in one DC is trying to access data within the same DC
2. Application running in one DC is trying to access data that's stored on a separate DC but belongs to the same organization
3. Application running in one DC is trying to access data belonging to a different organization

The solution that will be proposed in section III will address all of these scenarios using ZT principles and would be able to govern resource access regardless if the application and data are situated on the same DC or not. This approach would also make it possible to allow a specific application to access some parts of your data, even though that application is not part of the same organization, making it easy and safe for different enterprises to collaborate. These deployment scenarios we are trying to facilitate are shown in Fig. 1.

II. RELATED WORK

ZTA has become a necessity as modern enterprise requirements no longer consist of local networks and on-site access, but are rather oriented toward remote access and resources stored and operated from untrusted environments. As a globally present enterprise, Google developed BeyondCorp, its access control solution that follows ZT principles [9], [10], [11]. They treat devices as managed or unmanaged and periodically collect data about them, such as OS version, installed software, etc. to determine their trust level. This aids them in specifying context-aware access policies such as: *Only full-time engineers can access a bug tracking system from an engineering device.* The brain of the system is the Access Control Engine. It evaluates policies and makes authorization decisions based on trust assessments, requested resources, and real-time credentials. The Access Control Engine is invoked by gateways, such as web proxies and SSH servers that enforce actions based on the engine's decisions.

This comprehensive solution touches many aspects of ZT but is mainly applicable when services and infrastructure are enterprise-owned, which is not the case for a large number of enterprises. When relying on cloud services, providers offer Identity and Access Management (IAM) solutions that allow centralized management of users and policies. The problem with this approach arises when the enterprise decides to distribute its resources to multiple clouds or collaborates with another enterprise that uses the services of another cloud provider. There have been attempts to enable federated collaboration by injecting an access control module that would guard all cloud-to-cloud interactions [12], [13].

Google Cloud Platform (GCP) IAM is built on top of a distributed ACL storage and evaluation system called Zanzibar [14] There is also an open-source implementation based on Zanzibar, SpiceDB, with a layer on top of it, Authzed, that offers access control services [15]. Zanzibar and SpiceDB have a data model that belongs to the Relationship-Based Access Control (ReBAC) family [16]. In ReBAC models, policies are based on the subject's and object's relationships to other resources in the system. In domains such as social networks, where these models originate from, it is the most natural way of specifying policies. On the other hand, if relationships are not the primary source of information, these models would be inefficient or insufficient for expressing certain rules. For that reason, there are hybrid ReBAC and Attribute-Based Access Control (ABAC) [17] models that allow users to describe resource properties both by relationships and attributes, such as [18], [19], [20].

III. PROPOSED MODEL

In this section, we present a comprehensive access control solution for the DC environment that complies with ZT principles. Firstly, we introduce the employed access control model, its components, operations, and policy conflict resolution strategy. Secondly, we discuss how it can be configured as both an administrative and operational model for the platform. And lastly, we propose extensions to the platform's architecture that can support ZT in various deployment scenarios.

A. Access control model

ABAC models have been shown as promising in large-scale and dynamic systems that require fine-grained access control [21]. They have been applied to domains closely related to DCs, including cloud and edge computing, IoT, and more [22], [23]. As such, they serve us as a stable starting point on top of which we further build our solution. The major challenge we encountered with pure models like ABACα [24] is the lack of components that would allow us to efficiently represent and reason about policy inheritance over resource hierarchies. To say that for example ABACα couldn't be configured to support the platform would be an overstatement, but those configurations inevitably lead to attribute and policy explosion as the number of clients and resources increases. To mitigate the problem, we developed an attribute-based model that treats the aforementioned inheritance as a first-class citizen.

Operations supported by the system are performed on *objects* and are carried out by *subjects*. Subjects can be seen as runtime projections of *users* that possess a subset of the user's capabilities. Each subject only represents a single user, whereas a user can be represented by multiple subjects. The union of all users and objects in the system is referred to as *resources*. A resource is defined by its unique identifier and type.

To describe their relevant properties, resources can be assigned *attributes*. Every attribute consists of a name and a value. Resource's attribute set comprises unique names. When a subject is created, it claims a subset of its owner's attributes. This way, we can enforce the least privilege, as users are granted permissions based on their attribute values. Contextual information, such as the subject's current location, host machine, date and time, and more, is also provided via attributes. They are specific to and should be dynamically determined for every subject at the time of each request they make. Thus, we distinguish between *resource attributes* and *request attributes*.

In many real-world systems, resources exhibit clear interdependence relationships upon which security policies are designed. For example, organizations often have department hierarchies and manage employees' access to data based on their affiliations with those departments. Another example could be file systems with tree-like structures. If a user is allowed to view directory content, it may be sensible to allow them the same for all containing files and subdirectories. For those reasons, our model can keep track of such department-department, user-department, directory-directory, or directory-file relationships, called *inheritance relationships*. With resources as nodes, and inheritance relationships as edges, we can form an *inheritance graph*, a directed acyclic graph that lets us reason about policy inheritance. Each inheritance edge has a source and a target. The target node inherits policies from the source node.

A *policy* is a pair consisting of a *permission* and a *condition*. The permission specifies what operation is granted to the subject, while the condition states the rules that must be satisfied by the subject's and object's resource attributes and by request attributes. Permissions can be both positive or negative, granting or denying access to some operations. We opted for conditions constructed as logical expressions, supported by some policy language. The language specification is out of the scope of this paper and we only require expressions to evaluate to *true* of *false* based on attributes' presence and values.

Each policy must have a *subject* and *object scope* specified, both of which are resources. An object is in the object scope of a policy if that object is specified as the policy's object scope or if it inherited that policy through its inheritance relationships. Similarly, a subject is in the subject scope of the policy if that subject's user is specified as the policy's subject scope, or if the user inherited that policy through its inheritance relationships. When it comes to inheriting policies, we can enforce the least privilege by letting a subject claim only a subset of its user's inheritance relationships.

The model supports operations for creating and deleting resources, resource attributes, subjects, inheritance relationships, and policies. Their implementation must follow the model rules stated throughout this section, such as no cycles in the inheritance graph. When a resource gets deleted, all of its inheritance relationships get deleted too.

An authorization request should specify a subject, object, operation, and request attributes. Based on those, we can find applicable policies for that request. Those would be the policies defined for the requested operation for which the specified subject is in the subject scope and the specified object is in the object scope. As there can generally be multiple applicable policies, here we provide a policy conflict resolution strategy. Each policy is assigned a subject and object priority. The object priority is a negative value of the longest path length from the object to the policy's object scope. The same goes for subject priority. Policies are then sorted in descending order, first by subject priority and then by object priority. The authorization decision is determined by the first policy in that list with a condition evaluated to be *true*, or more precisely by its permission type. If there are multiple policies with the same subject and

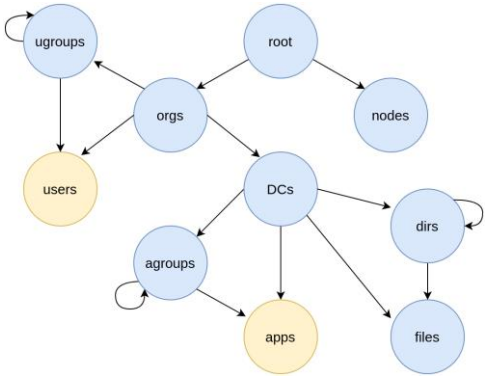

Fig. 2: Type graph for inheritance graphs

object priority whose condition is satisfied, but with conflicting types, we apply the *deny-wins* strategy.

B. Model configuration

Any action on system resources should be authorized by evaluating policies from the operational model. Likewise, any action on the operational model should be authorized by evaluating policies from the administrative model. We will configure the previously presented model to play both roles in our system. For each instance, we define resource types and inheritance relationships allowed in the inheritance graph. Besides that, we specify a set of operations supported by administrative and operational models and present administration workflows that support our deployment scenarios.

Inheritance graph constraints for both model instances are described via their type graph, displayed in Fig. 2. Each node in the type graph represents a possible resource type and relationships between nodes declare nodes of what type can be connected as a source or target with nodes of what other type. User nodes are colored yellow and object nodes are colored blue. Inheritance graphs of administrative and operational model instances should be kept identical at all times, either by synchronizing updates or by having only one graph that serves both purposes.

There should be exactly one node of type *root* and it should be the only root node of the graph. Its purpose is to enable the administration of policies applicable to all subjects or objects. A policy applicable to all subjects should have the root node as its subject scope, and the same goes for objects. In this way, we can declare policies analogous to the ones in regular ABAC models.

Resources (*DCs, dirs, files, apps*) and *users* belonging to a single entity are all part of an organization (*orgs*). Users and applications can be members of hierarchically organized groups, *ugroups* and *agroups* respectively. A structure like this facilitates policy administration in a complex setting with many clients.

Even though the inheritance graph is just one fully connected graph from the system's perspective, individual organizations will be responsible for managing only subgraphs that are related to them. For that reason, when we discuss access control management in a single organization, we will omit resources of type *root* and *nodes*, as they are not owned by any organization, and take into account only the corresponding *orgs* resource and other resources inheriting policies from it. Following this reasoning, we present inheritance graphs for our deployment scenarios in Fig. 3. Policies are represented by red arrows and labels and are not part of the inheritance graph. The source node of the policy arrow is a subject scope and the target node is the object scope. Permission types are omitted and considered to be *allow*, as well as conditions that are considered empty, hence always *true*. The only thing displayed is the operation name.

While the operational model instance should have policies regarding operations in the system, the administrative model instance should have policies regarding operations that can be performed on the operational model. As the first operation set is extensive and not relevant to this paper, we will not present it fully. Nevertheless, in Fig. 3 we can see some examples: *f.read* for reading files and *f.write* for writing to files. On the other hand, we are concerned with the second operation set, as it allows us to define who can do what on the operational model instance. When someone issues a request for which the operational model instance is the object, we first have to authorize that request on the administrative model instance. We now define those operations:

- *attribute.create*: Creating a new attribute for a resource
- *attribute.delete:* Removing an attribute from a resource
- *policy.assign-sub-scope*: Assigning a resource as policy's subject scope
- *policy.assign-obj-scope*: Assigning a resource as policy's object scope

Only operations for creating and deleting policies and attributes are mentioned as policy administrators are allowed to perform those, while resources, relationships, and subjects are managed automatically by the system. For example, an *app* node is created and connected to a *DCs* node as a result of a new deployment. The deployment will only be performed if the subject that triggered it was

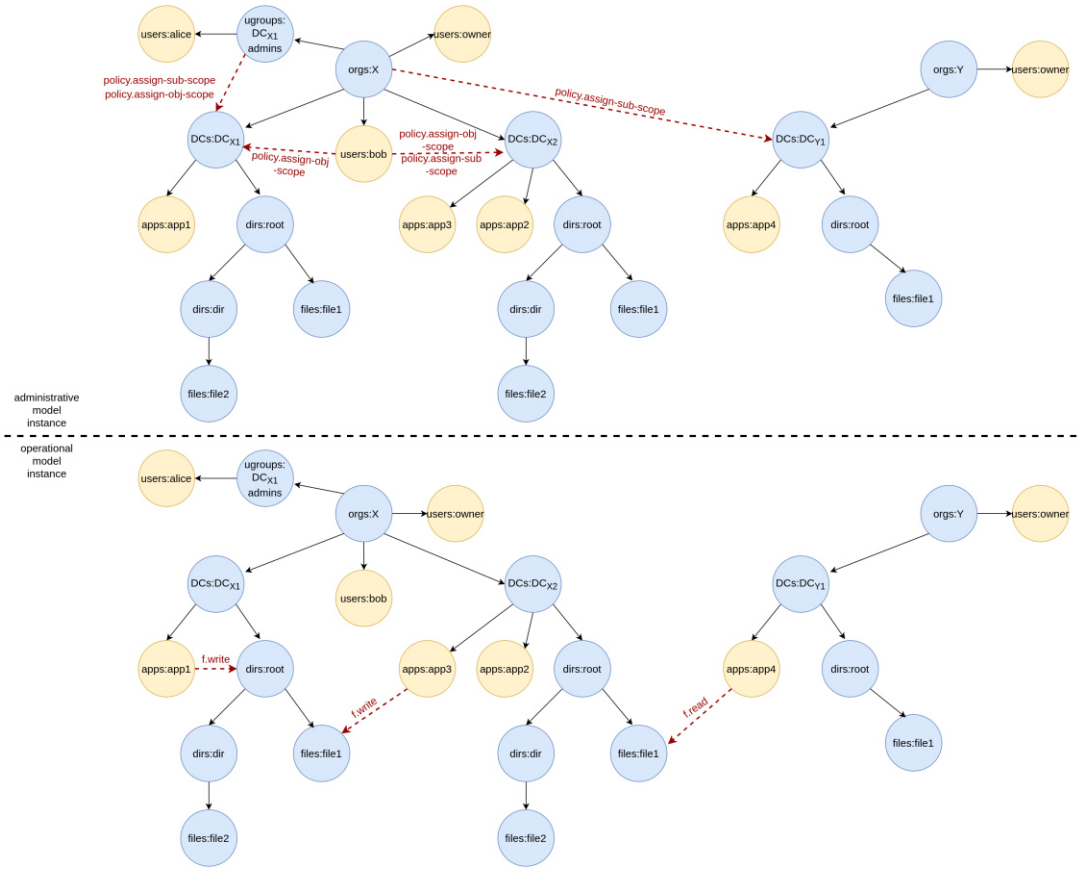

Fig. 3: Example of administrative and operational model configurations

authorized to do so. For a new policy to be created, the administrator must have the right permissions to set selected resources as subject and object scopes. In this way, we have control over what resource groups are managed by what administrators. In our example in Fig. 3, users from the group *ugroups:DC$_{X1}$ admins* can create policies with subject and object scopes in *DCs:DC$_{X1}$* but not in *DCs:DC$_{X2}$* . On the other hand, *users:bob* can create policies with subject and object scopes in *DCs:DC$_{X2}$* and object scopes in *DCs:DC$_{X1}$*. If we look at the state of the operational model, the only user who was able to create policy that allows *apps:app1* to write to all files in *DCs:DC$_{X1}$* was *users:alice*, while the only one who was able to create policy that allows *apps:app2* to write to *files:file1* in *DCs:DC$_{X1}$* was *users:bob*. With this, we demonstrated one possible way to control access to resources for the first two deployment scenarios, where subjects and objects are in the same organization.

When we configure models in this way, we encounter another problem: who is going to manage the administrative model? For this reason, we introduce owner accounts in our system, which are a special kind of user accounts that are registered as owners of organizations. Each organization initially has one owner. As one account has control over the entire administrative model instance for that organization, this poses a serious security risk. For this reason, we allow owner accounts to appoint other regular accounts as owners. Now when we have multiple owners for one organization, we can require every owner operation to be approved by the majority of owners.

Until now, we only talked about the cases where subjects and objects are members of the same organization. Even though this covers the first two of our deployment scenarios, the third one requires subjects and objects to be owned by different organizations. Therefore, we must have a way of specifying such policies. Referring to our example in Fig. 3, if we let the owner of the organization *orgs:Y* create a policy for *policy.assign-sub-scope* in the administrative model instance where the subject scope is any orgs node, in this case *orgs:X*, we have effectively allowed members of organization X to assign new policies to the members of organization Y. In this way, organization X can give controlled access to their resources. As *users:bob* is the only one with the permission to set resources in *DCs:DC$_{X2}$* as object scopes, he is the only one who was able to create a policy that allows *apps:app4* to read *files:file1* from the *DCs:DC$_{X2}$*.

C. Platform architecture

To support our deployment scenarios with adequate access control mechanisms, we need to extend the platform's architecture. In this section, we specify the necessary components, their interaction, and placement. As we have a choice of deploying components to a cloud or DC layer, different decisions will have different implications, so we will also discuss those.

ABAC reference architecture specifies several logical modules an access control system should comprise [17]:

- *Attribute store*: Our system will have an attribute store for the operational model - **$AttS_O$**, and an attribute store for the administrative model - **$AttS_A$**.
- *Policy Information Point (PIP*): A module for managing and retrieving attributes, as well as the inheritance graph in our case. We distinguish between **PIP_A** for the administrative and **PIP_O** for the operational instance. For each request, PIPs rely on attribute and inheritance graph stores.
- *Policy store*: As with the attribute store, we will have a store for the operational - **PS_O**, and for the administrative model instance - **PS_A**.
- *Policy Administration Point (PAP):* A module for managing policies, in our case there will be two of them - **PAP_O** and **PAP_A**. PAP reads from or writes to the policy store for each request it receives.
- *Policy Decision Point (PDP):* A policy engine that serves authorization requests, **PDP_O** for authorization on the operational model and **PDP_A** for authorization on the administrative model. To evaluate a request, PDP must have access to policy, inheritance graph, subject, object, and request attributes.
- *Policy Enforcement Point (PEP):* A guard that rejects requests if they aren't authorized by PDP and forwards them to the corresponding resource service if they are - **PEP_O** and **PEP_A** in our case

Besides these components, we will also add to the system the following ones:

- **Authentication service (AuthS):** A service that authenticates subjects based on certificates or tokens provided. It can also create subjects if it has access to the identity, inheritance graph, and attribute stores. We don't have a subject store as we expect tokens and certificates to carry all necessary subject information.
- **Gateway (G):** It intercepts all requests, resolves the subject by communicating with AuthS, and sends a request and subject information to the upstream service. Because of this, upstream services will always have all available information about the subject uniformly represented.
- **Inheritance graph store (IGS):** For keeping track of inheritance relationships in the system. We won't differentiate stores for model instances as they should always be in sync, but we can always keep multiple replicas.

We would normally want to place some components in the DC layer so that we have lower latency and some in the cloud layer for centralized control and resource abundance. However, a complex interplay between components must also be taken into account. For that reason, when evaluating placement options, we should follow a rule that states: *A request execution in one layer should never depend on data placed only in the other layer*. If we don't follow it, we won't attain better performance, as the cloud and DC will need to communicate and possibly transfer substantial amounts of data. We can draw some conclusions from this for our specific use case:

- PIP, attribute, and inheritance graph stores should be present in the same layer. This doesn't mean that we can't replicate data from the cloud to DC and vice versa, but that it can happen in an eventually consistent manner.
- PAP and policy store should be present in the same layer.
- PDP, attribute, inheritance graph, and policy stores should be present in the same layer.
- If we want AuthS to be able to create subjects, it should be present in the same layer with identity, inheritance graph, and attribute stores.

As we want a cloud layer to be a control plane where all actions can be performed, we would also want to place all newly added components there. However, requiring that all modifications and authorization go through the cloud would diminish performance improvements obtained by DC formation in proximity to clients. Because of this, we want to enable authorization on the operational model in the DCs. Then, when an app writes to a file, for example, the request can be executed in the DC entirely. For this to be possible, we must place G, AuthS and PEP, PDP, policy, inheritance graph, and attribute stores of the operational model instance in DCs. Additionally, as authorization operation on the operational model must be authorized on the

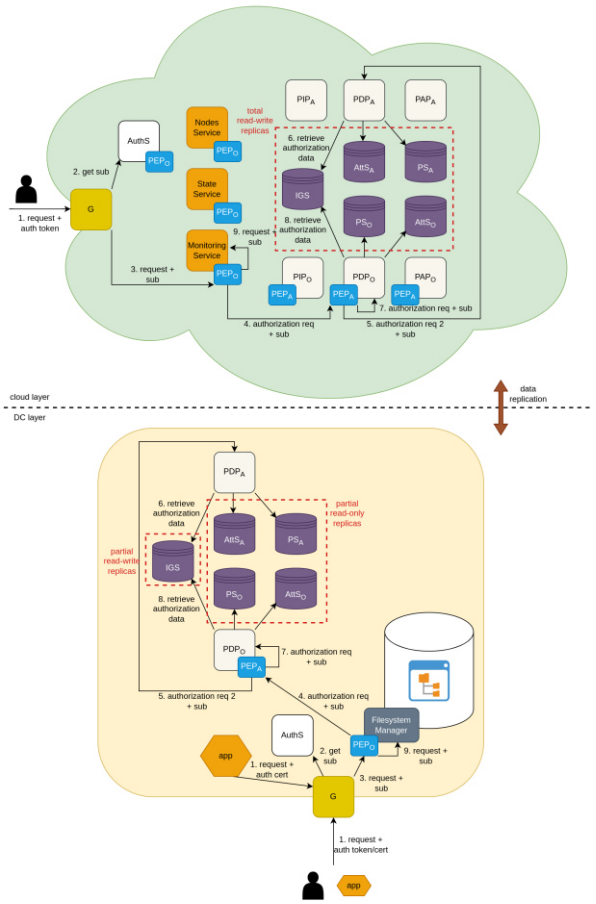

Fig. 4: System architecture

administrative model, we should also have its PEP, PDP, and attribute and policy stores in the DC.

This can raise a concern for resource consumption, as DCs can be quite resource-limited. To mitigate this, we don't require total replication of attribute, policy, and inheritance graph data to every DC, as most of it is not relevant to requests that occur there. We only need partial replication so that authorization can be carried out. For the inheritance graph, we only need a subgraph where the corresponding *DCs* node is the root, operational policies applicable to any of those resources as objects, and an inheritance subgraph of all resources that are in the subject scope of the relevant policies. Also, we need attribute data for all resources in the inheritance subgraph. For the administrative model, we only need policies related to the authorization operation, which can for example be only one policy stating that a subject can authorize its own requests. Therefore, storage consumed by the administrative instance is negligible.

We note that the replication direction won't always be from the cloud to DC replicas. If an app makes a change to the file system structure, the DC replica will be the first to receive the update and it will need to propagate those changes to the cloud. Details related to coordination and data consistency are out of the scope of this paper and need further investigation. Currently, all PIP and PAP components are placed only in the cloud layer, even though it is possible to distribute them too. As that would introduce even more complexity in the data management process, we leave such architecture refinements to future work.

In Fig. 4 we can see the proposed architecture for cloud and DC layers. Other than the components and their placement, two successful request flows are being displayed too, one for each layer. As we can notice, authorization in DCs requires no instant communication with the cloud, but we should be aware that data in DCs will only be eventually consistent because of this.

IV. Conclusion

In this paper, we presented an access control solution for distributed cloud environments that aligns with zero-trust principles. It introduced an attribute-based access control model with a focus on policy inheritance, providing fine-grained access control. The paper discussed model configuration, administrative and operational aspects, and explored the platform's architecture and the placement of key components to support zero-trust access control.

The proposed architecture allows for effective access control in distributed DC environments, addressing the challenges posed by modern, complex software systems. By implementing this model, organizations can enhance security and compliance in their multi-cloud deployments while minimizing latency and data consistency concerns.

While our solution integrates zero trust into the DC paradigm, there are still issues to be resolved. Currently, policy administration is centralized and supported only in the cloud layer. If the DC gets disconnected, it won't receive any data changes. Allowing policy administration in the DC layer could mitigate this problem, but this raises a concern of conflicting policies and inconsistent state. Thus, we leave this and other previously discussed limitations as open research questions.

Acknowledgments

This research was supported by the Provincial Secretariat for Higher Education and Scientific Research of Vojvodina, Republic of Serbia, project: Development of an Access Control Model for Distributed Cloud Computing Systems Based on Zero Trust Architecture Principles, Grant No: 142-451-3081/2023-01/01.

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Projects Using the National Platform for Artificial Intelligence of the Republic of Serbia:Review

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Abstract – In this paper, the authors will present the basic elements of the National Platform for Artificial Intelligence of the Republic of Serbia. The elements that will be displayed are based on the platform's architecture, functioning, and the way to access the platform. In addition to the presentation of the National Artificial Intelligence Platform of the Republic of Serbia, this paper will also present artificial intelligence platforms located in other countries. The aim of this work is to present the National Platform for Artificial Intelligence of the Republic of Serbia on real projects. The projects of users of the National Platform for Artificial Intelligence are also presented in this paper.

I. INTRODUCTION

Artificial intelligence is one of the popular topics today, but it is also becoming a part of our everyday life. What the very word "artificial" represents, in artificial intelligence itself, represents the very origin and way of creation in the beginning as a product of human invention and genius. Artificial intelligence is not a discipline that arose naturally, it was created by humans, observing natural processes in the desire to create systems that will imitate processes from nature. [1]

At the world level, there are several supercomputers that are applied in various aspects of research. One of the more famous supercomputers is the BlueGene/L Supercomputer. This supercomputer is a product of collaboration between IBM and The Lawrence Livermore National Laboratory as part of the United States Department of Energy ASCI Advanced Architecture Research Program. BlueGene/L Supercomputer represents a massive parallel system consisting of 65,536 nodes based on a new architecture that exploits system-on-a-chip technology to deliver target peak processing power of 360 teraFLOPS. This supercomputer was used in the period from 2004-2005. [2]

In 1985, the GF11 supercomputer model was presented. The GF11 supercomputer is a parallel supercomputer built by the Yorktown Research Center. This machine combines 576 floating-point processors arranged in a modified SIMD architecture. Each processor has space for 2 Mbytes of memory and is capable of 20 mFLOPS, giving the total machine a peak of 1,125 Gbytes of memory and 11.52 gFLOPS. [3]

Supercomputers have a wide range of applications in various areas of both the economy and other professions. One of the very common applications of supercomputers is in medical research. The group of authors [4] applied for the purpose of their research applied the supercomputer in Japan, "Fugaku", with the help of which they selected drugs for COVID-19 in order to prevent the spread of the pandemic. They used a computer simulation of 2128 potential drug candidates, where the Fugaku super computer selected 30 of the most effective and potential drugs to achieve the set goal. The Fugaku supercomputer reduced the calculation time from one year to ten days. [4]

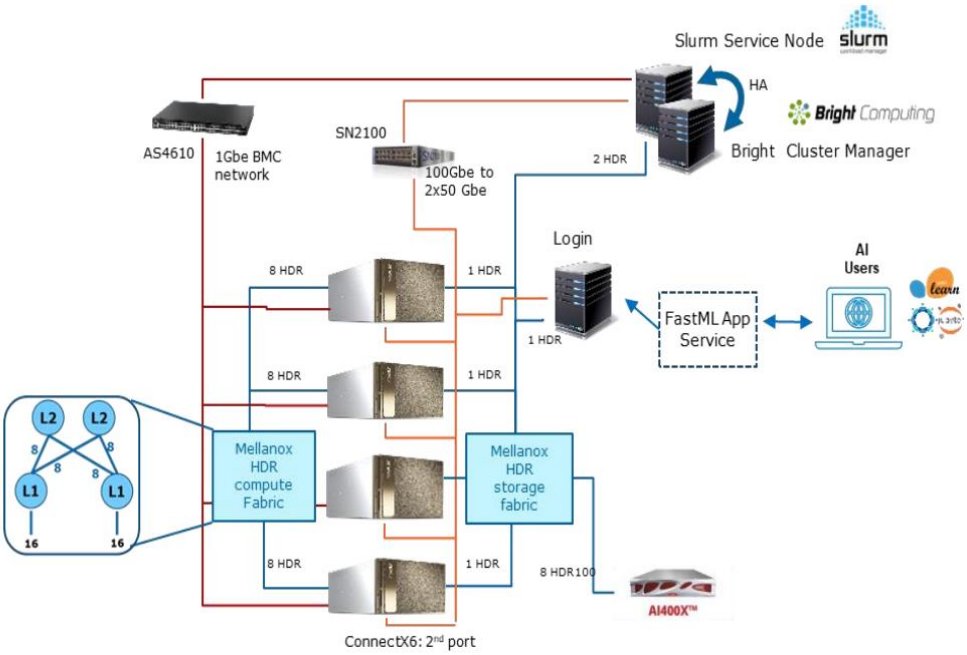
There are top five fatest supercomputer in the world. At the first place there is the „Frontire'' which is kept at the Oak Ridge National Laboratory in the USA. „Frontire'' has 8 699 904 cores, the computer clocked a Rmax Pflops of 1 194. This super computer need 22 703kW to run. On the second place is Supercomputer „Fugaku'' in Riken Center for Computational Science in Japan. „Fugaku'' has 7 630 848 cores and the computer clock Rmax Pflops of 442.01. On the third place is „Lumi''. This supercomputer is kept at EuroHPC/CSC in Finland. It has managed to secure an HPL score of 309.1 Pflops. The fourth place is „Leonardo'' and it is kept at EuroHPC/Cineca in Italy. This supercomputer noe boasts of an HPL score of 239 Pflops. On the fifth place is „IBM

Power System''. This sistem is placed at the Oak Ridge National Laboratory in the USA. „ IBM Power System'' has 2 414 592 cores, and it has registered an HPL score of 148.60 Pflops.[5]

II. THE NATIONAL PLATFORM FOR ARTIFICIAL INTELLIGENCE OF THE REPUBLIC OF SERBIA

In order to develop and apply artificial intelligence technology in the performance of public administration bodies, research work in the academic community and its institutions and the entire industry of the Republic of Serbia, as well as help startup companies in developing their products. The National Platform for Artificial Intelligence of the Republic of Serbia is located in the State Data Center in Kragujevac. The national platform for artificial intelligence of the Republic of Serbia is currently used by 32 institutions and 32 startups, totaling around 320 active users.

The National Artificial Intelligence Platform consists of four DGX-A100 nVIDIA servers with a total of 32 GPUs for multi-node DL and HPC simulation processing. It is a universal system for artificial intelligence computing tasks, from analytics to training and inference. This system sets a new standard for computing density by delivering 5 petaFLOPS in 6 U units, replacing legacy infrastructure silos with a single platform for any artificial intelligence computing task.



Picture 1- ***Architecture of The National Platform for Artificial Intelligence of the Republic of Serbia***

The NVIDIA DGX A100 represents the world's first AI system built on the NVIDIA A100 Tensor Core GPU. Integrating eight A100 graphics processors, the system provides acceleration and is optimized for NVIDIA CUDA-X software and the NVIDIA data center stack solution. NVIDIA A100 graphics processors bring new precision to the TF32. The A100 offers an additional two-fold increase in performance with just one additional line of code using FP16 precision. MIG splits a single NVIDIA A100 GPU into seven independent GPU instances. These instances run around the clock, each instance working with its own memory, cache and streaming multiprocessors. Since MIG fences off GPU instances, fault isolation is enabled, more specifically a problem in one instance will not affect others running on the same physical GPU. The NVIDIA DGX A100 features Mellanox ConnectX-6 VPI HDR InfiniBand/Ethernet network adapters with a maximum bidirectional bandwidth of 450 gigabytes per second. The DGX-A100 system enables working with training data sets up to 5AI PetaFlops.

Mellanox's Quantum InfiniBand switch provides up to forty ports with 200Gb/s of full bidirectional bandwidth. This switch enables the National Platform for Artificial Intelligence of the Republic of Serbia to compute in the network using the Co-Design Scalable Hierarchical Aggregation and Reduction Protocol topology.

The data storage solution is based on DDNs by A3I products. These products use DDN's EXAScaler software stack in a specific way to support AI tasks. EXAScaler is a comprehensive software stack based on a parallel file system. The storage solution is based on the Nvidia SuperPOD

reference architecture and is comparable to the system used by Nvidia at its own facilities in California. The build storage system is an AI400X with 24 x 7.68TB NVMe drives. The system runs four virtualized and combined Data- and MetaData servers that provide services to clients. This system forms a file system (unique if necessary) with more than 176TB of raw capacity (Raw storage) for data storage. The system can be scaled by adding more storage-blocks of the same specification to get more capacity and better performance. The data storage solution is based on DDNs by A3I products. These products use DDN's EXAScaler software stack in a specific way to support AI tasks. EXAScaler is a comprehensive software stack based on a parallel file system. The storage solution is based on the Nvidia SuperPOD reference architecture and is comparable to the system used by Nvidia at its own facilities in California. The build storage system is an AI400X with 24 x 7.68TB NVMe drives. The system runs four virtualized and combined Data- and MetaData servers that provide services to clients. This system forms a file system (unique if necessary) with more than 176TB of raw capacity (Raw storage) for data storage. The system can be scaled by adding more storage-blocks of the same specification to get more capacity and better performance.

- Data set management,
- A framework such as cycle management,
- Experiments, specifying the desired development environment or directly submitting your encapsulated application to the container image,
- Running various training models, advanced users can directly specify their containerized images if the desired runtime environment is not available,
- Pulling and comparing results with monitoring as a service (including tensorboard),
- JupiterLab as a service,
- Hyperparametric instrumentation to run multiple compute node cluster jobs in a single action.Svi čvorovi računanja, upravljanja i prijave uključeni u predloženo rešenje rade pod istom verzijom RedHat Enterprise Linux 8 (RHEL 8).

III. PROJECTS USING THE NATIONAL PLATFORM FOR ARTIFICIAL INTELLLIGENCE OF THE REPUBLIC OF SERBIA

The National Platform for Artificial Intelligence of the Republic of Serbia has visibly influenced the development of scientific achievements in various branches of research, production and economy.

The Institute for Artificial Intelligence of the Republic of Serbia created several different projects with the help of the platform. Of all the projects in this paper, we will highlight the work "Zero-and Few-Shot Machine Learning for Named Entity Recognition in Biomedical Texts.". Authors [6] are created solution for two problem for Named Entity Recognation in Biomedical Texts. Named entity recognation is an NLP that involves identifying and classifying named entities in text. The authors recognize two problems. The data for fine-tunning pre-trained LLMs is large and labeling is a time-consuming and expensive process that requires expert domain knowledge. Domains with an open set of classes yield difficulties in tradicional machine learning approches since the number of classes to predict needs to be pre-defined. Authors solution to the two metioned problems is based on data transformation for factorizing the initial multiple classification problem into a binaty one and applying crossencoder-based BERT architecture for zero and few-shot learning. To create dataset, they transformed six widely used biomedical datasets that contain various biomedical entities suach as genes, drugs, disseases, adverse events, chemicals into a uniform format.

The authors [7] from mathematical faculty from Belgrade proposea goodness-of-fit test that is tailored specifically for Student-t distibutions. Student-t distributions are extremely appealing for financial applications, the single major reason being that stylized facts of finansial assets indicate that the corresponding empirical distribution in lepokurtic relative to the normal distribution. They extend the method to a multivariate GARCH model and thereby test for Student-t distributions innovations. They present the corressponding asyomptotics. In they project authors showed the result of Monte Carlo study illustrating the finite-sample properties of the method.

Authors [8] from Faculty of Mining and Geology worked on many projects solwing language problems with artificial intelligence. One of them is creating a web services for named entities recognation, liking and mapping. This project was the lack of tools and resources for annotating, reseearching, and analyzing bilinqually aligned Italian-Serbian text. Also they created two system GPT2-Orao and GPT2-Vrabac. This two system can generate new text or continiue text input. This two systems have equal input support in Cyrillic and Latin. In addition to the above, the model was trained on other corpora of the Society for

Linguistic Resources and Technologies, including corpora of modern Serbian language: SrpKor2013 and SrpKor2021, as well as the PDRS 1.0 corpus developed by the Serbian Language Institute of Serbian Academy of Sciences and Arts. Both models were trainter on the National Platform for Artificial Intelligence of The Republic of Serbia.

IV. CONCLUSION

The national platform for artificial intelligence of the Republic of Serbia provides is accessable to all state institutions, startups and science and technology parks. Users of the platform have the opportunity to solve problems from different areas of economy and science with the help of artificial intelligence.

The projects that were created on the National Platform for Artificial Intelligence of the Republic of Serbia have become of great importance in scientific achievements, but also in the preservation of the Serbian language and literature.

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Attitudes of Teachers and Professional Associates on the Organization of School Work Using the Platform Microsoft Teams 365

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Abstract - It is the changing times that bring us new opportunities and possibilities. IT services and platforms have, in the crucial times of Covid-19 pandemics, made a digital transformation possible, as a priority task for not only today, but tomorrow as well. Every school that is striving for quality, must manage the changes and take up the challenges of the new times. In the times of COVID pandemics, from 2019 to 2020, Primary school "Dr Jovan Cvijic" in Zrenjanin started using Microsoft Teams 365 platform for online teaching to improve school processes and efficiency of school organization. After 2 years of using the platform, a research was conducted, based on the attitudes of teachers and school professional associates, and their opinion on the effects of the use of platform, both in the aspect of improving functioning of the school and the efficiency of school organization. The aim of the research was to pinpoint the problems with use and map new opportunities by improvement of quality and scope of the use. Analysis of the school maturity stage was the very starting point for introduction of this innovative approach, to use of IT platform. Research results confirm the hypothesis of the research that teachers think this platform helps with the school organization in every aspect. Some teachers have proposed new examples for the implementation of platform capabilities in the school.

I. INTRODUCTION

In today's digital age, educational institutions are under increasing pressure to modernize their working methods and approaches to learning. The Covid-19 pandemic has further accelerated the process of digitalization of education and introduced new challenges in the organization of schoolwork. Schools become communities of active learning and intellectual adventures, enabling students in the new circumstances to solve problems in new ways, and to reach highest peaks of success and self-realization, by taking small and safe steps.

Continuous professional development of teachers is very important in this process, especially the development of digital teachers' competencies. Finding a unique path to realize the vision of the future is a real challenge of education, in a new environment and circumstances.

This research we did proved Microsoft Office 365 platform, and its component Microsoft Teams, to be a good choice for facilitating distance teaching, and to have helped significantly in realization of innovative solutions for organization of schoolwork.

A. Basic Notions

Improvement of a system is the aim of the set of modernization goals. For an organization to thrive and be successful, it must promote culture of creativity and must be ready for continuous professional development and progress. Human resources are the most valuable driving force of innovation in organizations. All employees are part of a team that will use its strength derived to overcome all the challenges of everyday life, with the joint commitment.

The goal of each organization is to achieve quality in its own branch of work, and to create a recognizable positive organizational image [1]. For these reasons, the modern school must be an experimental lab that experiments daily looking for new, better and more efficient work modalities.

Information is in the core of the truly organized system. The Internet has provided us with the availability of information that can be acquired very quickly – this is now essential for everyday communication and work. Searching for information, gathering, storing, and using it, as well as producing new information, are activities that require constant internet availability from different locations. Modern information technologies enable faster, simpler, and better digital information management. Modelling an effective modern organization as a unique coherent

system can be established through implementation of information system for that organization. If the information system is well implemented and used, the organization can expect benefits in increasing efficiency and improving the quality of work.

Challenge of time has brought us new opportunities, with availability of new information and communication technologies – IT helps save the time while offering multiple communication channels between people. Electronic services and platforms have emerged at the crucial moment of the pandemic and made digital transformation a priority for both current moment and the future.

During pandemic, Ministry of Education Republic of Serbia has created a plan for the realization of educational work in these difficult conditions, with the goal to help deliver the compulsory education to children in K12 education system. Ministry offered to schools: online platforms, other online tools for distance learning and variety of online learning resources. Microsoft made available for Serbian schools Microsoft Office 365 platform, with collaboration tool Microsoft Teams. Platform was specially adapted for education. Microsoft also offered training for the use of Teams and Office 365 platform, in cooperation with the Ministry of Education, to all teachers in k12 education. Microsoft Teams offers teaching in both synchronous and asynchronous modalities, as well as sharing educational content related to the online classes, and grading of students and automatic grade reports etc.

The reference [2] promotes the framework of digital competences of teachers, by classifying them into six categories as per competences needed for the successful online teaching.

The key to the success of any organization in modern times is the quality of employee education, as well as the ability of employees to behave responsibly about their own professional development [3]. The Ministry of Education Republic of Serbia recognized the role and importance of digital technologies for the improvement of the education system, and role of its employees. An important document for Serbian education is the Framework of the Digital Competences of Teachers. This document serves as the base for the Serbian Strategy for the Development of Education, and acts as a roadmap on the path of digital education and professional development of teachers.

"Digital competences are set of knowledge, skills, attitudes, abilities and strategies necessary for a teacher to acquire, so he/she can use ICT and digital media to improve teaching process (as well as other school processes related to teaching profession), in a flexible and safe way, both online and offline." [15]

B. Related Works

The application of new online platforms for the online teaching in extraordinary conditions has already been the subject of research by many experts. Many of those research works concluded that online platforms are very useful when implemented in education, but that it takes careful planning and implementation to get the desired results. It is of utmost importance to establish a balance between online and direct teaching.

Reference [4] considers the views of teachers and professional school associates from six universities from Serbia, Slovenia and Croatia. Its conclusion is that the use of online platform contributes to faster communication, better access to teaching materials and better peer cooperation.

University students like using information and communication technologies for learning, and they know how they can work with them well, as concluded in reference [5].

Research [6] is about the use of interactive platforms for creating virtual environments and its use in online teaching. Conclusion of this research is that there are both positive and negative sides to it. Also, this research points out that social changes we are going through, and other circumstances, will make online teaching even more important in the future education, anywhere in the world. Also, this research states that new technologies and teaching methods have improved the role of teachers in the teaching process, and also, that teacher education about creating teaching content with new technologies should be of utmost priority.

School administrative processes can be, by applying the platform, made more efficient and transparent. The benefits of using such platforms in this way are: having electronic records, enabling online communication, planning and organization, being able to have financial and resource management in a digital way, and having digital archive of documentation.

It is almost impossible to do proper school management, especially its modernization, without different document models, including models for school's planning, instructional planning documents, documentation for school evaluation etc. [7].The research and analysis of school needs, as factors of modeling of efficient school organization and its work, indicates that each school's organization should modeled per its needs, and only than planning and structuring of different elements that answer this needs should be done, finally connecting

them together into unique system that is maximally efficient and coherent [8].

The organizational structure of the school is a unique system that, along with its synergistic effects, contributes to the efficiency of work [9].

The success of project-oriented organization in a dynamic business environment is dependent on the use of software tools that are supporting project management [10].

The legal framework for the work organization of employees in the online environment also acknowledges new circumstances and the use of new technologies as an important segment for the continuous development of employees [11].

C. Normative aspects

There is a strategic and legal framework of documents in the Republic of Serbia that regulates and promotes use of ICT in school processes and in

In the Standards of Competences for the Principals of Education Institutions, as a legal document, in the section dedicated to school development and quality assurance, defines an important indicator. This indicator states about promotion of continuous innovation in school and encouragement of teachers and school professional associates, to use modern methods and modern technologies in work [12]. School must continuously measure state of this indicator.

The Normative of Duration of Work with Students for Teachers and Professional School Associates regulates the teaching time (this legal document also covers time normative of school professional associates) and defines other tasks of teachers within their working time in school e.g. keeping school documentation and contributing to the work in school's professional bodies [13].

The Standards of Quality for Schools, in the chapter 5.5. for standard related to school ethos, define school as a center of innovation and educational excellence. "The school is a center of innovation and educational excellence in the wider and narrower local and professional community as the result of the established system of teamwork and partnerships are examples of good practice" [14].

The Strategy for the Development of Education in Serbia until 2023 defines the framework of digital competences of teachers, with the final goal of its formulation, to enable the use of digital technologies to enhance innovation and improve the quality of education [15].

The Framework for the Digital Competences of Teachers in the Republic of Serbia defines a set of knowledge, skills, attitudes, abilities and strategies that teacher should have in order to be able use information and communication technologies and digital media for the improvement of the teaching and learning process, as well as for the other activities related to the teaching profession. Definition of the professional development of employees in the online environment, in that document, states that "the teacher uses digital technologies for the collaboration with his/ her school colleagues to exchange information, teaching materials or for the work on the projects." [14]

D. Research Subjects

The starting point for the implementation of the project was self-assessment of digital competences of school's teachers ("Selfie" project [17]).

The research of digital competences of teachers in elementary school "Dr Jovan Cvijic" in Zrenjanin was based on the Framework of Digital Competences of Teachers. We highlight as this initial research results: that 43.8% of respondents know how to define search keywords through internet search engines, 14.6% use advanced search techniques in order to find digital teaching content, 58.3% of teachers knows how to use new digital content of various formats (including multimedia content), 56.3% of respondents participate in the development programs through professional online networks independently finding information and resources for their own professional development, while 10.4% use digital technologies to create themselves and deliver trainings that contribute to the development of pedagogical and digital competences of employees in education. [16]

The research presented in this paper followed this initial research. The research presented in this paper analysed the experiences of teachers and professional school associates of the Elementary School "Dr Jovan Cvijić" in Zrenjanin with implementation of Microsoft Office 365 platform for the organization of school work and use of its component Microsoft Teams for the teaching and support of teacher communication and sharing of documents.

Research problem: Has Microsoft Office 365 online platform enabled more efficient and functional organization of schoolwork?

The subject of the research are the views of teachers and professional school associates of elementary school "Dr Jovan Cvijic" Zrenjanin, about the organization of schoolwork using the Microsoft Office 365 platform.

Research goal was to determine the attitudes of teachers and professional school associates on the

subject of the school efficiency and enhanced school work organization by the use of the Microsoft Office 365 online platform. The end goal of the research was to identify the problems and possible new improvement opportunities.

In line with the research goal, the following tasks were defined:

Determining the frequency and the way that teachers use to access Microsoft Office 365 services

- Determining the time invested into accessing information on the Microsoft Office 365 platform
- Research teachers' attitudes on the availability of information relevant for the work and organization of the school on the platform
- Research teacher satisfaction with the simplicity and ease of use of the data and documents uploaded to the platform
- Research attitudes of teachers and professional school associates related to the impact of the platform on communication and cooperation in the school

II. MATEIALS AND METHODS

A. Population and Research Sample

The research is comprehensive, as it included all the representatives of the population consisting of primary school teachers, subject teachers and professional school associates, employees of the primary school "Dr Jovan Cvijić". School has 52 teachers and school professional associates. 50 of them were covered with the research. Out of the total number of respondents, there are 41 female respondents (82%) and 9 male respondents (18%). Stratification of respondents by the job role: 30 teachers specialized in teaching distinct subjects in age groups from K5 to K8 (60%), 17 teachers teach all the subjects in the age group from K0 to K4 (34%) and there are three professional school associates (6%).

The largest number of respondents 29 (58%) completed undergraduate studies at the university, 12 respondents completed master studies (24%), 6 respondents completed higher school (12%), 1 respondent completed specialist academic studies (2%), 1 respondent completed magisterium studies (2%) and one is with the PhD (2%).

Regarding professional experience, structure of respondents is as follows: the largest group of respondents has from 21 to 30 years of service (34%), followed with 15 respondents group with 11 to 20 years of service (30%).

Work engagement data for the respondents: 44% of respondents have a full norm, 20% of respondents are engaged with more than the full norm, 18% of respondents have a norm in the range from 40% to 69%, 7 respondents have a norm in the range from 10% to 39%, while only 4% of respondents have a norm in the range from 70% to 99%.

Of the total number of respondents, 35 persons (70%) are employed exclusively in primary school "Dr Jovan Cvijic", while 15 colleagues (30%) are employed in more than one school.

The research was carried out in three phases and lasted from October 2022 to April 2023.

B. Research methods, techniques, and instruments

The views of teachers and professional school associates were researched by a questionnaire containing 12 questions, according to the research hypotheses.

The research questionnaire consists of standardized questions or claims that examine the specific opinions and attitudes of respondents in the field of work organization, mutually related. A combined questionnaire was created for the purpose of this research, which is structured according to the established propositions. This instrument evaluated views of respondents on the use of the Microsoft Office 365 online platform for the organization of schoolwork. Out of a total of twelve questions, ten question types were with closed type answers (six of them with binary answers), one was with the open answer type, and one was with ranking per Likert's four-stage scale.

The questions in the Questionnaire[1] are grouped into themes according to defined research hypotheses. Each group of questions contains questions related to examining the attitudes and opinions of respondents on the themes: the method and frequency of the access to the platform (4 questions), the time spent (3 questions), the availability of information (3 questions), the simplicity and transparency of the platform (one question), communication and cooperation of respondents through the platform (one question).

The results of the research are processed in both quantitative and qualitative way. Quantitative data processing is based on mathematical and statistical indicators, enabling precise quantification of data with accurate and objective formulation of results.

Analysis and interpretation of data is based descriptive statistics, done by applying counting methods in data analysis (absolute and relative

[1] The questionnaire form is available on request, please send an email to the first author.

frequencies). Descriptive statistics enables disambiguation and description of data sets based on statistical measures, which directly enables precise conclusions.

For determining the linear relationship between different variables, as per Pearson correlation coefficient, the SPSS (Statistical Package for the Social Sciences) program was used.

III. Results and Discusion

The conducted research examines the attitudes of teachers and professional associates of elementary school "Dr Jovan Cvijic" in Zrenjanin about the organization of schoolwork by applying the Microsoft Office 365 platform. The aspects of the use of the platform that were represented in the survey and which effects were studied were: the manner and frequency of access to the platform, the time spent, the availability of information, the simplicity and visibility of the platform, communication and cooperation of respondents through the Microsoft Teams platform.

Statistical processing and analysis of data obtained by the research confirmed following facts:

- The Microsoft Teams app is installed by teachers and professionals on the computer they use at school, as well as on the computer they use at home. As many as 94% of respondents independently access the platform several times a month or several times a week depending on the jobs defined by the 40-hours long work week. 88% of respondents confirmed that they use the platform more often than documentation in paper form. **Teachers and professional school associates access the Microsoft Office 365 platform and Microsoft Teams application often and without effort.**
- Accessing information through the platform takes much less time than when information was only available in print, 90% of respondents confirmed. 98% of respondents confirmed that the platform provides flexible access to documents in regard to timing (they can access the documents when they have time to do it, according to their own time schedules). The availability of documentation for respondents even at the time they are not physically at school, being the special gain, was pointed out and confirmed by as many as 90% of respondents. **The use of platform brought maximum time savings.**
- More than 94% of respondents confirm the fact that complete school documentation is available on the platform, as well as legal documents regarding schoolwork regulations and laws. Only 4% of respondents believe that in order to have more efficient and functional organization of schoolwork, the following should be also available on the platform: announcement board, class schedules etc., while the other 96% of respondents did not have any suggestions believing that everything necessary is already available on the platform. **Information relevant to the schoolwork and its organization is available to employees.**
- Microsoft Office 365 platform provides a comfortable and easy way to download documents and information, both on a computer/laptop and on mobile devices, making easier communication between users. As many as 90% of respondents confirmed that documents are classified by folders in good manner, and as many as 92% of respondents confirmed that the folders are named according to the content, and that the documents are chronologically and neatly sorted according to school years. **The information and documents are logically organized and easy to download and use.**
- The Microsoft Office 365 platform facilitates communication, collaboration, and efficiency of work within an organization, offering an integrated environment for team collaboration and coordination of activities. Some of the resources and tools: messaging, direct communication between team members, holding videoconferencing meetings and presentations, sharing a document, working together on the same documentation, archiving, and storing documentation, and more. **By using the Microsoft Office 365 platform, and its tool Microsoft Teams, communication within the school is simplified.**

IV. Conclusion

The introduction of innovative modern solutions is valid only when they can become practically applicable work systems, with guidelines for the use attached to them. "*The main goal of school changes is to encourage the work motivation, which directly affects the professional and personal satisfaction of employees, due to efficiency, productivity and functionality.*"

Respondents believe that the use of the platform facilitates the organization of schoolwork in all aspects, regardless of the respondents' sex, seniority and work experience, whether they work in one or more schools, as well as other independent variables.

The Microsoft Office 365 platform, and its collaboration tool Teams, are an important tool for

collaboration and communication of teams within the school, as well as for the organization of school documentation and educational materials. In the process of implementation multiple professional trainings of school employees for the proper use of the platform and for ensuring data security were conducted, and this improvement of teacher competencies is another benefit of this modernization project. To additionally improve the quality of schoolwork, a School Action Plan was created, with following action items:

- To implement of improvement proposals obtained through research.
- To start using the Microsoft Teams calendar for marking the dates (as per School's Annual Work Plan).
- To organize lectures on the use of new tools and applications accessible through the Microsoft Teams platform.
- To organize school team meetings through videoconferencing calls.
- To start the teamwork on creating School Documentation Repositorium using SharePoint.
- To present the examples of good practice on the meetings of Primary Schools principals.
- To present the good practice examples at the webinars organized by the Teachers' Union of the Republic of Serbia or the Association of School Principals of Serbia.
- To use Microsoft Teams in cooperation with primary school in Slovenia, while conducting activities in the Erasmus + project.
- To measure the success of school work organization by
- applying the Action Plan.

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Discipline of Students - the Problem of Modern Education

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Abstract - The twenty-first century brought many reforms, including the reform of the school system. The indiscipline of students that has been present for decades is coming to a climax. Children's rights and forgotten obligations are one of the key arguments used to justify the illegal behavior of students. Often times, the teaching staff's hands are tied and inappropriate behavior is justified by the fact that the school has lost its educational role. This research covers the school administrations of Belgrade and Niš. Views on this problem of all actors of the educational process were analyzed: students, teachers and parents. The research provides causes, ways of responding and determines some of the possibilities for overcoming the problem of student indiscipline.

I. INTRODUCTION

In this paper, we analyze the models and strategies of class discipline, that is, the characteristics of the beliefs of modern theories of education, but we also analyze the opinion of teachers about the process of establishing and maintaining class discipline and the disciplinary procedures that teachers apply in classes, considering their causes and consequences. The second item is students. The survey that was conducted among the students of several elementary and secondary schools in Belgrade and Niš is analyzed. The third item is the parents' view of the causes of student indiscipline.

The goal of the research was to determine the expressiveness of models and strategies for establishing and maintaining class discipline and their correlates (interconnection of models and strategies, as well as their connection with: the educational concept of the teacher, the degree of satisfaction of the teacher's need for autonomy in school, demographically and professional characteristics of the teacher). [1]

This research led to the conclusion that a necessary part of the teacher's professional development is awareness of personal beliefs about class discipline and continuous monitoring and self-evaluation of one's own work. Based on the results, it is necessary to adapt the teaching process to the needs of students and society as a whole.

For decades, we have been looking at student indiscipline, both in and out of school, as a significant pedagogical and sociological problem for which concern is expressed not only by students' parents and teachers, but by everyone who analyzes pedagogical and social reality. In school practice, the problem of (in)discipline is already an everyday problem. [2] Issues related to the establishment and maintenance of discipline in the school deserve special attention. [3] Classroom discipline is increasingly highlighted as an essential issue for all other classroom issues. This is something that makes or breaks teachers. [4]

II. TEACHER - STUDENT RELATIONSHIP

Authors of sociocentric conceptions of education clearly point to the importance and necessity of looking at education in the social context, respecting its socio-historical conditioning. They share the belief that school is society (state) in miniature and that it is an important (key) institution for the maintenance and progress of society. Natorp emphasized the necessity of school education in the service of the community. He does not deny Rousseau's position that a man should be a man, not a citizen, but complements it with the words that he should really become a citizen, i.e. community service member.[5] A well-organized school can contribute to this to the greatest extent, where the individual learns to adapt to the general organization and faithfully perform his duty. Her role is to immerse students in the social order. [5] In school, you learn to force yourself to do what is necessary. Durkheim also understood school as a social microcosm, and school life as the germ of social life. He wrote that everything that goes into education is taken from society, has the same

character and necessarily reflects that society. In the school, as in the city, there is one discipline. The rules that determine the student's tasks can be compared to the rules that prescribe his behavior to an adult. The penalties and rewards associated with these rules are quite similar to the penalties and rewards sanctioned by others. [6] The development of each child is to a certain extent determined by the coincidence of inheritance, belonging to a social class, place of residence, but from the pedagogical point of view, it depends to the greatest extent on the profession he will engage in, for which he is preparing.

Education has a significant role in social differentiation. Therefore, the state must necessarily monopolize teaching, that is, school education must be subject to its control. [6]

III. STUDENT INDISCIPLINE - A PROBLEM OF MODERN SOCIETY

It is not necessary to emphasize that the problems of discipline in the school caused a lot of headaches for all pedagogues throughout history. Disciplined behavior of students in class and at school is behavior that is in accordance, that is, does not deviate from the rules and regulations on the work and behavior of students at school. Discipline problems can be considered from several aspects. There is an important difference between traditional and modern discipline. Traditional discipline, which is characteristic of the "old school", was based on blind obedience, fear and authority of the teacher. It corresponded to and was a necessary prerequisite for lecture-examination classes, in which the student passively listened to and memorized the professor's presentations, possibly demonstrating on the school board. In the traditional sense, discipline in school referred to the control of behavior that was introduced from the outside. Thus, the internal effects of discipline were imposition and obedience. Today, the discipline is treated significantly differently. Students are active and self-initiative in the teaching process, so the discipline has become more flexible, and more suitable to the very nature of young people. Educational work today is not a discipline based on fear, but a discipline in which order and a working atmosphere reign, which at the same time enables dialogue with the professor and individual students, seeking additional explanations, freely expressing opinions and defending one's own views, using literature, and so on. further. Therefore, "positive" discipline is - ruling over one's own will, feelings and inclinations in order to achieve something in a positive sense. Rule over something is strict, but here we have an addition - in order to achieve something. The issue of student discipline is particularly delicate in secondary schools, among other things, for the simple reason that secondary school pupils are in a very sensitive period of their lives - adolescence. We know that in that period there is an increased tendency to deviant behavior, especially in boys, due to the increased secretion of testosterone, compared to the pre-puberty period, which is proven to promote aggression. When we bear in mind that adolescence is a period of personality development and growth, as well as that this period marks the transition from childhood to the world of adults and usually lasts from fifteen to twenty years of age, we can state that all the difficulties that accompany that period can be reflected in behavior students and lead to undesirable forms of student behavior. [1]

Discipline should not be intimidating, it should have a strong positive teaching function. It should help the student develop self-control, and a judicious degree of conformity. The basic functions of discipline consist in teaching and helping students to discipline themselves as successfully as possible. Along the way, disciplining inevitably involves various conflicts. Further difficulties arise when it is borne in mind that discipline should ensure the optimum development of students. When you add to that the contexts of a democratic society, which are increasingly complicated in interpersonal relations, then you get a picture of the difficulties that arise when you try to make student discipline grow into self-discipline. Discipline is necessary for the school to function as a community, the only question is what kind of discipline and by what means it is achieved. An authoritarian or totalitarian discipline is one where goals, rules of conduct and sanctions are determined exclusively by an authority, be it an individual, group or institution. The student has no role to play. He is only expected to be calm, quiet and obedient. Discipline here becomes an end in itself, achieved at the cost of the students' basic needs. The consequences can be: fear, apathy, insecurity, impaired self-confidence. Democratic discipline implies the equal involvement of all members of the community in deciding on goals, rights and sanctions. This means that students are actively and responsibly involved in the important issues of school life, which enables them to develop the ability to make realistic decisions and make the right choices, and to develop self-control. Discipline is one of the pillars of good teaching. If that pillar keeps breaking, the building of good teaching collapses. [1]

Real, pedagogically valuable, is conscious and working discipline, which is complete when it grows into self-discipline, which means without external pressures. The path to conscious and working discipline is long, complex and not always certain. It starts in the family and continues in the school. [1]

IV. RESEARCH METHODOLOGY

The subject of this research is determining the key causes of student indiscipline and ways to prevent them. As part of the research, the aim was to check the subjective judgments of teachers (beliefs, attitudes, values, assessments, opinion) and their connection with behavior. This connection is not simple and unequivocal. Teacher's beliefs include willingness to behave, so they influence actions, which does not mean that beliefs and behavior are always and completely aligned. When deciding how to proceed in class, teachers rely on previous experiences and their own way of looking at problems. [7]

Given that teachers in their practical work act primarily on the basis of, more or less consciously, personal beliefs and attitudes about the educational process, the teacher's understanding of the importance, success and possibility of applying certain disciplinary procedures largely depends on the teacher's views on basic pedagogical problems. Teachers' beliefs about basic pedagogical issues (what is the child's nature, what is the goal of education, how do students learn, what motivates their behavior...) are socially constructed and cannot be viewed independently of the broader social context in which teachers live and work.

A. Objectives of the research

The main goal of the research is to determine the main causes of student indiscipline. In addition to the main goal, specific goals were also expressed:

-Strategy for establishing and maintaining class discipline.

- Consideration of differences in views on indiscipline from the point of view of teachers, students, and parents.

B. Research tasks

Based on an open-ended survey, determine what are the key causes of student indiscipline, how teachers react, and how to prevent indiscipline.

Forming a survey with offered answers based on the first survey and analyzing the results obtained on a large sample.

C. Population and sample

Students, parents and teachers of several primary and secondary schools participate in the research. The students are aged from fifth to eighth grade of elementary school and from first to fourth grade of high school. In the research, care was taken to ensure that the number of respondents was as large as possible in order to obtain the most relevant results. Since it is an online questionnaire, user confirmation was used to prevent multiple questionnaires from being sent from the same address. Also, the students filled out the questionnaires in the computer science classes. They were distributed to parents through class teachers, and teachers received them through the textbook user mailing list.

This research included 147 teachers, 1583 students and 2120 parents.

D. Hypotheses

We assume that the classroom discipline models and strategies used by teachers are related and reflect their educational concepts and personal sense of autonomy in school. In the most general sense, it can be assumed that a certain connection between the educational concept of teachers and models and strategies of class discipline will be shown, as well as the connection of their beliefs about the degree of their own autonomy in school with models and strategies of class discipline. Also, we assume that teachers who feel a low degree of their own autonomy in school apply controlling type classroom discipline strategies.

We expect that the main cause of indiscipline is the inappropriateness of the material, the lack of interest of the teachers and the poor equipment of the schools. In addition to this, we will also examine the point of view of parents, where we expect the teacher's guilt, poorly prepared classes and low motivation to work with children as the main cause of indiscipline.

Therefore, we expect empirical confirmation of the hypothesis that to a certain extent there is a connection between the models and strategies of class discipline that teachers apply, as well as their connection with the educational concept of teachers and their experience of the degree of their own autonomy in school. We expect confirmation of stereotyped and entrenched notions about school and student indiscipline.

E. Research technique and instrument

The technique used to conduct this research is surveying, and the basic research instrument is a survey.

The research was conducted in two stages, first a printed survey questionnaire was distributed, and then a second closed-type survey was formed based on the analysis of that questionnaire, which was assigned to respondents via the Internet. For the second survey, the software application Google questionnaires was used.

The second part of the research was conducted on a much larger sample than the first due to the use of software tools, both for distributing the questionnaire and for analysis and processing. The survey that was used in the second part of the research was formed by first processing a test survey with an open response model each respondent could independently enter the answer to the question. The sample on the basis of which the survey was formed for the second part of the research is 15 teachers, 20 students and 10 parents, so 45 respondents. In this first step, no distinction was made between the respondents. Based on the open question of the first survey, we arrive at three groups of questions.

The first group consists of causes:

1. Unadapted curriculum

2. Bad working conditions at school

3. Inadequate punishment of offenders

4. The desire to stand out, to be a leader

5. Bad social examples

The options offered within each question for the first group of questions were:

- Very influential

- It affects

- It doesn't affect

- It doesn't affect one bit

The second group consists of teachers' reactions:

1. They do not react to indiscipline

2. Warning without registration

3. Enter in the work diary

4. They question and by questioning they bring order to the class

The options offered within each question for the second group of questions were:

- He always reacts in the specified way

- He mostly reacts in the mentioned way

- Mostly it doesn't react in the specified way

- It does not react in the specified way

The third group consists of ways to eliminate student indiscipline

1. Increasing sanctions against criminals

2. Using different methods and forms of work

3. Forming groups of students according to their intellectual abilities and adjusting the scope of the material to the group

The options offered within each question for the third group of questions were:

- Completely eliminate indiscipline

- Partially eliminate indiscipline

- It almost won't eliminate indiscipline

- It will not eliminate indiscipline

The survey was formed by sending these questions in the form of an online questionnaire to students, teachers and parents of several elementary and secondary schools in Belgrade and Niš. A four-point scale was introduced for each question in order to avoid the golden mean effect.

V. ANALYSIS OF RESULTS

A look at the results of the survey shows agreement and disagreement in opinions between different groups of respondents.

The first group of questions:

What are the causes of student indiscipline?

By considering the main causes of indiscipline, we see that the students emphasize the desire for leadership in the first place, followed by inadequate punishment, and in the third place are inadequate conditions at school. With teachers, the picture is somewhat different, for them, bad social examples are in the first place, inadequate punishment is in the second place, and the desire for leadership is in the third place. The parental image can be characterized as the key cause of their indiscipline being bad social examples, then an unsuitable curriculum and inadequate punishment of students.

Here we see that the elders emphasize bad role models first, and the students emphasize the desire

for leadership. From this, it can be concluded that the main cause of student indiscipline is the desire for leadership guided by bad role models.

Another group of questions:

How does the teacher react to indiscipline?

Within the first question, it can be concluded that students and parents do not see the teachers' reaction to indiscipline or it is absent, and on the other hand, teachers say that they react to forms of indiscipline. This discrepancy should be discussed separately in a separate paper. Examine all aspects of the reaction.

Analyzing the second question, we can conclude that when teachers react, they usually draw the students' attention to the transgression with a warning.

Students, parents and teachers are almost unanimous that teachers do not write students in the work diary, or do so very rarely. The conclusion can be drawn from this that this is one of the key reasons for the absence of disciplinary procedures and adequate punishment of offenders.

In the fourth question, we get a picture symmetrical to the picture in the first question, with the fact that here we have the opinion of parents and students who think that teachers solve the problem of indiscipline with strictness and grades, and on the other hand, there is the opinion of teachers who think that student indiscipline does not affect the grade.

The third group of questions:

How will indiscipline in classes be suppressed?

For all three offered questions, we have the agreement of all three groups that each offered model would significantly contribute to the increase of discipline in the class.

VI. CONCLUSION

The teaching profession is one of the most emotionally demanding professions. Experienced emotions, as well as the way teachers regulate their emotions, can affect the teacher in every way, on job satisfaction, personal life and work. Consequently, student indiscipline is one of the key problems that every teacher must deal with and must not turn a blind eye to. In this paper, only introductory research has been carried out, and each topic could be carried out in an unrelated exhaustive research. The key results were commented on, but there were no more detailed discussions.

Based on the analysis of the results of this research, we have come to new knowledge. It is possible to express them succinctly through the belief that based on the characteristics of teachers' beliefs about education and class discipline, to a certain extent, their behavior in maintaining discipline in the class can be explained and predicted, i.e. the strategies they apply. Teachers' beliefs are rationally and experimentally based and subject to change, which opens up space for movement from controlling teaching practices (in the field of class discipline) to those related to supporting student autonomy in class. It is necessary to provide them with support to reconsider their personal beliefs, to think about different perspectives, which will allow them to understand the essence of the problem of student indiscipline. In addition to this, parents should be educated so that they understand the real causes of student indiscipline.

Whichever model of preventing student indiscipline we choose, we must respect the integrity and personality of students, and in order to achieve the basic learning outcome - knowledge.

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Importance of Application of Standards and Procedures of Work Plans Quality Assurance for Teaching Process Quality

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Abstract - This paper provides an overview and analyzes the significance of the application of the quality standards of teaching coursework plans, as well as the quality assurance procedures thereof, on the selected example of a university of vocational studies. It was assumed that through the quality assurance system, i.e. through the Rulebook on Standards and Procedures for Ensuring and Improving the Quality of Work, Self-evaluation, of the Technical College of Applied Studies in Zrenjanin and Self-evaluation of Study Programs; prescribe standards and procedures for ensuring the quality of work plans on teaching courses. The application of the standardization of work plans ensures the specified quality of the realization of teaching courses and, consequently, the quality of the teaching process in the accredited study program. Control of the implementation of work plans and prevention of their deviation from the accredited Teaching Course Specifications enables: ensuring the planned quality of the accredited study program during one accreditation cycle; and provides insight into the data for possible minor changes to the study program (for its improvement) or its re-accreditation in the next cycle.

I. INTRODUCTION

Standardization of the quality of higher education work on the territory of the Republic of Serbia, and especially in the sphere of quality assurance on accredited study programs (of all study levels), is regulated by the basic principles of the Law on Higher Education [1] and results in harmonization with the European system of higher education. To ensure and improve quality, all higher education institutions, and thus also higher schools of applied studies, are subject to external quality control and subsequent accreditation [1]. The verification of the fulfillment of quality requirements is carried out by the act on standards and the procedure for external quality control, as well as with the acts on the accreditation of institutions and study programs. [1,2,3,4].

The teaching process represents a vital and imperative segment of the work of higher education institutions and takes place exclusively in accredited study programs. The internal standards for ensuring and improving the quality of the teaching process in the study programs of higher schools of applied studies are prescribed by the Statute [5], general acts of the institution, that is, by the comprehensive internal system of quality assurance [6].

The quality standards of the teaching process aim to improve, objectify, and harmonize the overall teaching process in higher schools of applied studies with EU standards [7,8].

The quality of the teaching process in higher schools of applied studies is ensured through the following activities [7]:

- adoption and observance of work plans for each teaching course and work plans for study programs;
- the interactivity of teaching;
- professional work of teaching staff;
- a correct and open attitude towards students;
- understanding and understanding the needs of students;
- respecting different learning styles;
- regular monitoring and evaluation of the work of students during classes.

The quality assurance standards and procedures of the teaching process include the quality assurance standards and procedures of the following segments [7]:

- classes;
- work plans for each teaching course and a summary work plan for the associated study program;

- assessment.

This paper provides an overview and analyzes the significance of the application of the quality standards of teaching coursework plans, as well as the quality assurance procedures thereof, on the selected example of a university of vocational studies. It was assumed that through the quality assurance system, i.e. through the Rulebook on Standards and Procedures for Ensuring and Improving the Quality of Work, Self-evaluation, of the Technical College of Applied Studies in Zrenjanin and Self-evaluation of Study Programs; prescribe standards and procedures for ensuring the quality of work plans on teaching courses. The application of the standardization of work plans ensures the specified quality of the realization of teaching courses and, consequently, the quality of the teaching process in the accredited study program.

II. QUALITY STANDARDS OF WORK PLANS FOR TEACHING COURSES

Within Standard 5 - Standards and Procedures for Ensuring the Quality of the Teaching Process, which is an integral part of the Rulebook on Standards and Procedures for Ensuring and Improving the Quality of Work, Self-evaluation, of the Technical College of Applied Sciences in Zrenjanin and Self-evaluation of Study Programs [7], the standards are prescribed the quality of work plans for all teaching courses.

The observed higher school of applied studies provides a work plan for each teaching course [7] in the following ways:

- documentation for accreditation;
- work plan for study programs;
- informing the students by the teacher at the beginning of the implementation of the course in each school year.

Teaching in all courses is carried out exclusively by the work plan [7].

The work plan for each course has prescribed content, structure, and form [7].

A. Content of the work plan

The main purpose of the work plan is to inform students about the subject, and forms of teaching, as well as the way of monitoring and evaluating the work of students in the teaching course [7].

The work plan for each teaching course contains the following information [7]:

- name of the course;
- status and type of the course;
- the credit value of the course expressed in the ESPB;
- names of teachers and teaching assistants;
- prerequisites for enrolling in the course;
- goal and outcome of the course;
- a brief description of the content and structure of the course;
- teaching plan;
- literature;
- the maximum number of points that each form of pre-examination obligation brings;
- the minimum number of points necessary to fulfill the pre-exam obligations as a condition for taking the exam;
- the ratio of points obtained in the pre-exam obligations and the final exam in the structure of the student's overall grade in the course.

Forms of students' pre-exam activities, which are evaluated, can be [7]:

- active participation of students in the work of classes - participation of students in discussions, analysis of cases, creation of tasks and other forms of work during lectures, exercises, and other forms of work;
- independent individual work of students outside of class - an independent project or seminar work that is presented in one of the forms of teaching;
- independent group work of students - implementation of a group project, group seminar work, or presentations;
- participation in forms of knowledge testing in classes - colloquium, solving tasks, testing, etc.

The specific forms of pre-exam activities must be determined so that their fulfillment is a function of mastering the course [7].

B. Structure and form of the work plan

The structure, form, and visual appearance of the work plan are prescribed by the Instructions for the Preparation of the Work Plan, which is an integral part of the Rulebook on Standards and Procedures

for Ensuring and Improving the Quality of Work, Self-evaluation, of the Technical College of Applied Sciences in Zrenjanin and Self-evaluation of Study Programs [7].

III. PROCEDURES FOR QUALITY ASSURANCE OF WORK PLAN FOR TEACHING COURSES

Procedures for ensuring the quality of work plans in the observed higher school of applied studies include the following elements [7]:

- ways of ensuring and improving the quality of the work plan,
- rules on creating a work plan;
- the procedure for consideration and adoption of the work plan;
- method and procedure for changing the work plan.

A. Ways of ensuring and improving the quality of the work plan

The quality of work plans is achieved [7]:

- consistent compliance with the rules on the content, structure, and form of the work plan;
- by taking appropriate measures in case of non-compliance with the rules on the content, structure, and form of the work plan;
- by constant improvement based on perceived deficiencies to the level of minor changes to the study program.

B. Rules on creating a work plan

The unique proposal of the work plan for the teaching course is prepared by the teacher (or teachers if more than one is planned for the realization of the course) in consultation with the associates on the course. Teachers and associates on the course are required to prepare a work plan for the next school year by the end of the summer semester of the current school year. When creating the work plan, every teacher is obliged to follow the rules on the content, structure, form, and visual appearance of the work plan [7].

C. The procedure for consideration and adoption of the work plan

At the session of the Teaching and Professional Council of the observed higher school of applied studies, the work plan for each teaching course is discussed and adopted before the beginning of the school year.

Adopted work plans are sent to the assistant director for teaching for further processing [7].

D. Method and procedure for changing the work plan

If, during the consideration of the work plan, the Teaching and Professional Council of the observed higher school of applied studies do not agree with the proposed work plan, the teacher is ordered to make appropriate changes [7] and returns to the review and adoption procedure.

IV. IMPORTANCE OF THE APPLICATION OF STANDARDS AND PROCEDURES OF WORK PLAN QUALITY ASSURANCE FOR THE QUALITY OF TEACHING PROCESS IN THE HIGHER SCHOOL OF APPLIED STUDIES

The observed higher school of applied studies has through the quality assurance system, i.e. through Standard 5 of the Rulebook on Standards and Procedures for Ensuring and Improving the Quality of Work, Self-Evaluation, the Technical College of Applied Studies in Zrenjanin and Self-Evaluation of Study Programs [7] prescribes the quality standards of work plans on teaching courses and the procedure for ensuring the quality of work plans.

The quality of the teaching process is ensured, among other things, by the application of standardized procedures for:

- adoption and obligation to respect work plans for teaching courses;
- taking the necessary measures in case it is determined that the quality of the plan does not comply with the standards or is not respected/implemented in the teaching conditions of the current school year.

The observed high school of vocational studies, for each school year, adopts the work plan for individual teaching courses within the work plan of the study program but also adopts the schedule of teaching implementation according to the adopted plans (the so-called class schedule). Work plans for teaching courses are publicly available on the official website through the Course Specifications (Course Book) for each accredited study program because they form an integral part of the documentation for the accreditation of study programs.

The work plan for each teaching course for each school year must be by the data specified in the Course Specification in the accreditation documentation. With the accredited data, that is, the work plan, the teacher introduces the students at the beginning of the implementation of the course in the current school year in the form of the so-called criteria, which must not be changed during the same accreditation cycle. Namely, in the first class, the teacher introduces the students to the Course Specification, the structure of pre-exam obligations, learning goals and outcomes, course content, as well as the recommended literature, the method of obtaining pre-exam and exam points, the fund of lectures and exercises, work methods, assessment methods, etc. The structure, content, and form of the work plan are standardized [7] and are harmonized with other general acts of the observed higher education institution.

Work plans for individual teaching courses, which are implemented in the study program during one accreditation cycle, must be identical, except in the case of approved minor changes to the study program. The teaching implementation plan by working weeks in the semester and the class schedule must be derived from the work plan for each teaching course, that is, from the accredited Course Specification to ensure the quality of the teaching process during one accreditation cycle of the study program.

V. CONCLUSION

The application of the standardization of work plans ensures the specified quality of the realization of teaching courses and, consequently, the quality of the teaching process in the accredited study program. Control of the implementation of work plans and prevention of their deviation from the accredited Teaching Course Specifications enables: ensuring the planned quality of the accredited study program during one accreditation cycle; and provides insight into the data for possible minor changes to the study program (for its improvement) or its re-accreditation in the next cycle.

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Utilizing Natural Language Processing for Enhancing Educational Content and Accessibility in Technical Education

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Abstract - This paper explores the key theoretical aspects of applying natural language processing (NLP) in technical education, with a special focus on improving accessibility and the efficiency of educational content. The theoretical framework of NLP, the historical context of its application in education, theoretical models and principles of accessibility in education, as well as the ethical aspects of this approach, are analyzed. Theoretical scenarios for the application of NLP for personalized learning and enhancing student experiences are also considered.

I. INTRODUCTION

In the era of digital transformation and rapid technological advancement, the application of natural language processing plays an increasingly significant role in the field of technical education. NLP, as a subfield of artificial intelligence (AI) dedicated to the interaction between computers and human language, opens up new possibilities for enhancing accessibility and the efficiency of educational content. Technical education faces challenges in adapting to the modern needs of students, the demands of the job market, and the emergence of new technological paradigms. In this context, NLP represents a key tool for addressing these challenges.

This paper aims to explore the theoretical aspects of applying NLP in technical education. Focusing on the theoretical foundations allows for a deep understanding of the NLP concept, its evolution, and prospects for enhancing education. Additionally, analyzing the ethical aspects of NLP application in education emphasizes the importance of responsible use of this technology.

II. BASICS OF NLP FUNCTIONALITY

Within the realm of Natural Language Processing (NLP), a series of fundamental steps is undertaken to enable computers and artificial intelligence systems to comprehend and interact with human language seamlessly. These steps serve as the building blocks of NLP, underpinning its vast array of applications. In this section, we'll explore these key processes to gain a comprehensive understanding of how NLP functions at its core.

The first essential process in NLP is tokenization. At this stage, the text is meticulously dissected into its fundamental units, namely sentences and words. This segmentation is a critical step as it allows NLP systems to break down complex language into manageable components, paving the way for deeper analysis.

Following tokenization, the NLP system engages in lemmatization, a process where words are transformed into their base or root form. By reducing words to their core, NLP systems effectively eliminate the need to account for various grammatical variations of the same word. This not only streamlines language analysis but also ensures more accurate results in subsequent NLP tasks.

After that, it encompasses grammar and semantic analysis. Here, the intricate relationships between words within a sentence are meticulously deciphered. This analysis helps in grasping the underlying structure of language, allowing NLP systems to identify subject-verb agreements, sentence tense, and the nuanced meanings embedded within text.

A pivotal component of NLP is named entity recognition (NER), which extends its capabilities to identifying specific entities within text. NER facilitates the discernment of names of individuals, locations, organizations, and more. It plays a vital role in extracting structured information from unstructured data, making it invaluable in a wide range of NLP applications.

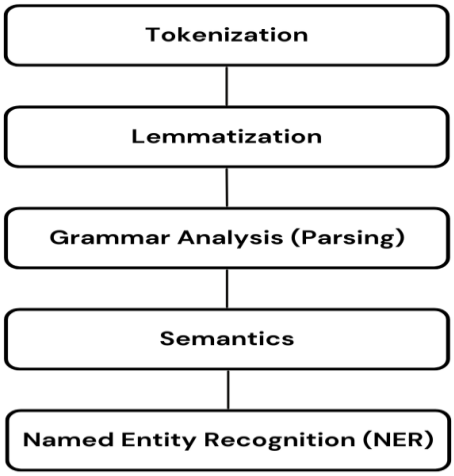

Figure 1. NLP Key Steps

APPLICATION OF NLP IN EDUCATION

When it comes to the application of NLP in education, there are many potential uses. NLP can assist in automating assessments and providing quick feedback to students. It can also be used for personalizing educational materials and tailoring the curriculum to individual student needs. In technical education, NLP can be particularly useful for analyzing technical texts, supporting programming learning, and facilitating the understanding of complex technical concepts. This technology can significantly enhance the educational experiences of students and teachers.

Historical Overview

Pioneers in NLP: The beginnings of NLP are associated with the work of researchers such as Alan Turing and Noam Chomsky. Their theoretical achievements laid the foundation for the development of NLP technologies.

Initial steps in education: The first applications of NLP in education began to develop in the 20th century, with a focus on language education and text analysis.

Development of tools: Advances in technology and computing enabled the development of NLP tools for education. This includes early versions of chatbots for language and literacy learning support.

Global progress: More sophisticated NLP technologies aimed at education began to develop worldwide, including text analysis tools, automatic grading, personalized learning, and adaptive resources.

Current situation: Today, NLP technologies are playing an increasingly significant role in education worldwide. Their applications encompass language learning support, assessment, and personalization of educational experiences.

III. THEORETICAL MODELS FOR ACCESSIBILITY IN EDUCATION

NLP has significant potential to greatly enhance the accessibility of educational resources for students with diverse needs. Some of the ways in which NLP can achieve this goal include

A. Automated generation of customized content

NLP technologies can analyze the needs and abilities of each student and automatically generate tailored educational content. For example, texts, assignments, or audio-visual materials can be adapted to best suit the individual requirements of each student [1].

B. Conversation and learning support

NLP-based chatbots can provide interactive and personalized support to students during their learning process. They can answer questions, clarify concepts, and offer additional resources in an accessible manner for all, including students with special needs [2].

C. Translation and interpretation

NLP tools for translation and interpretation can be invaluable for students who have learned in another language or those with communication impairments. These tools enable access to educational content in their native language or through other communication channels [3].

D. Detecting and supporting difficulties

NLP can analyze students' writing and speech to identify challenges in understanding the material or communication. Based on these analyses, targeted support can be provided, such as additional exercises or explanations [4].

E. Progress monitoring

NLP technologies can track and assess each student's progress in real time. This allows for the adaptation of the educational plan according to individual needs and abilities [5].

Through these and other methods, NLP has the potential to enhance the accessibility of educational resources for all students, regardless of their specific needs and challenges. This is a key aspect of its application in the field of education, including technical education.

IV. ETHICAL ASPECTS OF NLP APPLICATION IN EDUCATION

A detailed analysis of ethical issues and challenges arising from the use of NLP in education is essential to ensure the responsible application of

this technology in educational settings. Below are some of the key ethical aspects and challenges:

Data Privacy: Using NLP to analyze and monitor students' activities can raise questions about data privacy. The collection, storage, and analysis of student data must be carefully regulated to ensure that personal data is preserved and used in accordance with laws and ethical guidelines.

Bias and Discrimination: NLP models can inherit biases and prejudices present in the data they are trained on. This can result in unfair decisions or assessments that impact students. It is important to identify and mitigate any irregularities in models to ensure fairness.

Transparency and Interpretability: Some NLP models, such as deep learning models, can be extremely complex and difficult to understand. This creates challenges related to the transparency and interpretability of the decisions they make. Ensuring that students, teachers, and parents understand how decisions are made is an ethical concern.

Intellectual Property Rights: Issues related to intellectual property rights can arise when using NLP tools to generate and distribute educational materials. Who owns the generated content? How are copyright rights recognized?

Security and Misuse: NLP tools can also be used for unethical purposes, including plagiarism and falsifying academic work. Ensuring the security of the system and detecting misuse is crucial for preserving the integrity of the educational process.

Accessibility and Inclusivity: While NLP can enhance accessibility, it is essential not to overlook that technological solutions should be accessible to all. Ensuring that all students have access to and benefit from NLP, including those with special needs, is a concern.

To ensure responsible application of NLP in the educational environment, clear ethical guidelines need to be established, teachers and administrators should be trained on ethical issues, and mechanisms for reporting irregularities should be provided. It is also important to develop NLP tools and models with responsibility and fairness as priorities to avoid ethical problems.

V. Theoretical Scenarios for NLP Application

Exploring theoretical scenarios for the application of NLP in education provides insights into how this technology can be used to enhance educational experiences. Key theoretical scenarios include:

A. Creating Adaptive Educational Resources

NLP enables the analysis of student behavior and their interactions with educational materials. Based on this data, adaptive educational resources can be created that tailor the level and learning style for each student. For example, NLP can identify learning points that challenge students and adjust resources to help them overcome these obstacles.

B. Automating the Generation of Educational Content

NLP can automatically generate educational content, including tests, quizzes, lessons, and learning materials. For instance, it can analyze existing materials and generate additional resources to support students. This type of automation can significantly reduce the workload of teachers.

C. Personalized Educational Experiences

NLP allows for personalized educational experiences tailored to the needs and interests of each student. Through data analysis, NLP can recommend additional materials, lessons, or activities that would suit each student. This creates a deeper and more relevant educational experience.

D. Automatic Feedback and Evaluation

NLP can quickly and accurately assess student work, including essays and open-ended responses. This streamlines the assessment process and provides prompt feedback to students. It can also identify areas where students are prone to errors and offer additional support.

E. Keeping Students Engaged

Through the analysis of learning data, NLP can identify when students are less engaged and provide interactive activities or materials that re-engage them in learning. This helps maintain student motivation throughout the course.

VI. Conclusion

This paper explores the key theoretical aspects of applying natural language processing (NLP) in technical education, with a particular focus on enhancing accessibility and the efficiency of educational content. The theoretical framework of NLP provides an understanding of the fundamental concepts and principles underlying this technology. The overview of the development of NLP technologies highlights key milestones in the global and Serbian application of NLP, emphasizing significant events in the field of education.

The analysis of theoretical models for accessibility in education examines ways in which NLP can improve the accessibility of educational resources for students with diverse needs. This

analysis underscores the potential to adapt resources for all students, creating an inclusive educational environment.

A detailed analysis of the ethical aspects of NLP application in education emphasizes the importance of responsible technology use. While NLP brings numerous advantages, it faces challenges related to data privacy, algorithm biases, and other ethical issues that require careful consideration.

Considering theoretical scenarios for NLP application in education presents a vision of the future where such technology is used to create adaptive educational resources, automate content generation, and facilitate personalized educational experiences. These scenarios open the door to new methods of learning and teaching.

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The Classrooms Workload as a Parameter for the Quality Analysis of Teaching Schedule

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Abstract - A well-organized class schedule is the basis of a teaching process quality. The classrooms workload is a factor that affects the flexibility of the schedule and provides additional comfort in the work of the teaching staff and students. In this paper, workload by day will be considered based on data for 183 classrooms of the Faculty of Technical Sciences in Novi Sad, and then a comparative analysis will be given for the winter and summer semesters.

I. INTRODUCTION

A higher education institution must have sufficient teaching staff and available space for quality performance of accredited study programs. In the accreditation procedure, the ability of the higher education institution to carry out the proposed study programs is checked. In this paper, we will consider the workload of classrooms, as an additional parameter that is not formally considered in the accreditation process but could be very useful in assessing whether a higher education institution needs additional space (as a recommendation).

Accreditation of a higher education institution and all study programs realized at that institution is a legal obligation [1]. Accreditation of a higher education institution implies the fulfillment of the following thirteen standards [2]:

Standard 1: Basic tasks and goals of a higher education institution

Standard 2: Planning and Control

Standard 3: Organization and management

Standard 4: Studies

Standard 5: Scientific research and artistic work

Standard 6. Teaching staff

Standard 7: Non-teaching staff

Standard 8: Students

Standard 9: Space and equipment

Standard 10: Library, textbooks and IT support

Standard 11: Internal mechanisms for quality assurance

Standard 12: Sources of funding

Standard 13: The public in work

Standard 6 obligates that the total number of teachers must be sufficient to cover the total number of teaching hours in the study programs realized by the institution, so that teachers achieve an average maximum of up to 180 hours of active teaching (lectures, exercises, practical work and field work) per year, i.e. up to 6 hours per week, with a tolerance of 20% [2].

Based on Standard 9, the higher education institution provides space for teaching, namely 4 m2 of gross space per student, or 2 m2 per student for teaching in shifts, except for the field of art. The space per student is calculated by dividing the gross space of the institution by the total number of accredited students at the institution on all study programs and all years of study, whereby the total number of students does not include students who are on a study program conducted at a distance. A higher education institution should have amphitheatres, classrooms, laboratories, or other rooms for teaching, as well as library space and reading room, suitable workspace for teaching staff. A higher education institution should have a place for every student in the amphitheater, classroom and laboratory.

In this paper, we will analyze workload by day based on data for 183 classrooms with 6298 places at the Faculty of Technical Sciences in Novi Sad [3]. The workload of classrooms is observed on Monday, Tuesday, Wednesday, Thursday, Friday and Saturday in the period from 6:30 AM to 10:30 PM in 65 time intervals of 15 minutes each. Based on the data for each day, a workload diagram is created and the average daily workload is calculated. Data from the winter and summer semester will be analyzed in the Section II and Section III, respectively. A comparative analysis will be given in the Section IV. Also, in the Section IV we will consider average

The research has been conducted within the project “Improvement of teaching and research processes as well as the Faculty's financing system in accordance with new challenges”, Faculty of Technical Sciences, University of Novi Sad, Republic of Serbia.

classrooms workload and calculate total for winter and summer semester, respectively.

II. WINTER SEMESTER ANALYSIS

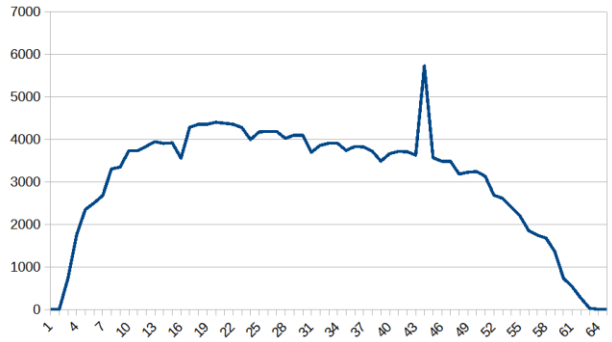

Figure 1. Monday (winter semester).

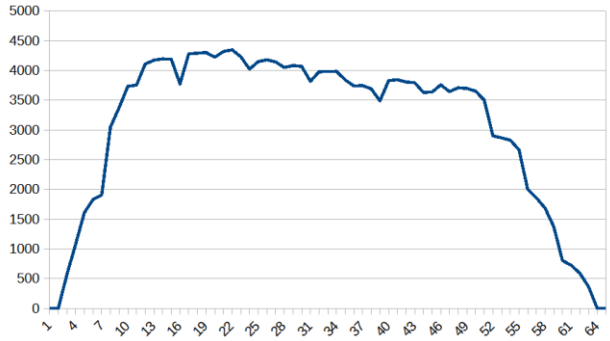

Figure 2. Tuesday (winter semester).

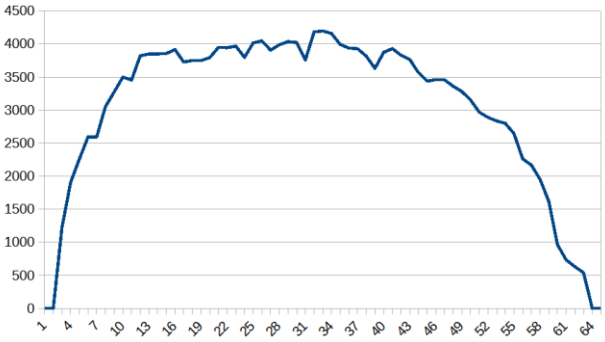

Figure 3. Wednesday (winter semester).

A. *Monday*

The Figure 1. presents classrooms workload diagram for Monday. Maximal workload is above 5000 busy places in classrooms and is achieved in 5:15 PM.

B. *Tuesday*

The classrooms workload diagram for Tuesday is given in the Figure 2. Around noon, there are maximal values which are above 4000 busy places.

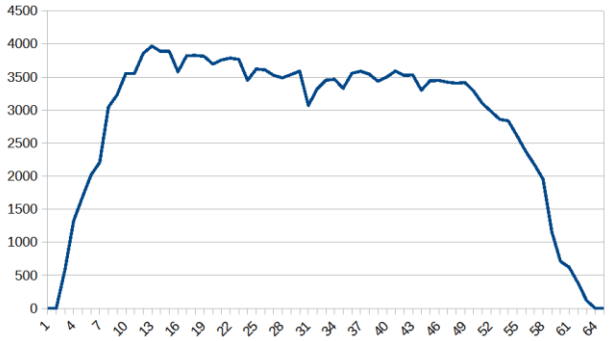

Figure 4. Thursday (winter semester).

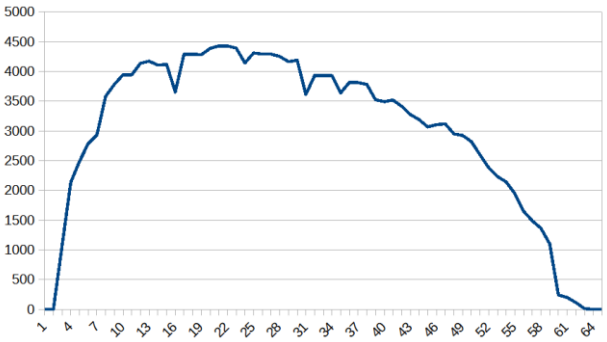

Figure 5. Friday (winter semester).

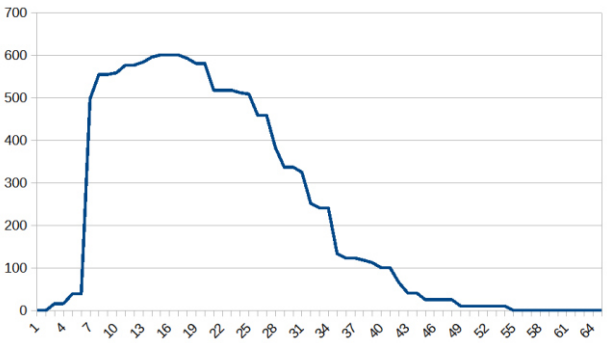

Figure 6. Saturday (winter semester).

C. *Wednesday*

The Figure 3 presents results for Wednesday. After noon, there are maximal values which are above 4000 busy places.

D. *Thursday*

The classrooms workload diagram for Thursday is given in the Figure 4. Maximal workload is about 4000 busy places in classrooms and is achieved in 9:30 AM.

E. *Friday*

The Figure 5. presents classrooms workload diagram for Friday. Around noon, there are maximal values which are around 4500 busy places.

F. *Saturday*

The Figure 6 presents results for Saturday. Before noon, there are maximal values which are about 600 busy places.

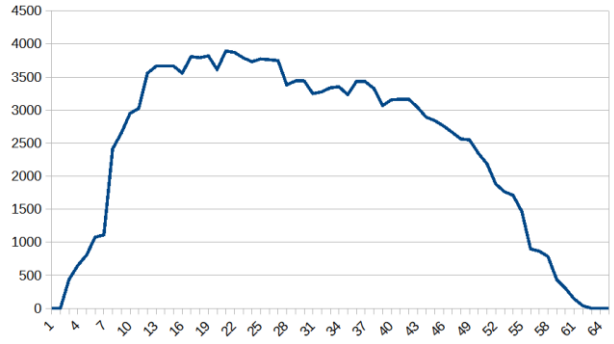

Figure 7. Monday (summer semester).

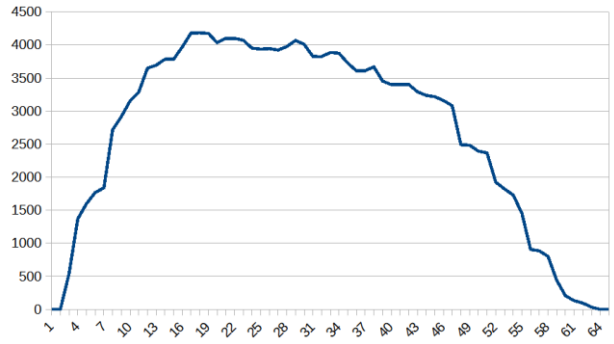

Figure 8. Tuesday (summer semester).

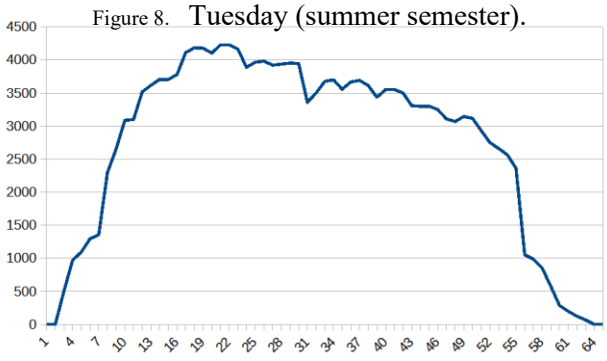

Figure 9. Wednesday (summer semester).

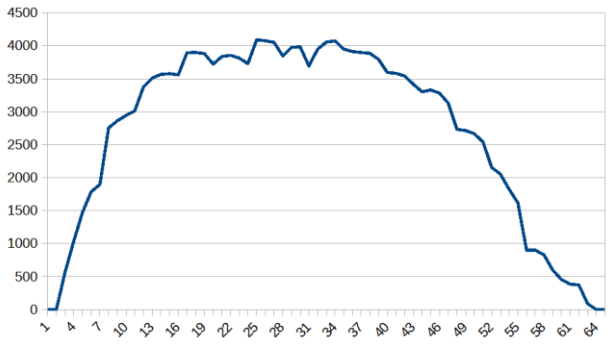

Figure 10. Thursday (summer semester).

III. SUMMER SEMESTER ANALYSIS

A. *Monday*

The Figure 7. presents classrooms workload diagram for Monday. Before noon, there are maximal values which are until 4000 busy places.

B. *Tuesday*

The classrooms workload diagram for Tuesday is given in the Figure 8. Around noon, there are maximal values which are above 4000 busy places.

C. *Wednesday*

The Figure 9 presents results for Wednesday. Around noon, there are maximal values which are above 4000 busy places.

D. *Thursday*

The classrooms workload diagram for Thursday is given in the Figure 10. After noon, there are maximal values which are above 4000 busy places.

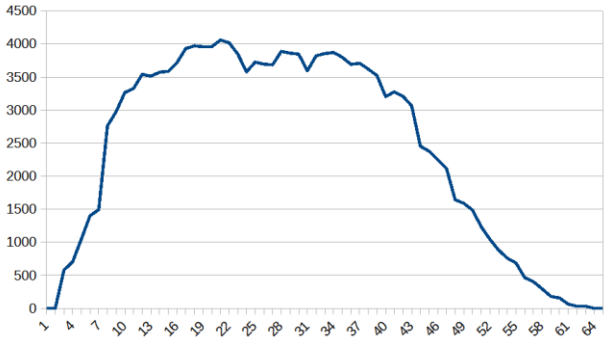

Figure 11. Friday (summer semester).

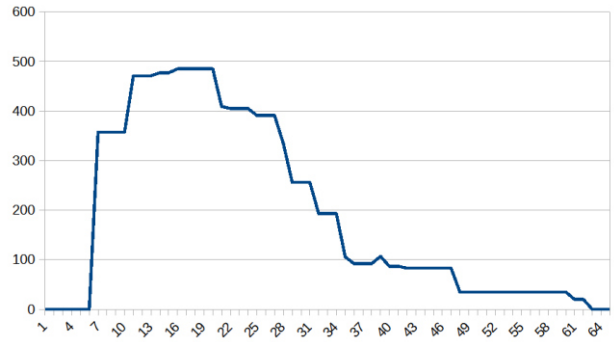

Figure 12. Saturday (summer semester).

E. *Friday*

The Figure 11. presents classrooms workload diagram for Friday. Around noon, there are maximal values which are around 4000 busy places.

F. Saturday

The Figure 12 presents results for Saturday. Before noon, there are maximal values which are until 500 busy places.

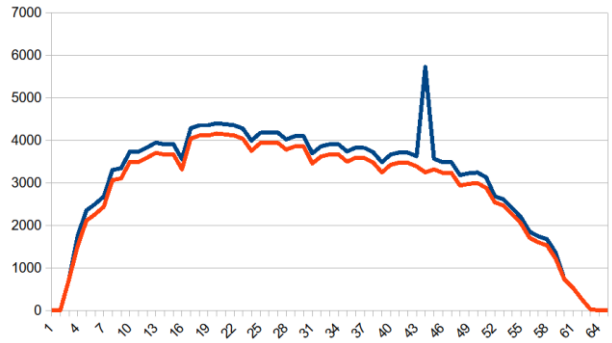

Figure 13. Monday (comparative analysis).

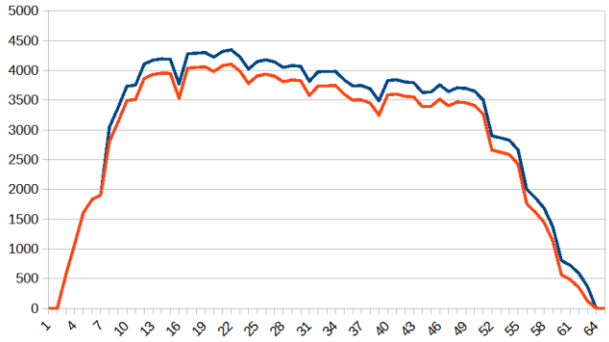

Figure 14. Tuesday (comparative analysis).

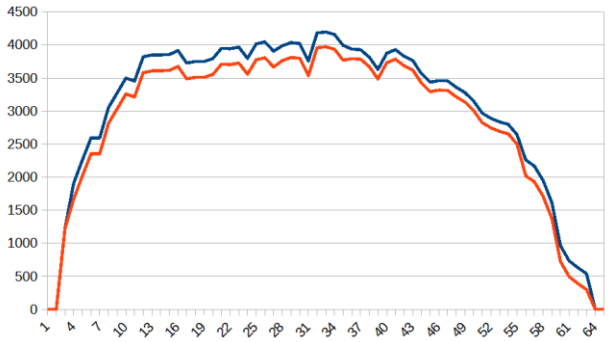

Figure 15. Wednesday (comparative analysis).

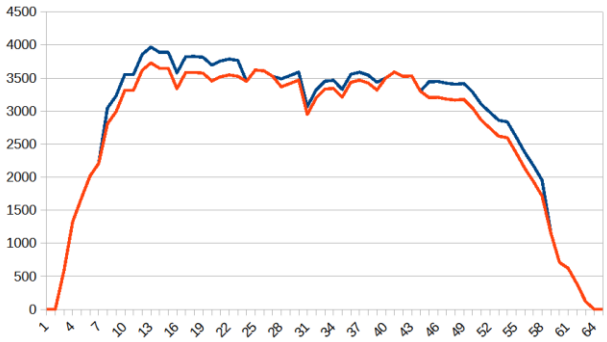

Figure 16. Thursday (comparative analysis).

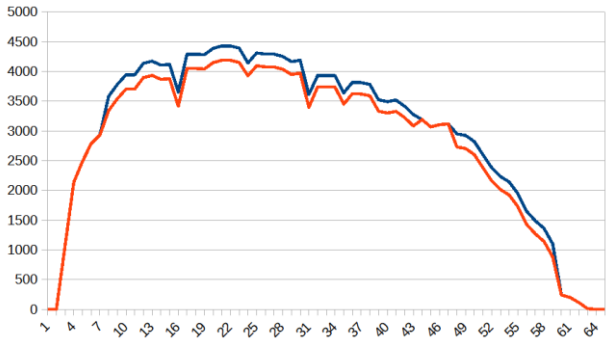

Figure 17. Friday (comparative analysis).

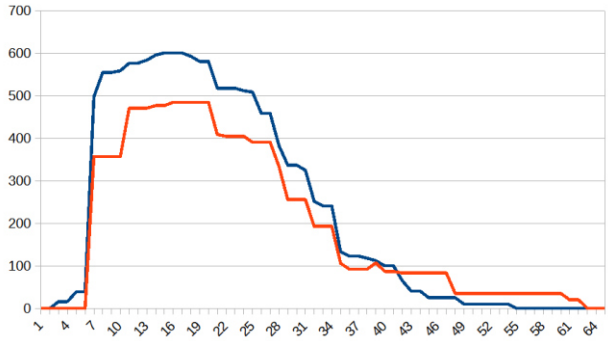

Figure 18. Saturday (comparative analysis).

IV. COMPARATIVE ANALYSIS

A. Monday.

The Figure 13. presents comparative analysis for Monday. Blue line is for winter and red line for summer semester. Obviously, summer semester has less classrooms workload.

B. Tuesday

The comparative analysis for Tuesday is given in the Figure 14.

TABLE I. ANALYSIS OF AVERAGE CLASSROOMS WORKLOADS

Average Classrooms Workload		
Day	***Winter Semester***	***Summer Semester***
Monday	3050.85	2436.85
Tuesday	3067.32	2685.02
Wednesday	3038.51	2726.72
Thirsday	2833.00	2704.31
Friday	2973.02	2397.71
Saturday	229.14	190.06
TOTAL	**2531.97**	**2190.11**

C. Wednesday

The Figure 15. presents comparative analysis for Wednesday.

D. Thursday

The comparative analysis for Thursday is given in the Figure 16.

E. Friday

The comparative analysis for Friday is given in the Figure 17.

F. Saturday

The Figure 18. presents comparative analysis for Saturday.

G. Average Classrooms Workload

The average classrooms workloads per days are given in the Table I, separately for winter and summer semester. Last row presents total average classrooms workloads per semester. Obviously, average classrooms workloads are less every day in summer semester. The total average classrooms workload is 2190.11 for summer semester and 2531.97 for winter semester.

V. CONCLUSIONS

The classrooms workload was analyzed in this paper, as a parameter that can be useful to estimate – how much higher education institution can provide flexible schedule and additional comfort in the work of the teaching staff and students. This analysis can be very useful for higher education institution work, since well-organized class schedule is the basis of a teaching process quality.

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[3] http://ftn.uns.ac.rs/n1675911948/rasporedi-i-realizacija

Curriculum of Marine Ecosystem Characteristics

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Abstract - Marine ecosystem characteristics curriculum taught in the elementary school in Montenegro is analyzed in this work. The curriculum covers seven teaching units: sea water characteristics, sea basin zones, sea biocoenosis, sea nutrition relations, economic importance of sea, sea pollution and protection measurements and endangered species and their protection. The curriculum has logical course of content and valuable broadening of knowledge in the area of: biology, chemistry, physics, geography and protection of the sea ecosystem. The curriculum enhances the knowledge and values by learning, both, at: theoretical classroom classes, practical activity and experimental work. It is highly praised that in the natural sciences curricula, the curriculum Marine ecosystem characteristics was introduced.

Key words: marine ecosystem characteristics curriculum, elementary school, Montenegro

I. INTRODUCTION

In the era of great scientific, technical-technological and social changes, the educational system of every country strives to improve and adapt education to the needs of human and social development. Reforms of the education system in the former Yugoslavia were frequent. Changes in social science programs were more extensive than in natural sciences. Curriculum reforms in the former Yugoslavia were not complete and were the result of various decisions, rather than the professional and scientific needs of education. In the last decade, the Serbian language experienced the biggest virtual reform [1]. The ongoing reforms of natural science curricula try not to repeat the mistakes of earlier reforms, which were mostly reduced to moving certain thematic units from one grade to another and the latest scientific achievements of natural sciences were omitted [2]. Recent reforms aim to make curricula more diverse, more content, more interesting and more attractive for pupils. The aim of the lessons, for pupils, is to acquire knowledge that will be useful for them. This is a difference compared to previous education in these geographical areas, where, among other things, contents taught had no application and benefit. Changes in plans and programs, printing of textbooks and equipping schools with teaching equipment are conditions that should be respected in order to achieve a successful current education reform. With the reform of curricula in the Republic of Montenegro, elective subjects from seven scientific fields were introduced. One group of elective subjects is from natural sciences and mathematics and within this group is the elective subject the Marine ecosystem characteristics.

From the school year 2004/2005, the Republic of Montenegro switched from an eight-year primary school to a nine-year primary education [3]. Primary school in the Republic of Montenegro is compulsory and free for all children [4]. With the transition to the nine-year elementary school, the curricula were restructured. Elective subjects, grouped into seven scientific areas, were introduced: linguistics, natural sciences and mathematics, informatics, social sciences, technical sciences, arts, physical education and an interdisciplinary group of subjects [5]. In the natural sciences and mathematics group of subjects are: Mathematical workshop - combinatorics and elementary number theory, Mathematical workshop - geometry, Mathematical workshop - sets, relations, functions, Measurement in physics, Oscillations and waves, Chemistry through experiments, Medicinal plants and the Marine ecosystem characteristics. The elective subject Mathematical workshop - combinatorics and elementary number theory is a one-year subject that is studied in the seventh grade, the elective subject Mathematical workshop - geometry is studied in the eighth grade, while the elective subject Mathematical workshop - sets, relations, functions is studied in the ninth grade with one class per week. The elective subject Measurement in Physics can be chosen in the seventh grade, while the elective subject Oscillations and waves can be chosen in the eighth grade of the nine-year elementary school. The elective course Chemistry through Experiments is a multi-year course that can be taken for a shorter period of time during the eighth and ninth grades with a pool of classes of two hours per week. The elective subject Medicinal herbs can be chosen in the eighth grade with one lesson per week. The elective course the Marine ecosystem characteristics is a one-year course that is not linked to the grade and can be studied in the seventh, eighth or ninth grade [6].

Curriculum of Marine Ecosystem Characteristics

The curriculum content of the Marine ecosystem characteristics has seven topics:

1. Characteristics of sea water
2. Zoning of the sea basin
3. Marine biocenoses
4. Nutritional relationships in the sea
5. Economic importance of the sea
6. Sea pollution and protection measures and
7. Endangered species and their protection.

Topic: Characteristics of sea water, introduces pupils to the physical and chemical properties of sea water, understanding the changing conditions of life in the sea depths and familiarization with organisms that live at different sea depths. This teaching topic includes activities that include determination of the sea salinity, determination the depth of light penetration, measuring temperature at different depths and analyzing the effect of temperature on organisms. Terms and contents that are adopted within this thematic unit are: salinity, solubility of gases, underwater light zones and layered population of the marine ecosystem with different organisms due to different temperatures.

Topic: Zoning of the sea basin, is based on the acquisition of knowledge that represents the living world changes with the change of depth, and pupils are trained to recognize the conditions of life in different sea zones.

Topic: Marine biocenoses, pupils get to know different representatives of marine biocenoses, pupils observe and identify benthic, planktonic (phytoplankton and zooplankton) and nektonic organisms.

Topic: Food relationships in the sea, the food chain and the interdependence of organisms through the process of matter circulation and energy flow are described to the pupils.

Topic: Economic importance of the sea, introduces to pupils the technology of growing fish, oysters and mussels, types and rules of fishing. The curriculum recommends learning fishing skills from professional fishermen, taking pupils to ponds and observing fish, oyster and mussel farming techniques, familiarizing them with methods of catching fish, using fishing lines and nets, and sorting catches by species.

Topic: Sea pollution and protection measures, introduce pupils to possible sources of pollution, polluting substances and protection measures against pollution. Pupils are informed about the existence of natural indicators of sea pollution, one of the indicators are algae: *Enteromorpha intestinalis* and it is necessary to show it to the pupils. For this thematic unit, fieldwork is recommended, which, among other things, includes a visit to the Working Organization for Wastewater Processing.

Topic: Endangered species and their protection, envisages introducing pupils to endangered species, the causes of their disappearance and protection measures aimed at preserving endangered species. Pupils are expected to be able to list and draw endangered species.

The planned resources for teaching include measuring devices, technical and laboratory equipment: microscope, binoculars, fishing equipment (hook and net), thermometer, probe for measuring salt concentration and many more. Laboratory equipment for the Marine ecosystem characteristics elective subject includes: microscope equipment, test tubes, pipettes, Petri dishes and many more.

The elective subject the Marine ecosystem characteristics is a continuation and expansion of the biology knowledge acquired in the previous grades of elementary school. Concepts are systematically introduced and knowledge about the Marine ecosystem characteristics is expanded. The curriculum foresees that the marine ecosystem can best be learned through theoretical teaching, work in the field and conversation with people whose profession is fishing. The teaching recommendations are alternate acquisition of theoretical knowledge with the application of learning methods through independent, team and experimental work in the field, in the laboratory and in the classroom. It is expected that after learning the subject, the pupils will apply the acquired knowledge in their everyday life. The content of the program should be brought closer to pupils through the desire to discover new things, through curiosity, independence and the constant development of interest in biological science. It is necessary to point out to the pupils the change in the state of nature under the influence of various factors. It is recommended to teach pupils about the preservation and rational use of the natural resources of the sea. Through upbringing and education, it is recommended to learn about the preservation and improvement of nature, about environmental awareness and natural resources [7].

Didactic recommendations for the elective course the Marine ecosystem characteristics keep up with the modern requirements of education. In addition to theoretical teaching, the subject teacher should organize field and laboratory work, organize a visit to the Organization for wastewater treatment,

organize the introduction and conversation of pupils with fishermen and many more. Teachers were given a recommendation for choosing the type of lessons, the choice of teaching method and form of work, the choice of teaching equipment and activities for each thematic unit.

CONCLUSION

With the introduction of elective subjects in primary school education, teaching content was made more interesting for pupils and a shift towards a modern educational system was made. The analysis of the representation of elective subjects in elementary school for the school year 2008/2009, which was carried out in 75 elementary schools in Montenegro, shows that pupils mostly choose the elective subject Sport for athletes, which is admirable that pupils choose physical activity [5]. The Institute for Education regularly collects data and analyzes the representation of elective subjects, and the results from the 2008/2009 school year indicate that after the Sport subject, the linguistic group of subjects is most often chosen. The languages chosen are Italian and Russian. The Italian is chosen in southern parts and Russian in northern parts of Montenegro.

The elective course of the Marine ecosystem characteristics was chosen by 515 seventh grade pupils who worked in 22 groups or 7.7% of the pupils. In the eighth grade, 28 pupils have chosen the Marine ecosystem characteristics or 0.6% of the pupils. The introduction of the elective subject the Marine ecosystem characteristics represents a contribution to general biological education, real life and further professional needs of pupils. Teaching methods include: traditional teaching, methods that encourage pupils to learn independently, experimental teaching and field teaching. The elective subject the Marine ecosystem characteristics indicates that primary school education tends to increase the content of natural sciences. Pupils develop the ability to do research through work in nature. Pupils are expected to apply the acquired knowledge in practice, economy, science, research and teaching. It is difficult to resist the challenges of technical and technological progress and urbanization, and man is increasingly moving away from nature. The introduction of the elective subject the Marine ecosystem characteristics allow pupils to get to know nature. All praise for the introduction of the elective subject the Marine ecosystem characteristics in primary school education. In addition to classic biological disciplines: botany, zoology, ecology, then modern biological disciplines: genetics and molecular biology, pupils' knowledge is expanded by getting to know the marine ecosystem, marine biodiversity and ways to preserve endangered species.

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Development of Tests for E-learning Studies

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Abstract - As during e-learning process a student individually sets the speed and pace of e-learning process, the potentialities to motivate the student for intensive and good quality study process are reduced. The certain system has to be created to keep the speed of studies and control the quality of acquired knowledge. In an e-learning process this function is given to knowledge tests. Different types of tests are used to control study process and valuate acquired knowledge. Tests in e-learning environment give more potentialities to valuate student's knowledge than traditional tests.

Creating e-learning course "Industrial cutting of garments", it was decided to make analysis of 15 tests produced for "Clothing technologies" e-learning course developed by X University with similar topics and structure. The following parameters of the tests were analyzed: content of questions, number of questions, types of answers, the use of different types of answers in one test, commentaries on answers, evaluation system. Based on the analysis several recommendations were developed to form high quality tests with questions and answers. They are divided in three groups: general recommendations for development of tests, recommendations for study process control tests and recommendations for valuation of acquired knowledge.

Key words: e-learning; tests; testing methods; clothing technologies; textile spreading and cutting

I. STRUCTURE OF E-LEARNING LECTURE

E-lecture is one of the most often used e-learning method. It is a specially prepared study material in form of texts, structured in several importance levels [1,2]. The structuration of information allows the student to acquire study material in different ways:

- Only most important– not entering deeper information levels;
- More profound – adding more information, comments, explanation of terms;
- Extensive – textual information supplementing with images, diagrams, tables, photos, animations, videos.

As a student individually sets the speed and pace of e-learning process, the potentialities to motivate the student for intensive and good quality study process are reduced. Therefore some kind of system has to be created to keep the speed of studies and control the quality of acquired knowledge. In an e-learning process this function is given to knowledge tests which can be used for two aims [1,2]:

- Tests to control the study process – help students to estimate acquired understanding of certain topic, discover still not understood parts of the topic, ascertain unsteady knowledge, make an effort to comprehend the most complicated information;
- Tests to valuate knowledge – help teachers to valuate students' knowledge, acquired during study process about a separate topics or all study course.

II. TYPES OF TESTS

Different types of tests are used to control study process and valuate acquired knowledge. The choice of the type is determined by particularities of certain study course [3].

True or false test – one of the simplest types of tests. There is one statement given and the student has to determine if it is right or wrong. This type of test does not give objective valuation of knowledge. The student can guess the right answer as only two variants (yes, no) are offered.

Multiple choice test– the most popular type of tests. The student has to answer a question choosing right ones among several given answers. In this kind of tests to guess the right answer is more difficult than in the objective test.

Matching test– in this type of test two groups of objects are given: - words, sentences, phrases. A student has to find the right couples of objects from the first group and the second group. As every object is used only once, with the every next couple it is easier to guess the right combinations.

Fill-in-the-blank-type test – in this kind of tests sentences are with empty spaces to be filled with words or phrases offered on the side. These words or phrases can be used once or more times. With every next word it gets easier to guess the right placement of words, as the choice of free words is lesser [4].

Test with spare words in text – this is specific type of tests used in foreign language studies. There is a text with one or more spare words in every sentence. The student has to choose the correct ones and tick them. If the text is created skillfully, the tests can give objective valuation of knowledge.

Tests with written answers – there are given questions and a student has to write down the right answers. This is most objective way to valuate knowledge as the right answer is not given and the student has to write it down by himself. A teacher has to spend additional time to correct these types of tests.

III. TESTS IN E-LEARNING ENVIROMENT

Tests in e-learning environment give more potentialities to valuate student's knowledge then traditional tests [5]. Their advantages are following:

- Questions can be supplemented with images, photos, animations, video;
- Testing is accomplished automatically and objectively;
- The results of a test can be automatically given as a certain amount of points;
- Tests can be passed individually at any time and any place to control the level of acquired knowledge.

Test questions are characterized by number of important parameters: a title (number), text, image shown/video, estimation (points, percentage), penalty coefficient (if the test can be passed several times), the commentary assigned to an answer, final estimation (points, percentage), final result with commentary.

IV. THE ANALIZE OF CLOTHING TECHNOLOGY TEST DEVELOPED BY X UNIVERSITY

Wide range of guidelines are available to understand test formation principles [1,2,3,4]. However, they are overly general and do not give firm recommendations how to develop a high quality test. Therefore, while creating e-learning course "Industrial cutting of garments"[6,7,8,9], it was decided to make analysis of the "Clothing technologies" e-learning course developed by X University with similar topics and structure.

15 tests of e-learning course "Clothing technologies" were analyzed to understand and define the principles of good quality knowledge evaluation tests. Analyzed tests are provided to control study process of 15 different topics of the e-learning course. They are produced as tests with questions and answers. The tests can be passed repeatedly, unlimited times, not taking into account the results of the previous attempts. There are not limits of test passing times and time intervals between two attempts.

A short characterization of the certain test (the name of a topic, number of questions, number of points for every right answer and every wrong answer) and instruction (how to give answers, estimation principles) introduce the tests.

All questions of the tests have to be answered sequentially. After giving the answer to every question, a student automatically gets a commentary about right and wrong answers. After passing the test, the student gets the estimation of his knowledge – the final obtained number of points as well as the maximal number of points.

A. Content of questions

Tests „Seam, stitch and thread selection", „Sewing and garment assembly" also „Interlining" would have to be mentioned as well developed. The questions are posed in logical sequence in accordance with the overall design of the study course. The content reflects the most important aspects of the topic, many questions are supported with informative images providing the required additional information to understand them. However, some shortcomings encountered during the analysis should be mentioned too:

- Some questions are set down inexactly. Statement of the questions is not stated clearly enough, additional information, informative images are missing. Phrases that can be understood differently sometimes are used in the questions (for example: what is the *most popular* …?). All these problems create lack of understanding and can be the cause for wrong answers. Finally, students are discontent with the results of the tests and can loose motivation to improve their knowledge in such kind of not objective conditions;
- Often, not enough questions are given to accent the main aspects of a topic/ process. So it makes it more difficult to examine and verify the quality of apprehension of the certain topic (tests: „Lay planning", "Spreading");
- Sometimes unreasonable number of questions is given about less relevant aspects of a topic (test „Fabric spreading"). This way the wrong concept about the described topic and its main

parts can be created during knowledge formations process;

- Questions that without reason accent certain parts of study material sometimes are included in tests. For example, in a test „Interlinings" too much attention is put on questions about modes of spreading (4 questions from 10), but in a test „Health and safety" all 4 questions check only one of many topics described in the study material (work place safety signs);
- In some tests (for example, test „Fabric cutting") questions are put in a mixed order ignoring logical sequence of a topic/process. This kind of testing sequence during knowledge formation process significantly complicate perception and could be a reason of many wrong answers;
- Sometimes questions are presented to see how carefully the student has read the study material and how clearly he remembers the selected phases, nuances of the text. This way, the statement of questions do not test and promote the student's understanding of certain technological process in general (for example, test „Fabric cutting");
- Some tests with their structure and statement of questions are too complicated for beginners' level (for example, test „Fabric cutting") They are useful for training a staff of production enterprises but not for students who do not have any background in these topics;
- In some tests certain topics are linked with information very little described or not described at all in study material creating high complexity questions. They are too complicated for students without preliminary knowledge (test „Fabric cutting", questions: 12, 13, 14);
- In many questions informative images are missed to give full understanding of question (test „Lay planning", questions 5, 6, „Fabric spreading"- questions 2, 3). At the same time many other questions are illustrated with images which do not give any additional information to certain question (for example, test „Fashion design" questions 6, 8, 9; test „Sewing development" – questions 3, 13, 14).
- Questions that request to write down one figure or interval of figures are used too often. They do not test knowledge objectively as, asking just a figure without any other information, only students' memory is checked.

B. Number of questions

The number of questions in one test is very different (4 - 26). Although, the amount of information describing various topics is different, such large difference is not reasonable. Tests with large number of questions that examine knowledge of voluminous and complicated topics („Seam, stitch and thread selection" – 26 questions, „Sewing threads"- 24 questions), are to be positively valuated as well as the testing of less complicated topics with 10 – 15 questions. Lack of questions is evident for tests „Garment specification" and „Health and safety" (only 4). Although mentioned topics describe comparatively less complicated study material, 4 questions can not control knowledge formation process.

C. Types of answers

Answers to questions are produced in different ways – as an expanded phrase, a term/ word, a figure or an interval of figures and as a statement or negation. The assessment and analysis of different types of answers is following:

- Most often questions are used with answers set down as more or less expanded phrases (65% from all questions of the tests). This kind of questions uses to be without images (52%), supplemented with images without informative meaning (19%) and with an image that gives additional information to a question and its answer (29%). The Questions with expended answers are perceptible best of all as they reflect the study course most precisely. The quality of questions is raised noticeably using images that give not only additional information about question but also possibility to use visual memory in knowledge formation process.
- The second most often used type analyzed is answer that asks to write down certain figure or an interval of figures (20%). Questions with this answers use to be without images (65%) or with images that do not give additional information (35%). Such a frequent use of this kind of answers is surprising as memorized figures weakly test knowledge and its formation process. In some of the tests this type of questions are used too often (in test „Interlinings" – 55% of questions, in test „Sewing and garment assembly" – 35%, „Sewing threads" – 33%). Moreover, in two tests („Interlinings" and „Sewing and garment assembly") the questions with this type of

answers follow each other not interchanging with other kind of answers. Monotonous testing of figures, learnt by heart, do not create interest about study material - even opposite, reduces it and push the student to use maximal effort to remember figures instead of understand a topic.

- The next most utilized type of answer is that to request to write down certain word or a term (15% of all questions). The questions with these answers use to be without images (60%), with an image without informative meaning (13%) and with an image that gives additional information to a question and its answer (27%). The use of this type of answers in tests is reasonable as in most part of topics certain terms, names of some articles, steps of processes have to be remembered. However, this kind of answers should not predominate in tests as they by themselves weakly examine knowledge. For example, in the test "Fabric cutting" answers with words/ terms are used in approx one third of questions (35%). However many important processes are not described in the certain topic and answers with expanded phrases should be used much more.
- The smallest number of questions has answers that ask to give a statement or a negation (3%). The use of this type of questions raise the probability that a student even not knowing the right answer can guess it as only two variants of answers are given. This way objective assessment of knowledge is not possible. Baseless use of this type of questions is seen in test "Garment specification" as from its 4 questions (100%) 2 have answers with a statement or a negation (50%).

D. The use of different types of answers in one test

In the most part of tests different types of answers are used, while answers with more or less expanded phrases dominate. This kind of tests can control the understanding of topic in a good quality and at the same time, they are not monotonous as students tend to keep their attention during the entire test. Test „Seam, stitch and thread selection" has to be valuated very positively as there are three different types of answers used and a half of all questions have answers with expanded phrases that are supplemented with images giving addition information. As one not so successful combination of different types of answers is the test "Interlinings" where 11 questions (55%) from 20 in their answers ask to write down a figure or an interval of figures. Besides, the sequence of questions makes the situations even worse as the questions with figure answers follow each other during all the second part of the test.

E. Commentaries on answers

The commentaries on answers should be valuated approvingly. Students can see them immediately after acceptance of their answers to a certain question. The commentaries deal with rightness or wrongness of all answers and give extended motivation. However, as commentaries are written in expanded way it is not always perfectly clear which of given answers are right and which are wrong. This kind of situation confuses a student and, already during test passing process, disposes him to negative results.

F. Evaluation system

The answers to certain questions (immediately after acceptance of selected answers) and also total results after finishing the test are assessed in analyzed tests. Assessment is given in points. The maximal achievable number of points and the number of acquired points are shown. The assessing system that was developed together with commentaries after every question should be considered as successful as it gives the student information about his results during the test in an objective and rational manner. However, there are no commentaries of the final test results – acquired level of knowledge, advises how to improve knowledge.

V. RECOMMENDATIONS FOR DEVELOPENT OF HIGH QUALITY TESTS

Based on analysis of 15 tests of e-learning module "Clothing technologies" produced by X University, several recommendations were developed to form high quality tests with questions and answers. They are divided in three groups: general recommendations for development of tests, recommendations for study process control tests and recommendations for valuation of acquired knowledge.

A. General recommendations for development of tests:

- If the study course is developed for wide use, the groups of potential users have to be defined precisely and in accordance with their background, different tests have to be developed for beginners and specialists of production enterprises who have practical experience and preliminary knowledge.
- Questions have to be stated precisely and unmistakably, not excluding the situation

when because of some phrase or term the question can be perceived differently.

- If the text can not give full concept of a question, it has to be supplemented with images, photos, videos, which also help to grasp the information using visual memory. The images can not be used just to design a page this way misinforming a student about its connection with certain question.
- The number of questions included in a test has to be proportional to the volume and complexity of the topic. The test has to reflect all important aspects of the topic and accent most important and harder perceptible information.
- The answers to the questions should be produced as expanded phrases, giving comparatively less importance to answers with figures and terms/words. During the tests the types of answers have to be shuffled not to form monotonous perception of the test, this way reducing the student's attention.
- If students have to remember certain figures, the control of these figures within questions has to be set together with some other information characterizing these figures to make expanded answers with the figures in them.
- Tests have to promote logical thinking of students and knowledge formation process, not improvement of their memory skills.
- Among specially added wrong answers illogical ones can not be used as students could recognize then only because of their irrationality, without even using knowledge in certain topic.
- It is recommended to sort out the conditions of a test performance – to indicate and restrict test performance time and time interval between two reiterative performances. Limiting test performance time, the student would be able to estimate the nature of his knowledge (marginal variants – quick; convincing answering to questions indicates stabile, well-grounded knowledge; and also, long lasting search of right answers trying to find logic in them and comparing answers – shows weak knowledge). Setting a certain time interval between two reiterative performances (one or more days), the student would not be able to repeat the test immediately after the first unsuccessful attempt. This would prevent student from knowingly or not knowingly learning questions and their right answers by heart.
- In test valuation system it is advisable to use both assessment in points and commentaries of answers. In the final assessment of tests it is preferable to include expanded description of acquired knowledge level and recommendations on how to raise it.

B. Recommendations for study process control tests:

- All important information of a certain topic have to be included in a test, highlighting in the right way the most important aspects as well as accenting less important information to make a student positively settle his understanding of a topic during test performance process.
- If the process described in a question has several equally important elements, parts or processes, all of them have to be mentioned in answers, adding one or more wrong variants. This way test performance is not only control of knowledge but also knowledge formation process.
- Questions have to be asked in a sequence that reflects right exposition of the topic or of a certain technological process in a logical sequence to achieve the right understanding of the topic/ process to reduce possible confusion during knowledge formation process.
- If a student passes a test several times, it is advisable to change the sequence of questions after certain number of attempts no to give feasibility to use remembered regularities of the tests and not his own knowledge answering the questions.
- Wrong answers specially included in questions have to reflect frequent mistakes of perception of the study material to reinforce student's attention on them in case of incorrect answers.
- If an expanded commentary is also given with the answer to a question, the right answers have to be clearly accented to let a student unmistakably weigh up the result of his answers.
- In a test comparatively small number of questions has to ask to write down very limited information – figures, formulas. These questions mostly check the memory of students not perception of a topic and stabile knowledge. Memorizing large number of figures and its' checking during a test in a

monotonous way reduce student's interest about study course and do not promote knowledge formation process.

C. Recommendations for valuation of acquired knowledge:

- Questions set in illogical, mixed sequence are advisable to use only valuating students with extended knowledge and practical experience. Illogical sequence of questions helps to valuate deepened and stable knowledge.
- Complex questions in which knowledge of several topics are included can be used in tests to examine final knowledge of a study course, student's deep perception of certain topic and its connection with other topics, the student's ability to use different knowledge in development of certain situations, tasks.

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Interpersonal Relationships as a Prerequisite for Success in Educational Institutions: an Emphasis on Conflict Management

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Abstract - Conflicts in educational institutions are most commonly discussed in the context of conflict management and their impact on the educational process. Although it is acknowledged that conflicts can also be functional, discussions regarding conflicts in the educational sector predominantly revolve around their resolution, reduction or minimization. Despite numerous studies investigating the effects of interpersonal relationships within institutions, there is still room for new research aimed at better understanding this construct, supplementing existing knowledge and resolving uncertainties.

Therefore, the aim of this study is to deepen the existing knowledge of the significance of interpersonal relationships in the context of educational institutions by examining the connection between different styles of resolving interpersonal conflicts, which is the most common way to operationalize the construct of interpersonal relationships and individual-level business success, measured through prosocial organizational behavior and work engagement.

Keywords: interpersonal relationships, conflict, work success, prosocial behavior, work engagement.

I. INTRODUCTION

Interpersonal relationships play a fundamental role in the overall success of educational institutions. Their quality significantly impacts various aspects of an institution's functionality, particularly its effectiveness in managing conflicts. This study delves into the importance and implications of interpersonal relationships in an educational context, focusing on conflict management, formal and informal group dynamics, social support, and their roles in fostering organizational prosocial behavior and work engagement.

II. INTERPERSONAL RELATIONSHIPS IN A BUSINESS CONTEXT – SIGNIFICANCE AND IMPLICATIONS FOR THE BUSINESS SUCCESS OF EDUCATIONAL INSTITUTIONS

Interpersonal relationships at work are an inescapable aspect of organizational life. While people often associate "interpersonal relationships" with friends and family, the significance of relationships with colleagues in the workplace is frequently overlooked. However, considering the amount of time spent at work, these professional relationships are not only critical for business success but also play a vital role in overall life quality [1]. Identified as a significant psychosocial factor in the business context, interpersonal relationships possess the potential to impact well-being, job satisfaction, business performance, and productivity [2]. Furthermore, positive social interactions have been shown to significantly influence physical health, affecting cardiovascular activity, as well as the function of the immune and hormonal systems [3].

Interpersonal relationships have been identified as a significant psychosocial factor in the business context, potentially impacting well-being, job satisfaction, business performance, and productivity [2]. Additionally, positive social interactions are significantly linked to positive physical outcomes, such as cardiovascular activity, and the functioning of the immune and hormonal systems [3].

In educational institutions, where relationships between professor, administration and students are crucial for a successful educational process, understanding and enhancing these interpersonal interactions becomes critically important. The establishment of constructive and supportive relationships can positively influence the efficiency of the teaching process, create a stimulating learning environment, and contribute to the overall success of the institution.

At the organizational level, the results indicate that employees' identification with the organization is associated with enhanced motivation, job satisfaction, group cohesion, and reduced turnover. Liden, Wayne, and Sparrowe [4] find that positive interpersonal relationships are a key predictor of organizational commitment, while Kostova and

Roth [5] state that positive interpersonal relationships are positively linked to team efficiency and effectiveness.

III. Interpersonal Relationships: Formal and Informal Groups

Interpersonal relationships at work encompass a wide range of interactions at both the organizational and group levels. Many employees and members of educational institutions are part of various groups within their organization, which can be formal, such as workgroups and teams, or informal, like workplace friendships [6]. Some organizational groups might be temporary, such as those formed for a specific project [6]. Groups provide a social context within which employees interpret the organization [7]. As such, both formal and informal groups enable the organization to meet the need for belonging among its employees and all members of the institution. This part emphasizes the significance of both structured and informal connections within work and academic settings, highlighting their complexities, advantages, and potential adverse consequences.

IV. Interpersonal Relationships: Social Support and Conflicts

The concept of interpersonal relationships in the business context is exceedingly broad and is commonly operationalized in research through the study of social support and conflicts.

Social support, as a meta-construct [8], covers a broad spectrum of constructs, including emotional, instrumental and structural support. While emotional and instrumental support are conceptually different, research shows a significant correlation between these two forms of social support, which frequently leads to their integration in studies [9].

Within educational institutions, the significance of interpersonal relationships remains equally vital. Favorable social bonds among teachers, professors, staff and students establish an environment conducive to learning and productivity. When educators, administrators, and students uphold encouraging and cooperative relationships, it can lead to decreased overall stress levels, resulting in a more favorable and efficient learning atmosphere. Conversely, tense relationships among educators, administrators, and students may elevate stress and potentially contribute to burnout within the educational community. Hence, prioritizing the cultivation of social support and positive relationships among colleagues and supervisors in educational institutions is imperative, not only for the enhancement of job satisfaction and learning but also for the improvement of the overall educational experience and academic achievements [10].

Conflicts within the workplace are most commonly discussed in the context of conflict management and their potential effects on productivity. Many studies indicate that workplace conflicts have an impact on mental well-being. While it is suggested that conflicts can also be functional for the organization itself, discussions about conflicts in an organizational context primarily revolve around their resolution, reduction or minimization.

A conflict is defined as an interactive process that emerges from incompatibilities, disagreements or differences within or between social entities (e.g. individuals, groups, organizations, etc.) [11]. Conflicts occur when a social entity:

- Needs to engage in an activity that is not aligned with its needs or interests;
- Is dissatisfied with the implementation of its behavioral preferences;
- Desires mutually beneficial resources that may be lacking, causing wants to not be fully met by all [11].

Conflicts can also arise when two or more social entities:

- Have partially exclusive behavioral preferences concerning their joint actions and
- Are independent in executing their functions or activities [11].

In the context of educational institutions, three significant sources of conflict exist, impacting interpersonal relationships and group dynamics:

- Differentiation: variations in goals, values, roles and perceptions among educators, administrators, or students can lead to conflicts. These differences in viewpoints or functions might trigger misunderstandings and tensions among the individuals within an educational setting;
- Task interdependence: conflict can arise due to the reliance of different parties on one another for tasks or responsibilities. In educational institutions, tasks and projects often require collaboration among teachers, administrative staff, or students. Misalignments in task expectations or dependencies can lead to disagreements and conflicts;
- Resource allocation: conflicts can emerge regarding the allocation or distribution of resources such as funding, facilities or educational materials. Disputes about fair

access to resources may arise among faculty, staff or students, creating tensions within the educational community.

Understanding these sources of conflict is vital for educators and administrators to manage and resolve disputes effectively in an educational environment. Addressing these areas proactively can help in creating a more harmonious and productive learning atmosphere for all stakeholders involved.

Considering every organization as a structured unit with established and formalized relationships, conflicts that arise may not solely be interpersonal but may also emerge from the existing structure. Conflicts within educational institutions can extend beyond individual interactions to those arising from the established structure itself. One form of organizational conflict within such institutions can be categorized into two primary types: horizontal and vertical conflicts.

Horizontal organizational conflict is rooted in the opposition between the section of the organization involved in development and planning, proposing new production methods or novel goods, and the production section, resistant to altering its work methodology. These conflicts arise between different parts or subsystems of an organization when one has advanced to a level that is not in harmony with the development of other areas. It's common for administrative and technical services to expand in scale disproportionately compared to the development and growth of production units.

Vertical or hierarchical conflicts constitute another form of specific organizational conflicts. They are clashes between hierarchically different sections, often seen as opposition demonstrated by subordinates to those parts of the organization that are higher in the chain of command. Such conflicts may stem from differences in remuneration or a perception that superiors are abusing their authority.

Understanding and addressing these types of conflicts are crucial within educational institutions to ensure smooth operations, foster an environment conducive to learning, and maintain a positive atmosphere among all members of the educational community.

Conflict resolution styles are categorized based on two primary dimensions, representing an individual's motivational orientations during conflicts: concern for self and concern for others [12]. The first dimension explicates the level (high or low) to which an individual pursues their own interests, while the second dimension focuses on addressing the interests of others. The combination of these two dimensions has resulted in five specific conflict resolution styles [12]:

1. Integration (high concern for self and others)
    - Encourages collaboration among educational community members through openness and information exchange to reach mutually acceptable solutions;
    - This style involves confrontation and problem - solving, aiming for innovative conflict resolution;
    - Demonstrates an interest in understanding differences and a willingness to find creative problem-solving strategies.
2. Obliging (low concern for self, high concern for others)
    - Prioritizes the interests of others over self - interest within the educational environment;
    - Focuses on minimizing differences and emphasizing shared interests to address the needs of others;
    - Manifests selfless generosity or compliance, showing a willingness to accommodate the interests of others.
3. Dominance (high concern for self, low concern for others)
    - Reflects a win - lose orientation and a focus on achieving personal goals within an educational framework;
    - Often involves asserting personal rights and may disregard the needs and expectations of others;
    - Typically seen as a style of enforcing decisions, especially by higher authorities or supervisors.
4. Avoidance (low concern for self and others)
    - Involves indifference towards conflicts, often leading to the postponement or disengagement from resolving disputes;
    - Shows minimal interest in addressing one's own needs or those of others involved in the conflict.
5. Compromise (moderate concern for self and others):
    - Demonstrates a balanced concern for both self and others when

resolving conflicts within educational settings;
- Requires concessions from both parties to achieve mutually acceptable decisions;
- Sits between obliging and dominance styles in terms of addressing the interests of self and others.

In educational institutions, conflict management styles such as integration, obliging and compromise are seen as cooperative approaches. They prioritize collaboration and aim to find solutions through mutual agreement. On the other hand, avoidance and dominance are regarded as uncooperative styles. They often lead to unresolved conflicts and tend to have authoritarian decision - making patterns. These conflict management styles play a crucial role in shaping how conflicts are addressed and resolved in educational settings, affecting the overall dynamics and relationships among those involved.

The literature presents a broad spectrum of conflict resolution methods available for handling conflicts within educational institutions. These methods include voluntary processes that aid individuals in identifying or creating mutually acceptable solutions, either independently or with the assistance of a third - party mediator. Moreover, there are procedures where a third party decides on the conflict resolution method [13].

In Figure 1, potential conflict resolution methods are depicted.

On the left side, methods like negotiation and mediation involve cooperative problem - solving to find an agreement. These methods need teamwork and are flexible and voluntary, potentially improving relationships between conflicting parties. On the right side, methods get more formal. Each person presents their arguments to a third party, who then decides how to resolve the conflict. These methods usually lead to a "win - lose" outcome and often don't consider the relationships or the decision's future impact on the individuals involved [14].

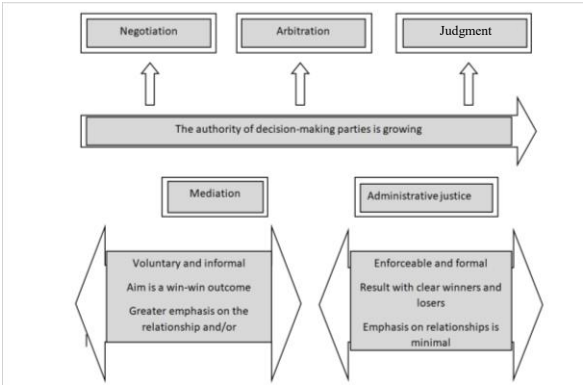

Figure 1. Conflict Resolution Methods

Therefore, there are five ways of resolving conflicts [14]:

1. Negotiation - a process in which conflicting parties voluntarily discuss their differences and work together to find a solution agreeable to both sides;
2. Mediation - a voluntary conflict resolution method in which a third person or group assists those in conflict to negotiate and find a mutually acceptable solution, also helping in transforming their interactions for a better relationship;
3. Arbitration - a method in which a third party makes the final decision on the conflict instead of the involved individuals, either as non - binding advice or a binding process, depending on the agreement of the participants;
4. Administrative justice - conflict resolution through a court or legal body that makes binding decisions within its authority;
5. Judgment - the conflict is resolved with the involvement of a judge or legal professional who makes a binding decision based on arguments presented, formalizing the process.

V. SUCCESS IN THE EDUCATIONAL CONTEXT – ORGANIZATIONAL PROSOCIAL BEHAVIOR AND WORK ENGAGEMENT

Success in educational institutions is a multifaceted concept influenced by various factors. Among these, the role of organizational prosocial behavior and work engagement plays a crucial part in achieving positive outcomes within an academic setting. This study delves into the significance of these behaviors and their impact on the success of educational institutions.

Organizational prosocial behavior, often referred to as OCB (Organizational Citizenship Behavior),

involves discretionary actions that go beyond formal job responsibilities and contractual obligations to benefit the organization [15]. In the context of educational institutions, this can take the form of educators dedicating their time and effort to help colleagues with specific tasks or voluntarily engaging in activities that support the institution's goals.

Work engagement represents an essential element for achieving success within the field of education. It embodies a positive and fulfilling mindset toward one's work, characterized by vigor, dedication and absorption. Vigor denotes a high level of energy and mental fortitude when confronting challenges. Dedication emphasizes a profound sense of importance and enthusiasm for one's professional responsibilities. Absorption indicates complete concentration and immersion in one's tasks and obligations [16].

The relationship between organizational prosocial behavior and work engagement is reciprocal. The outcomes of increased organizational prosocial behavior and work engagement are numerous. Students benefit from a more supportive and stimulating learning environment. Employee job satisfaction and retention rates increase, leading to a positive institutional reputation. Furthermore, higher levels of employee engagement are associated with improved institutional performance, such as research productivity and academic achievement.

VI. CONCLUSION

In summary, this study reaffirms the fundamental importance of interpersonal relationships within the realm of educational institutions, particularly highlighting their role in adeptly managing conflicts. The exploration of diverse dimensions, spanning the contextual relevance of these relationships in the business landscape, their implications for the success of educational institutions, the dynamics of formal and informal groups, the impact of social support in resolving conflicts and the interrelation between organizational prosocial behavior and work engagement, collectively underscores their indispensable significance in enhancing the holistic welfare of these establishments.

Evidently, effective conflict management, rooted in robust interpersonal relationships, serves as a cornerstone for the advancement and prosperity of educational institutions. As educators, professors, administrators and students diligently nurture and perpetuate these relationships, the prospects for achieving excellence and success within educational environments become increasingly promising. Beyond the scope of conflict resolution, these relationships play a pivotal role in fostering cooperation, communication, and heightened engagement, thereby enriching the overall prospects and positive outcomes of educational institutions.

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Design and Implementation of a Lambda Calculus Interpreter

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Abstract - This paper thoroughly examines the theory of lambda calculus, with a special focus on alpha-conversion and beta-reduction. Both basic and typed lambda calculus are covered. Following the theoretical foundations, the paper presents the implementation of a lambda calculus interpreter using the textX library. A user application has been created through the Flask framework, enabling users to perform interactive executions of lambda calculus expressions. As a final result, a functional lambda calculus interpreter has been developed, useful for further practical applications of this mathematical formalism.

I. INTRODUCTION

Lambda calculus is a computational model first introduced by mathematician Alonzo Church in the 1930s as part of his research in mathematical logic and computing 0. This model was fundamental to the development of computer science theory and serves as the basis for functional programming. The concept of lambda calculus emerged from Church's work on the decidability problem, known as the Entscheidungsproblem, posed by David Hilbert. Hilbert challenged the mathematical community to find a general process that could determine whether any mathematical statement is true or false 0. Church proposed lambda calculus as a potential solution. Lambda calculus initially defined the concept of a universal function or lambda functions, which today are fundamental to functional programming languages. Church demonstrated how functions could be modeled as abstract or anonymous functions, which do not require naming. Although lambda calculus was originally developed as a theoretical concept, it has had a significant impact on computing. Lambda calculus provided the basis for the development of Lisp, the first functional programming language 0. Since then, concepts from lambda calculus have been implemented in many programming languages, including Python, JavaScript, Haskell, and many others. The goal of this paper is to implement a software solution that allows users to execute functions written in the syntax of untyped pure lambda calculus and to view each step in the expression evaluation process.

II. THEORETICAL FOUNDATIONS

Lambda calculus is a model of computation, or in other words, it is a formal mathematical system. It uses a unique notation and a set of rules for evaluating its expressions. In lambda calculus, an abstraction refers to the process of defining a lambda function. Specifically, an abstraction in lambda calculus is an expression that describes a function by explicitly indicating which variables are its arguments. It takes the general form of λx.E, where λ denotes the abstraction, x is the variable (argument), and E represents the expression in which x is bound. The role of abstraction in lambda calculus is to create anonymous functions, or lambdas, which are functions not bound to an identifier.

The only concept in lambda calculus, apart from abstractions, is applications. The process of application involves applying a function to a specific variable, that is, passing an argument to the function and replacing the given argument in the function's body. Applications are left associative, and any lambda expressions can be applied to each other. In the case of untyped pure lambda calculus, the rules for forming lambda expressions are predefined and applied in an identical manner, regardless of the specific context in which the expression appears. This makes the grammar of lambda calculus a context-free grammar, according to Chomsky's hierarchy 0.

Beta-reduction is one of the most important processes in lambda calculus. It represents the application of a function to its argument and the return of the result. Formally, beta-reduction can be defined as follows: if (λx.M)N is a beta-reduced expression, then x is replaced with N within the expression M. This process is repeated as long as possible. Alpha-conversion represents the process of changing the name of a variable in a lambda calculus function. It resolves cases where name conflicts occur within the expression. Alpha-conversion introduces the concept of alpha-

equivalence. Two lambda expressions are said to be alpha-equivalent if and only if one expression can be converted into the other expression by alpha-conversion of bound variables only. The concept of alpha-equivalence is very significant in the context of Church encodings. Alpha-equivalence provides the ability to check whether two expressions have the same structure.

Alpha-conversion plays a crucial role in maintaining clarity and consistency in lambda calculus expressions. It allows expressions to be more easily manipulated and analyzed, relieves programmers of the duty to manage name collisions, and provides an additional layer of abstraction.

An alternative to alpha-conversion is De Bruijn indices, proposed by Nicolaas Govert de Bruijn 0. The main idea is to eliminate the need for renaming altogether at the outset, by naming variables according to a calculated index. Each variable is represented by a number indicating its distance from the abstraction that defines it. For example, if the given abstraction is λx.λy.x(y) and De Bruijn indexing is applied, the expression becomes λλ.2(1) as the variable x is bound to the abstraction two places away from the variable's definition, and y is replaced with the index 1 as it is the first parameter appearing from right to left that defines that variable. A major advantage of De Bruijn indices is the ease of checking equivalence between expressions. Two expressions marked with De Bruijn indexing are equivalent if they are syntactically equivalent, unlike alpha-converted expressions. However, the downside of De Bruijn indices is that expressions become less readable to humans after conversion. Since the goal of this paper is to understand lambda calculus and to demonstrate each step of evaluation to the user, alpha-conversion has been implemented instead of De Bruijn indices, although the latter is more commonly chosen in practice.

Eta-reduction refers to a method of simplifying expressions by discarding their unnecessary arguments. Unlike alpha-conversion and beta-reduction, eta-reduction is not essential for reducing lambda calculus expressions 0. In other words, an expression that is not eta-reduced will have the same normal form as an expression that is eta-reduced. Formally, η-conversion can be expressed as follows: λx.(f x) ≡ f, provided x does not exist in the set of free variables in f. This rule is part of the foundation for the concept of extensional equality of functions, where two functions are considered equal if they return the same result for the same argument, regardless of how they are internally structured. This concept is fundamental in functional programming and formal logic, where equivalence in value (or behavior) is often more important than structural equivalence 0. The use of eta-reduction is fundamental in a style of programming called point-free programming, which is often found in purely functional programming languages like Haskell 0. The main idea of point-free programming is that functions are not parameterized but rather composed of other functions.

Untyped, pure lambda calculus encompasses only the concepts of abstraction, application, and atomic values. With this in mind, Alonzo Church developed a way to represent any standard value using just these three concepts, using the Church encodings 0. It is a way of representing any natural number, using only the atom which represents the number 0, and the successor function. Any other number is represented by applying the successor function the appropriate number of times to the atom that represents zero. It is important to note that it doesn't matter what atom is used for 0, nor what function is applied to this symbol. As long as the expression has the structure of applying the same function n times to an atom, it can be thought of as the number n, which is a powerful abstraction.

System-F, also known as second-order lambda calculus, is an extension of simply typed lambda calculus that emerged in the 1970s. The upgrade introduced by System-F is the creation of polymorphic types 0. The parameter types in simply typed lambda calculus are limited to a predefined set of types, which is not the case with System-F. It allows for the abstraction of types in lambda expressions, effectively creating new types. This enables the creation of polymorphic functions that

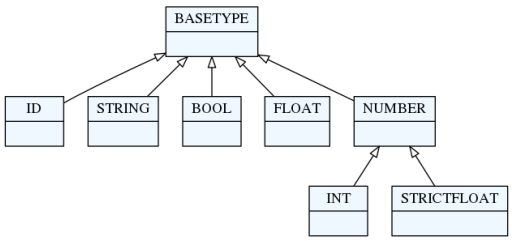

Figure 1. Type hierarchy in TextX 0

can operate on a larger number of types. For example, creating an identity function in simply typed lambda calculus implies creating an identity function for each defined type, while in System-F, this can be encompassed by a single function. A similar example can be given for a case more commonly encountered in practice, such as a function operating on a list of a generic type.

The Turing machine, created by Alan Turing in 1936, is a mathematical model that describes a machine manipulating an infinitely long tape divided into cells 0. All that the machine can do is position itself on a particular cell, read the symbol on the cell, and based on the state and transition function, modify the symbol in the cell and possibly move to a cell to the left or right. The Turing machine was created in response to the same problem that Alonzo Church addressed when creating lambda calculus – the problem of computability. Any formal system that can simulate a Turing machine is called a Turing complete system, and all modern programming languages are, conditionally speaking, Turing complete languages.

The Church-Turing thesis suggests that the Turing machine and lambda calculus are equivalent concepts – everything that can be computed with a Turing machine can also be computed with lambda calculus and vice versa 0. It is important to note that the thesis does not cover computations that involve an infinite amount of time and resources, nor does it cover nondeterministic, quantum computations, or other non-classical models beyond the scope of the Turing machine and lambda calculus. Turing, like Church, came to the answer to the decidability problem – it is not possible to create the system Hilbert described.

III. INTERPRETING LAMBDA CALCULUS

The implementation of an interpreter for untyped pure lambda calculus was realized in the Python programming language using the textX tool. TextX is a meta-language used for defining domain-specific languages 0. It allows the grammar of the desired language to be described in a specific format, based on which textX builds a meta-model of the language in the form of Python classes and a parser for the given language. The parser enables the analysis of expressions written in the given language and the automatic construction of a graph of Python objects of the meta-model. TextX supports typing, which are also regular expressions. The difference is that in the resulting Python model, typed expressions will be converted into the corresponding Python type, while all matches with ordinary regular expressions will remain as string type. Figure 1 shows the hierarchy of textX types.

Rule ID: Recognizes identifiers common in programming languages, similar to the C programming language, consisting of letters, digits, and underscores. The regular expression describing this rule is '[^\d\W]\w*\b'. When such a match occurs, the value is converted into a string object.

Rule INT: Identifies an integer number and converts the value into a Python int instance.

Rule FLOAT: Recognizes a floating-point number and converts it into a Python float instance. To differentiate between int and float types, a NUMBER type is introduced. The FLOAT rule is not strict; it will also convert int types into float instances. The resolution of this problem introduces the next rule.

Rule STRICTFLOAT: Recognizes a floating-point number. This match will be converted into a Python float instance. 'STRICTFLOAT' will not recognize 'INT'.

Rule BOOL: Identifies the words true or false and converts them into a Python bool instance.

Rule STRING: Recognizes text enclosed in quotes, and the value will be converted into a Python str instance.

A Sequence represents a series of textX rules that must be matched in order to satisfy the rule.

Options and repetitions in textX are defined similarly to how they are defined in most regular expression grammars. A question mark indicates a rule that may or may not be satisfied, an asterisk indicates a rule that can be fulfilled any number of times. The plus symbol signifies that the rule must be fulfilled at least once but can be more, and the hash symbol indicates that the rule can be satisfied in any order of the listed rules.

Another important capability of the textX tool is visualization. TextX, using the Graphviz library, enables the visualization of the meta-model, the model created by parsing, as well as the parsing tree 0. For an example of defined grammar,

```
HelloWorldModel: "hello" to_greet+=Who[','];
Who: name = /[^,]*/;
```

We get a visualization presented on figure 2.

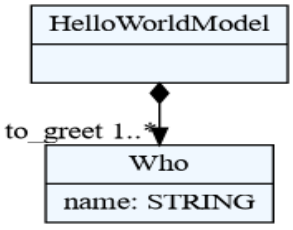

Figure 2. Graph of the example meta-model 0

Parsing the following text:

```
hello World, Solar System, Universe
```

We get a model visualization like presented on figure 3.

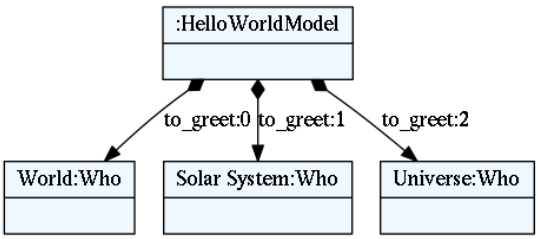

Figure 3. Meta-model graph for a more complex example 0

The grammar designed for the interpreter in this paper is as follows:

```
Statement:
   Assignment | Expression
;

Assignment:
   'let ' (name=INT | name=ID) '=' expression=Expression
;

Expression:
   Abstraction | Variable | Application
;

Variable:
   (name=INT | name=ID)
;

Abstraction:
   'λ' parameter=Variable '.' expression=Expression
;

Application:
   '(' left=Expression right=Expression ')'
;
```

The grammar was designed relying on the theoretical foundations previously described.0

IV. IMPLEMENTATION OF BETA-REDUCTION

The next step in creating the interpreter is to implement beta-reduction. TextX produces a graph, or a tree of Python objects, and beta-reduction will perform substitutions of parts of this tree from one place to another, thereby reducing it. More precisely, a new, reduced tree will be constructed. Beta-reduction will not be applied in the case of name assignment rules, as it will be done during the next usage, or evaluation. For each type of object in the meta-model, a function is defined that performs beta-reduction on that object. When it comes to beta-reductions of variables, no reduction occurs if the variable is not in the named expressions. If it is the name of some named expression, the beta-reduced expression of the corresponding named expression is inserted into the tree in its place. This process is described by the following function:

```
def beta_reduction_variable(node: Variable):
    variable = Variable()
    variable.name = node.name
    if node.name in named_expressions:
        named_expression_str =
named_expressions[node.name]
        named_expression =
lambda_meta.model_from_str(named_expression_str)
        return beta_reduction(named_expression)
    return variable
```

Reduction of abstraction results in an abstraction with beta-reduced parameters and body. The process of reducing abstraction is implemented as follows:

```
def beta_reduction_abstraction(node: Abstraction):
    abstraction = Abstraction()
    abstraction.parameter =
beta_reduction(node.parameter)
    abstraction.expression =
beta_reduction(node.expression)
    return abstraction
```

The last type of expression that undergoes beta-reduction is the application. Several cases need to be considered. If an abstraction is found on the left side of the application, it is necessary to perform alpha-conversion between the left and right sides, whether the right side is a variable or another abstraction. In every other case, the result is a new application that has both the left and right sides reduced. Also, in this case, it is necessary to primarily perform the beta reduction of the variable if it is a named expression.

```
def beta_reduction_application(node: Application):
    global applied

    if type(node.left) is Variable:
        node.left = beta_reduction(node.left)

    if not applied and type(node.left) is Abstraction:
        applied = True
        if type(node.right) is Variable:
            reduced_variable =
beta_reduction_variable(node.right)
            converted =
alpha_conversion(node.left.expression,
node.left.parameter, reduced_variable)
        else:
```

```
        converted =
alpha_conversion(node.left.expression,
node.left.parameter, node.right)
      return converted
   else:
      application = Application()
      application.left = beta_reduction(node.left)
      application.right = beta_reduction(node.right)
      return application
```

These functionalities can be merged into a singular universal function:

```
def beta_reduction(node):
   if type(node) is Application:
      return beta_reduction_application(node)
   elif type(node) is Variable:
      return beta_reduction_variable(node)
   elif type(node) is Abstraction:
      return beta_reduction_abstraction(node)
```

V. IMPLEMENTATION OF ALPHA-CONVERSION

Alpha-conversion is implemented by following its theoretical description in the chapter above. Functionalities of alpha-conversion are utilized by beta-reduction. It is necessary to keep in mind different scenarios of reduction, just like with beta-reduction. While interpreting an expression, alpha-conversion is handles both the righthand side and the lefthand side, which is implemented with the following Python function:

```
def alpha_conversion_application(node: Application,
to_convert, converted):
   application = Application()
   application.left = alpha_conversion(node.left,
to_convert, converted)
   application.right = alpha_conversion(node.right,
to_convert, converted)
   return application
```

Handling variables is a trivial case, because the alpha-conversion doesn't change standalone variables. Only a node must be created, so that it can be added to the resulting expression tree, just like in the function below.

```
def alpha_conversion_variable(node: Variable,
to_convert, converted):
   if type(to_convert) is Variable:
      if node.name == to_convert.name:
         return converted
   variable = Variable()
   variable.name = node.name
   return variable
```

The last, most complex case is the alpha-conversion of abstraction. The least complex case occurs if the renamed term does not appear in the abstraction variables. Then, there is no need for renaming. If the term appears in the abstraction, it is necessary to create a new free name for the given variable. The creation of a new name is done in lexicographical order, until the first free name is created. This can be achieved using the following two functions:

```
def generate_next_variable_name(unavailable_names):
   word = "a"
   MAXIMUM_NAMES_LIMIT = 1_000_000
   for _ in range(MAXIMUM_NAMES_LIMIT):
      if word in unavailable_names:
         word = nextWord(word)
      else:
         return word
```

```
def nextWord(s):
   if s == " ":
      return "a"
   ind = next((i for i, c in enumerate(s) if c != 'z'), -1)
   if ind == -1:
      s += 'a'
   else:
      s = s[:ind] + chr(ord(s[ind]) + 1) + s[ind+1:]
   return s
```

Using these two functions, for all occupied names composed of a single character [a..z], the name "za" is created, and if it is also occupied, the name "zb" is created, and so forth. The implementation is limited to a million possible words, which is an arbitrary number that satisfies the software use case. Using these two functions, the implementation of alpha-conversion for abstraction can be completed in the following way:

```
def alpha_conversion_abstraction(node: Abstraction,
to_convert, converted):
   global unavailable_names
   abstraction = Abstraction()
   unavailable_names = unavailable_names |
free_variables(converted) | bound_variables(converted)
   if node.parameter.name in unavailable_names:
      changed_name =
generate_next_variable_name(unavailable_names |
{node.parameter.name})
      changed_parameter = Variable()
      changed_parameter.name = changed_name
      abstraction.parameter = changed_parameter
      unavailable_names.add(changed_name)
      new_expr = alpha_conversion(node.expression,
node.parameter, changed_parameter)
      abstraction.expression =
alpha_conversion(new_expr, to_convert, converted)
```

```
    else:
        abstraction.parameter =
alpha_conversion(node.parameter, to_convert, converted)
        abstraction.expression =
alpha_conversion(node.expression, to_convert,
converted)
    return abstraction
```

With this functionality, alpha-conversion is fully implemented. As already mentioned, De Bruijn indexing is more suitable for most interpreter implementations. It would be significant in the described solution due to the ease of comparing expressions and would enable a simple method for Church encoding. Displaying the steps of interpretation is the primary functional requirement of this solution, thus alpha conversion was chosen instead.

VI. IMPLEMENTATION OF THE LAMBDA CALCULUS INTERPRETER

By implementing alpha-reduction and beta-conversion, the main parts of the interpreter have been implemented. The only thing remaining is their adequate application to the parsing tree.

As defined in the language grammar, a statement can either be an assignment statement or a lambda expression. The interpreter processes these two cases differently. In the case of an assignment statement, it is necessary to save the variable name in the dictionary of named expressions. The task of this functionality will not be to first process the expression, but to save it in its original textual form, as shown in the code below.

```
def add_named_expression(input_model):
    named_expressions[input_model.name] =
repr(input_model.expression)
    return [f'Added {input_model.name} =
{repr(input_model.expression)}']
```

The functionality of reduction is a convergence algorithm, which means that iteration is performed as long as changes occur. Pure untyped lambda calculus allows for beta-divergent expressions; hence the maximum number of iterations is set to an arbitrary value of 100. A change is detected by the act of function application – if an application occurs, the algorithm must attempt to apply the function again. When there are no more applications that the interpreter can evaluate, the interpretation is complete. The code that performs the described functionality is as follows:

```
def perform_reduction(input_model, user):
    i = 0
    applied = True
    evaluation_steps = []
    print(type(input_model))
    clear_unavailable()
    while applied and i < MAX_ITERATIONS:

evaluation_steps.append(model_to_string(input_model))
        input_model = beta_reduce_and_save(input_model,
i, user)
        applied = was_applied()
        set_applied(False)
        i += 1
    return evaluation_steps
```

Function that unifies these two functions based on the class type of the root node is implemented in the following way:

```
def handle_model(input_model, user):
    if type(input_model) is Assignment:
        add_named_expression(input_model)
    else:
        perform_reduction(input_model, user)
```

In the previously mentioned code snippets of this chapter, variables with names like 'user' appear, as well as side effects of functions that have not been explained. All the details of such implementation specifics will be explained in the next chapter, which describes the user application.

VII. FLASK APPLICATION

Flask is a micro web framework for the Python programming language, created with the idea of being simple to use while providing all the functionalities for building complex web applications 0. Flask focuses on minimalism and flexibility, having fewer built-in features than modern frameworks, but this allows for greater flexibility in designing architecture and choosing programming tools.

Flask provides mechanisms for managing web requests and responses, URL routing, sessions, templating using the Jinja2 template system, and much more. It also supports various extensions that enhance its functionality, such as extensions for forms, authentication, etc.

Flask is capable of server-side rendering (SSR), which is suitable for the needs of the application discussed in this work. A limited number of HTML pages are needed, serving only as an interface for the interpreter, without more complex logic.

Details of Flask Application Implementation:

Users of the web application are not authenticated during use. They are assigned a session, as well as a UUID for the session 0. During interpretation, images of parsing models, i.e., models built by the textX tool during parsing, are stored on the file system of the interpreter. Each image of evaluation is placed in a folder whose name is linked to the identification text of the user session. Their format is SVG, so there is no issue in loading them within Jinja2 templates, i.e., HTML, which natively supports such an image format. An example of use is shown in the sequence diagram in figure 4. Data stored in the session, besides identification, include the time of session creation, error data if an error occurs, and the steps of the last evaluated expression.

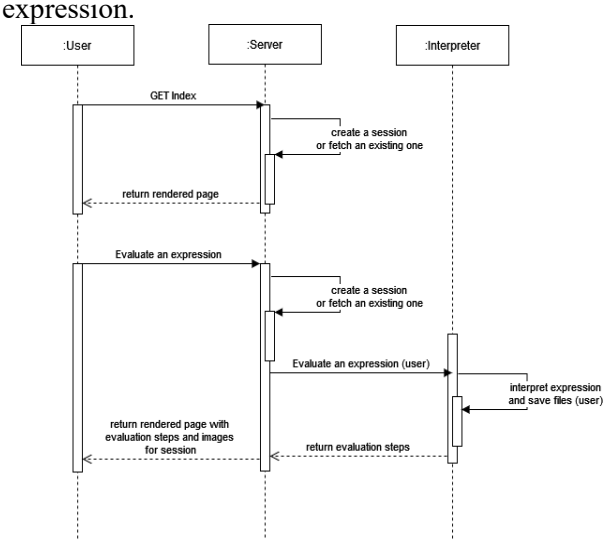

Figure 4. Sequence diagram of the basic use case

The diagrams generated by textX can occupy significant memory, and there can be an arbitrary number of evaluations by an arbitrary number of users. Flask supports the concept of request filters, i.e., the calling of certain functions with any web request. Using this mechanism, a function for clearing data from the file system has been defined. Session folder cleanup is performed if more than ten minutes have passed since the last use of the session (the last request related to that session). It is not expected that the number of users will be large enough to create excessive memory usage on any web server.

VIII. USE CASE

Upon arriving at the website, the user has access to three pages: the home page, a page containing the grammar of the language and the theory of lambda calculus, and a page that contains examples of lambda expressions. The home page is shown on figure 5.

Figure 5. The index page of the application

The user enters the lambda expression they wish to evaluate in a text input field and, upon pressing the Enter key, receives a result if the given lambda expression can be evaluated. In this way, two displays are obtained on the same page during the expression evaluation. The first display provides the steps of evaluation in the form of successive lines of text expressions, as shown in figure 6.

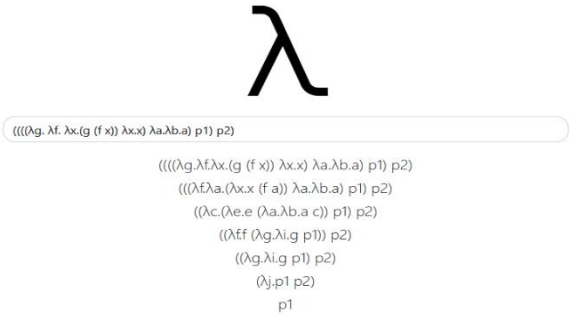

Figure 6. Textual view of the **evaluation** steps

In the second display, there is a gallery of images that textX generated during evaluation, as shown ion figure 7. The user can navigate through the gallery by pressing arrows. Each image in the gallery contains a tree that was generated, as well as the corresponding expression for which the tree was generated. In the figure **Error! Reference source not found.**8 the subsequent step was shown.

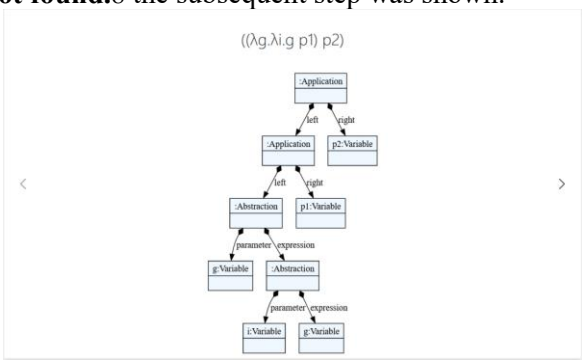

Figure 7. Evaluation step

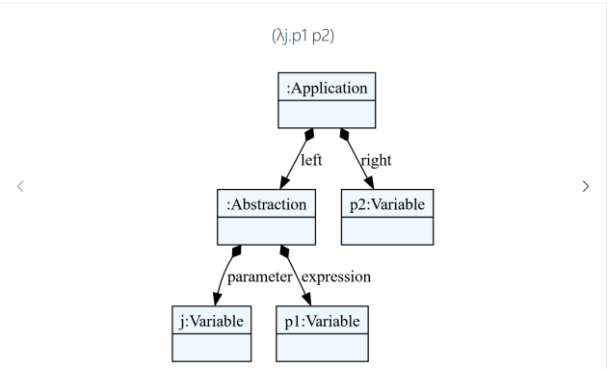

Figure 8. Evaluation step

IX. LIMITATIONS AND IMRPOVEMENTS

When using named expressions, the interpreter at the time of use unfolds the expression into a tree of objects representing it and inserts it at the point of occurrence. There are no implemented limitations on user input, so the user can enter arbitrarily long or complex input. There are limitations in the number of steps during evaluation; however, paradoxical expressions can be detected before the interpreter reaches the maximum number of steps by memorizing the evaluation of the previous step. Comparing two interpretation trees would be necessary for this functionality, as well as the implementation of eta-reduction.

Named expressions must be unfolded into their corresponding expression used during the entire evaluation and finally shown to the user. If tree comparison were implemented, it would be possible to translate each expression into its named pair before displaying evaluation steps, if one exists. This would allow users to more easily reason about the steps of evaluation. A similar effect could be achieved without comparing two trees, by coloring expressions. Each tree node could be extended with a field indicating its color or name. Then, during evaluation, named expressions could be unfolded into a form that would preserve the color. Finally, a color legend could also be displayed to the user. The drawback of this approach is that colors would need to be carefully managed during alpha-conversion and beta-reduction.

The dictionary of named expressions is not tied to the user session but is global, which is a limitation that would first need to be addressed upon releasing the application. A solution could easily be implemented by extending the user session with this dictionary, as well as refactoring alpha-conversion and beta-reduction to use that dictionary. Additionally, each user could be given insight into the named expressions. There is currently no display of existing named expressions, which would be a problem for more complex use. A special command like help could be added to list the current state of the dictionary. Another point of expansion would be insight into previously executed expressions, similar to the insight into previously executed commands on Unix operating system consoles.

Error handling in the application is not adapted to users, but to the application developer. Errors are forwarded to the interpreter page, regardless of their nature. This approach is appropriate for syntax errors recognized by textX, as textX gives a customized output of where exactly the error occurred. However, other possible errors could be displayed more adequately.

An additional enhancement could be the extension of untyped lambda calculus to a typed version. A type system would make the application easier to use, as the responsibility for defining some default values, like numbers, would not be left to the user. Some basic data types that could be added are Boolean values, strings, and natural numbers. Typing the lambda calculus avoids a whole class of problems of paradoxical expressions.

X. CONCLUSION

In this paper, the process of designing and implementing an interpreter for lambda calculus is presented. The initial chapters describe the theoretical foundations of lambda calculus, which are essential for building the interpreter and understanding its operation. The theoretical foundations include the syntax of lambda calculus, the set of valid lambda expressions, scopes and substitution of variables, β-reduction, α-conversion, Church encodings. Additional theoretical explanations added are De Bruijn indices, n-reduction, typed lambda calculus, and System-F, which form the basis for potential further extensions of the interpreter. The implementation details of the interpreter are also described. The basics of the textX meta-language, which was used to develop the grammar of lambda calculus, are shown. It is demonstrated how the grammar is implemented and how to handle objects produced by textX. The steps for beta-reduction and alpha-conversion in the Python programming language are explained, as well as the operation of the entire interpreter.

Subsequently, the paper describes the implementation of a Flask application that uses this interpreter, detailing its implementation and integration methods. It shows how users and their sessions are managed. Various practical examples of

using the interpreter, as well as visual examples of lambda expression interpretation, are presented.

Finally, potential limitations of the interpreter and proposed improvements are explained. These limitations include challenges with some aspects of implementation and potential paths for further optimizations and enhancements.

This paper provides a detailed insight into the process of creating an interpreter for lambda calculus, which represents one of the most fundamental and powerful concepts in the world of functional programming. Through a detailed review of the process, the deep complexity of this discipline is analyzed. Studying lambda calculus, despite its theoretical complexity, offers an accessible and practical insight into the field of mathematical logic and functional programming. The paper demonstrates the transformation of these demanding theoretical concepts into a real software product, including a detailed explanation of all steps in this process.

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Wordpress as a Website Development Platform – a Case Study

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Abstract – Considering that web marketing is an integral part of the business representation of any company, organization or an institution, as well as that its basic element is a website, its development and maintenance require special attention. In this context, the tools that can be used to create websites, i.e. content management systems, are of particular importance.

This paper presents the features of the Wordpress, as one of the most commonly used tool in this field. The application proved to be reliable for the development of dozens of websites for the needs of different clients, while only one was selected for the case study – the Ethno Village website. The emphasis is on the features used for the development of this site. The findings of this work can be used in planning the development of future sites, regarding the selection of the application, as well as the development strategy, based on the example of a good practice.

I. INTRODUCTION

In the digital age internet marketing is a key element of a successful business. Its ability to reach and target the right audience, measure results and enable interaction with users, makes it an indispensable tool for achieving competitive advantages and business goals. [1]

It is clear that internet marketing strategy certainly means more than creating a website, while, on the other hand, a website is a key element in the "implementation" of the strategy. If it doesn't work well and doesn't offer consumers what they want, then even the best strategy can be ineffective. [2] Considering the development of modern websites, WordPress stands out as one of the most popular Content Management System (CMS) systems. [3-6] CMS is a software platform that enables the creation, editing and management of digital content on a website, without the need for programming or advanced technical skills. [3,7-9] This paper presents the features of the Wordpress, used for the development of the Ethno Village website. The findings of this work can be used in planning the development of future sites, regarding the selection of the application, as well as the development strategy, based on the example of a good practice.

II. WORDPRESS

WordPress is known for its ease of use, flexibility and broad community support. With its intuitive user interface, it allows even non-technical users to manage the website easily. In addition, WordPress provides a wide spectar of themes and plugins that enable adjustment of website design and functionalities according to specific needs.

One of the key advantages of WordPress is its scalability. This platform is suitable both for smaller websites, such as blogs and personal websites, as well as for more complex web applications and corporate websites. Also, WordPress provides multilingual support, making it an ideal choice for websites with a global presence.

WordPress is also known for its active community of users and development teams. There are free and comercial themes and plugins that can be used to extend the functionality of a website. Also, various guides, tutorials and forums are available to support solutions of specific challenges during website development. [4]

The advantages of WordPress are:

• Ease of use: WordPress stands out for its intuitive user interface and ease of use. Regardless on the level of technical knowledge, it may be learned very quickly how to add, edit and manage website content.

• Large community of users: WordPress has an active community of users and development teams. This means that there are many resources, guides, tutorials and forums where programmers can find support and solutions for various challenges during website development.

• Customization and flexibility: WordPress provides a wide variety of themes and plugins that enable customization of the look and functionality of the website according to specific needs. This flexibility allows creation of unique websites that suit the needs of different professions.

• Scalability: WordPress is a scalable platform, which means that a website can be easily scaled as the business or project expands. Regardless on the size or complexity of the website, WordPress has the ability to expand and adapt to the new requirements [5].

Like any other technology, WordPress also has some drawbacks. Some of the disadvantages of WordPress are:

• Mandatory maintenance: In order to ensure the optimal functioning of the website, it is necessary to regularly update the WordPress version, themes and plugins. Also, it is necessary to regularly perform security checks in order to enable protection against potential attacks or hacking.

• Possibility of slower loading: Depending on the chosen theme and plugins, a WordPress site may have a slower loading time compared to some other technologies. It is important to choose themes and plugins carefully to ensure a fast and efficient user experience [5].

Despite these flaws, WordPress is a website development tool that has many advantages and provides the ability to create professional and functional websites for a variety of clients..

III. CASE STUDY: CREATION OF A WORDPRESS SITE FOR AN ETHNO VILLAGE

When developing the design and structure of the website for the ethnic village "Trofej", the goal was to create an attractive and intuitive website that reflects the rich culture and traditions of the region, as well as to attract visitors who are interested in an authentic experience. Many years of experience in creating websites of the authors of the paper have shown that in such cases, warm tones, natural elements and authentic symbols should be used, which will create the atmosphere of the ethnic village and highlight its uniqueness. The site design and structure plan includes the creation of the following pages:

• The home page of a website should be well organized in order to attract visitors immediately, at first glance. A rich photograph of the ethno village was used as a background, along with a title bar containing a welcome note and a brief description of the ethno village. A call-to-action button that leads to an accommodation or event reservation has also been added.

• About us: This section provides detailed information about the ethnic village "Trofej". It contains the history of the ethno village, its mission and values, as well as the peculiarities that make it unique. There is also a photo gallery that shows the authenticity of the ethno village and attracts visitors to explore more.

• Accommodation: In this section, visitors can find all relevant information about the accommodation units offered by the ethno village. Each unit has its own page with a detailed description, photos, prices and availability. A reservation system is also included and allows visitors to check availability and book accommodation directly through the site.

• Restaurant: This section presents the restaurant of the ethno village "Trofej" and offers visitors information about the menu, traditional dishes and special offers. It includes a reservation system for the restaurant so that visitors can book their place and enjoy authentic cuisine.

• Activities and events: This section shows the various activities and events that visitors can experience in the ethno village "Trofej". Each activity has its own page with a detailed description, schedule and possibility of booking. It also includes a calendar of events so visitors can keep up with current events.

• Contact: In this section visitors can find the contact information of the ethno village, including address, phone number, e-mail and working hours. There is also a contact form so visitors can send an request directly.

During the process of creating the design and structure of the site, Elementor, a powerful tool for creating websites within WordPress, was used. This platform allows flexibility in creating unique and custom designs, as well as easy content management. Given that the goal was to create a website without using ready-made themes, Elementor itself was used to manually design all pages and achieve the desired look and functionality.

Figure 1 shows the front page of the website. The following functionalities have been implemented on the site:

- Accommodation reservation (Figure 2): To implement the accommodation reservation, a suitable plugin was used, which allows visitors to send a request for the reservation of a specific accommodation unit. On the accommodation page, visitors can see overnight prices in certain units, as well as brief descriptions of the capacity and contents of the accommodation unit itself. After choosing the desired unit, they are redirected to the reservation form where they fill in their contact information.

Figure 1. Homepage of Ethno Village website

After successfully filling out the form, by pressing the "Send" button, the data from the form will be sent to the e-mail address of the ethno village.

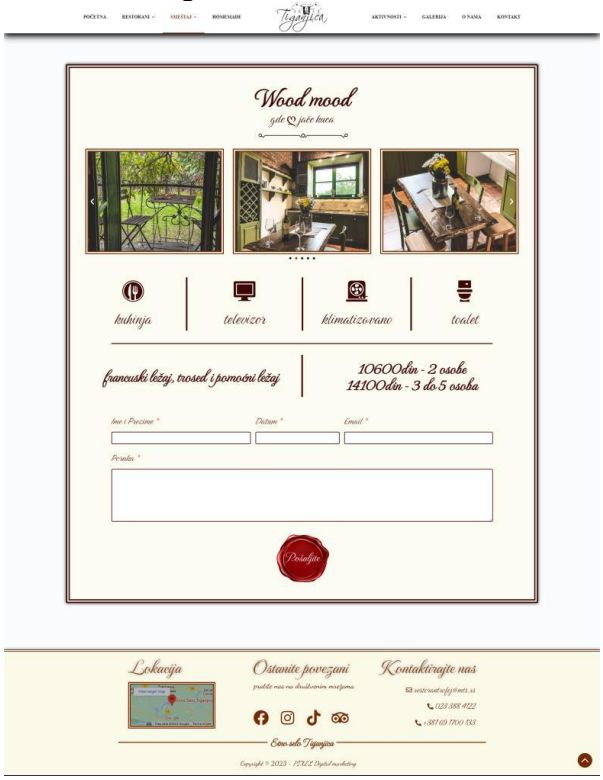

Figure 2. Example of accommodation booking and social network integration

- Reservation in restaurants: In order to make it possible to reserve a table in a restaurant, a reservation system that allows visitors to reserve their place in advance was implemented. On the restaurant page, visitors can choose the desired date, time and number of people for the reservation. After entering the necessary information, they press the "Book" button. The booking confirmation is also sent via e-mail.
- Contact form: On the Contact page, a contact form that allows visitors to directly send questions, comments or requests through the site has been implemented. The form is easy to fill out and includes fields such as name and surname, e-mail address, phone number, title and message. After clicking the button to send a message, the data from the form is automatically sent to the specified e-mail address. This enables easy and direct communication with visitors.
- Photo gallery (Figure 3): In the part of the site that shows the ethnic village "Trofej", a photo gallery that shows the authenticity of the village, its objects, interiors and surroundings has been implemented. The gallery is organized in a way that allows visitors to view photos and explore

different aspects of the village. Also, the gallery has been optimized so that images load quickly and display in a high resolution.

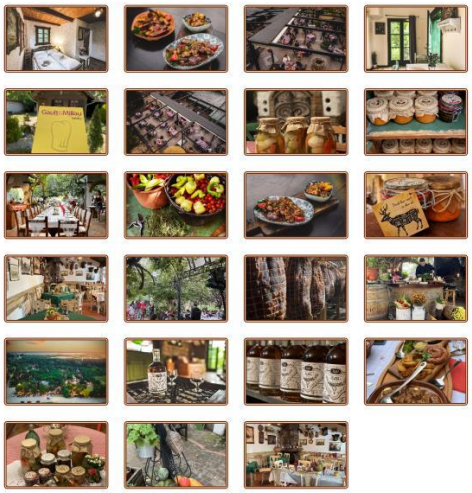

Figure 3. Gallery from the ethno village website

- Integration of social networks (Figure 2): In order to enable easier sharing of content and connection with the targeted audience, integration with social networks has been implemented. On all pages of the site there are buttons with profiles on platforms such as Facebook, Tripadvisor and Instagram.

Through the implementation of these functionalities on the website of the ethno village "Trofej", it is ensured that visitors have a positive user experience and all the necessary opportunities to interact with the content and services that are provided.

After the successful implementation of the functionalities on the website of the ethno village "Trofej", the next step was to test and optimize the site to ensure that all functionalities work properly and that visitors have a qualitative user experience.

After the completion of the website of the ethno village "Trofej", an evaluation of the results was carried out and the user experience was analyzed in order to evaluate the success of the project and identify opportunities for further improvement.

One way to measure the success of the site was to collect feedback from visitors. The possibility for comments and ratings on individual pages was opened so that users could express their impressions and suggestions. Also, analytical tools were used to monitor the number of visits, average time spent on the site and other relevant metrics.

Taking into account feedback and analytical data, it was determined that the website of the ethno village "Trofej" has a positive response from visitors.

IV. CONCLUSION

This paper presented the features of the Wordpress, as one of the most commonly used tool in the field of website development, used for the development of the Ethno Village website. Through an elegant yet ethnic design, functional reservation forms and overview sections, the site allows visitors to explore the offer of the ethno village and get all the necessary information. The integration of photo galleries, guest reviews and location maps further enhances the user experience and encourages visitors to visit the ethno village. The site is visually attractive, adapted to devices of different sizes and optimized for fast loading. Also, it uses clear and intuitive navigation so that visitors can easily find information. Through attractive designs, relevant information and functionalities, websites, such as the "Trofej" ethno village website, have become powerful tools for attracting visitors, providing information and achieving the goals of business entities. The findings of this work can be used in planning the development of future sites, regarding the selection of the application, as well as the development strategy, based on the example of a good practice.

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Enhancing Educational Practices through 3D Printing and Research Investigation

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Abstract - This study navigates the intricate landscape of 3D printing, shedding light on the pivotal interaction between infill density, material consumption, and the mechanical attributes of 3D printed components. Six PLA filament test specimens, exhibiting diverse infill percentages from 0% to 100%, were meticulously created and subjected to tensile testing. The results unveil the profound sway of infill density on the maximum load-bearing capacity of the PLA specimens. A discernible trend emerges, showcasing that as infill density ascends, so does the maximum load these specimens can withstand. These findings underscore the substantial role of infill density in shaping the mechanical strength of 3D-printed components. This research carries significant pedagogical implications for the realm of engineering education. It empowers students to grasp the profound insights of material science and 3D printing technology, engendering informed decision-making in the process. The study underscores the importance of aligning infill density with the desired mechanical properties of 3D printed components, offering students an enriched educational experience that melds theory and practical application.

I. INTRODUCTION

The application of subjects related to mechanical part design, code generation, 3D printing, and subsequent testing of manufactured components has emerged as a pivotal area of exploration in the field of engineering and, more specifically, mechanical engineering [1]. This multidisciplinary domain leverages the capabilities of cutting-edge technology, such as 3D printing, and the utilization of advanced software tools to revolutionize the way we conceptualize, design, and fabricate mechanical components [2], [3]. This transformative shift not only plays a significant role in streamlining the design-to-production process but also extends to offering invaluable hands-on experiences for students pursuing technical disciplines, particularly in the realm of mechanical engineering [4], [5].

The advent of 3D printing technology has redefined the traditional paradigms of manufacturing [6]. It allows for the rapid and cost-effective creation of complex components, fostering an environment where the boundary between prototype and final product is increasingly blurred. This technology, as delineated in the previous passage, is characterized by its ability to provide prototypes swiftly and cost-effectively, thereby facilitating a seamless transition from the design phase to the physical realization of components. Importantly, it has also opened the door to utilizing 3D-printed parts as end products, thereby expanding its scope beyond mere prototyping [7].

One of the most distinguished methodologies within 3D printing is Fused Deposition Modeling (FDM). FDM stands out owing to its accessibility, ease of use, and the versatility of raw materials [8]–[10]. With FDM, it is feasible to introduce continuous reinforcement fibers into the fabrication process, significantly enhancing the mechanical properties of the produced parts [11]. This is instrumental in a plethora of industries, including automotive, aerospace, medical, and beyond [12].

Furthermore, the heart of 3D printing lies in the meticulous control of an array of parameters governing the printing process. Parameters such as layer height, lattice orientation, infill density, and build orientation are meticulously calibrated to influence the mechanical properties of the resulting parts. The choice of materials is also paramount; polymers, particularly ABS, PLA, and nylon, are favored for their low melting temperatures and ease of printing. These materials, when fortified with additives like carbon fibers, have demonstrated impressive enhancements in tensile strength, ushering in a new era of material science and engineering [13], [14].

For students on technical pathways, especially those pursuing mechanical engineering, the integration of 3D printing, computational design, and hands-on testing presents an unprecedented opportunity for experiential learning [15]. They can delve into the intricate aspects of designing parts, generating code to control the 3D printing process, and then witnessing the real-world manifestations of their designs through the physical components produced [16]. This multifaceted approach not only aligns students with contemporary industry practices but also inculcates an acute understanding of the interplay between design decisions, material

properties, and fabrication processes, which is invaluable for their future careers.

In this context, the significance of employing cutting-edge software tools and hardware devices for 3D printing and testing is indisputable. These resources empower students to bridge the gap between theoretical knowledge and practical application, fostering a deeper appreciation of the complexities involved in the engineering design process. Through real-world testing, students can gain insights into the structural integrity, performance characteristics, and potential areas for improvement in their designed components. This experiential learning approach not only enhances their problem-solving skills but also equips them with a tangible skill set highly relevant to the demands of the modern engineering landscape.

In this research, an in-depth investigation was undertaken, focusing on the testing of specimens manufactured in strict accordance with the prescribed standards. These specimens were fabricated using PLA filament, a popular thermoplastic material often used in 3D printing due to its accessibility and ease of use. The PLA specimens were meticulously 3D printed at various infill percentages, specifically at 0%, 20%, 40%, 60%, 80%, and 100% infill densities (Speed option). This comprehensive range of infill percentages enabled a thorough exploration of the impact of infill density on the mechanical properties of 3D-printed components. By systematically varying the infill density, the research sought to uncover valuable insights into the relationship between infill percentages, time required for production, and the tensile strength of the printed specimens, thereby enhancing our understanding of the material's behavior under different conditions.

II. MATERIALS AND METHODS

As part of educational activities at the Technical Faculty "Mihajlo Pupin" in Zrenjanin, Serbia, a specific research project was undertaken to provide students, particularly those in the second year of mechanical engineering, with a holistic understanding of the entire engineering process. These students played an active and integral role in every stage of the investigation, contributing to the design, fabrication of test specimens, operation of the Hegewald & Peschke universal testing machine, and subsequent data analysis. This hands-on involvement not only enriched their academic experience but also enabled them to bridge the gap between theoretical knowledge and practical application, fostering a comprehensive grasp of the complexities inherent in the field of engineering.

The research project followed the guidelines of the ASTM D638-14 standard, which outlines the standard test method for the tensile properties of plastics [17]. Specifically, Type IV dogbone-shaped specimens (as illustrated in Figure 1) were employed, as they are designed for this type of tensile testing.

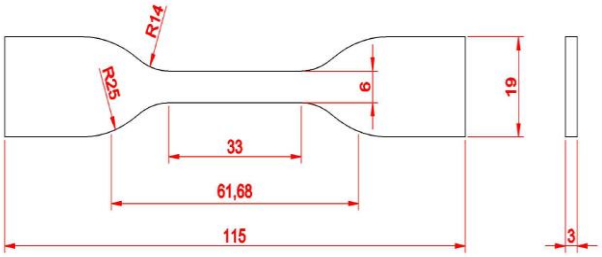

Figure 1. Type IV specimens (ASTM D638-14 standard)

The technical drawing of the specimen, complying with the ASTM standard, was created using computer-aided design (CAD) software - AutoCAD, to ensure precision and adherence to the required specifications. The stl. file format, which is suitable for 3D printing, was generated from the CAD drawing. Additionally, the G-code for 3D printing was developed as part of the student's coursework.

The 3D printing of the test specimens was carried out using a CreatBot DX Plus 3D printer (as shown in Figure 2). This printer is known for its reliability and precision, making it well-suited for academic and research purposes.

Figure 2. CreatBot DX Plus [18]

Subsequently, the tensile testing of the printed specimens was conducted on a Hegewald & Peschke Universal Testing Machine (Inspect table 5 kN), as depicted in Figure 3. This testing machine, utilized in collaboration with Continental R&D, provided

precise measurements of tensile properties. The collaboration between the faculty and the company facilitated access to this advanced equipment, enhancing the research capabilities and ensuring the reliability of the obtained results.

Figure 3. Hegewald & Peschke Universal Testing Machine - Inspect table 5 kN [19]

The combination of CAD software, 3D printing technology, and advanced testing equipment provides students with a hands-on experience that bridges the gap between theoretical knowledge and practical application. It also imparts valuable skills in material testing and analysis, aligning them with real-world engineering practices and standards.

III. RESULTS AND DISCUSSION

Table I provides a comprehensive overview of the PLA filament used in this study, detailing infill percentages, material consumption, and the time required for creating a single test specimen. The table's data is instrumental in understanding the economic and practical implications of 3D printing. Varying infill percentages, ranging from 0% to 100%, lead to diverse material consumption and time investment in the fabrication of individual testing specimens. This information is crucial for assessing the trade-offs between material efficiency, production time, and the resulting mechanical properties of 3D printed components, offering valuable insights for process optimization across different applications.

TABLE I. PRINTING MODE OF PLA FILAMENT TEST SAMPLES

Mode - Speed			
Fill percentage [%]	**Material PLA 2.80mm**		
	Consumption		**Required time for printing**
	kg	m	s
0	0.00493	0.64	960
20	0.00516	0.67	1020
40	0.00535	0.7	1050
60	0.00554	0.72	1080
80	0.00574	0.75	1110
100	0.00596	0.77	1140

Following the aforementioned preparatory activities, a series of six 3D-printed test specimens were fabricated. These specimens were specifically designed to exhibit varying infill percentages, ranging from 0% to 100%, in order to investigate the influence of infill density on the mechanical properties of the PLA filament. The culmination of these efforts is represented in the results displayed in Figure 4, which graphically illustrate the findings obtained through the tensile testing of the 3D printed specimens.

The graphical representation in Figure 4 vividly illustrates the correlation between Ultimate Tensile Strength (UTS) [N] and time for PLA filament specimens with varying infill densities ID [%]. It provides a visual insight into how changes in infill percentage influence the load-bearing capacity of the specimens under tensile forces, offering a concise overview of the material's performance over time.

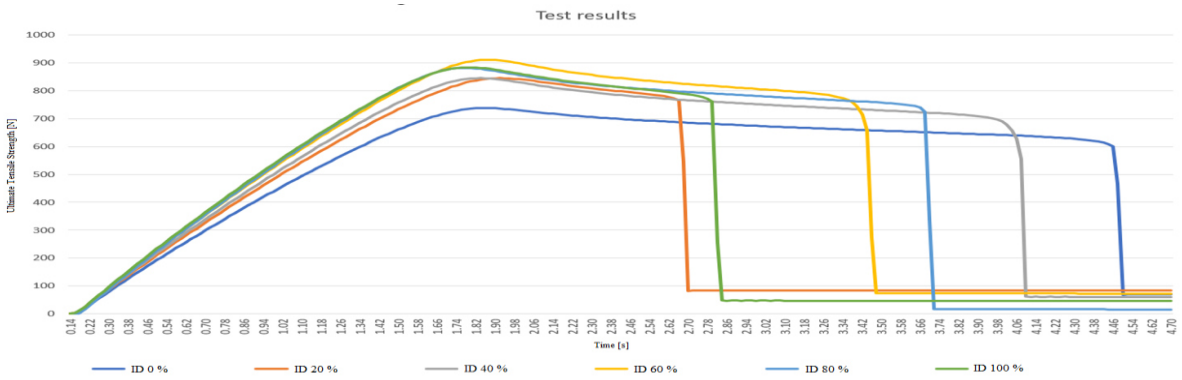

Figure 4. Obtained test results

The data presented in Table I, which outlines the material consumption and time required to fabricate PLA specimens with varying infill percentages, offers crucial insights into the practical aspects of 3D printing. It is evident that as the infill density increases, both the amount of PLA filament consumed and the time needed for specimen creation rise incrementally. This relationship is logical, as a higher infill density necessitates the deposition of a larger volume of material, thereby extending the 3D printing process. The data underlines the importance of judiciously selecting the infill density in 3D printing to strike an optimal balance between material efficiency and production time.

Moving on to the results depicted in Figure 4, the impact of infill density on the maximum load-bearing capacity of the PLA specimens becomes apparent. The specimens with 0% infill density exhibit the lowest maximum load, measuring 737.635 N, while the specimens with 60% infill density reach the highest maximum load, with a value of 910.295 N. These results emphasize that infill density plays a pivotal role in determining the mechanical strength of 3D-printed components.

A more detailed analysis of the tensile testing results reveals a consistent trend: as the infill density increases, the maximum load-carrying capability of the specimens generally improves. This trend can be attributed to the increased volume of material within the specimens, resulting in enhanced structural integrity and load-bearing capacity. Higher infill densities provide a denser internal structure, making the specimens more resistant to mechanical stress.

However, it is noteworthy that the relationship between infill density and mechanical strength may not be linear or monotonic. Beyond a certain point, increasing infill density may yield diminishing returns regarding mechanical performance while significantly increasing material consumption and production time. This implies that selecting the ideal infill density is a crucial decision for optimizing 3D printing processes, as it involves striking a balance between material efficiency, production time, and mechanical properties.

In practical terms, understanding the effects of infill density on mechanical strength is vital for engineers and designers when developing 3D-printed components for various applications. By making informed decisions about infill density, it becomes possible to tailor the mechanical properties of the final product to meet specific performance requirements. Consequently, the findings presented in this study offer a valuable reference for optimizing 3D printing processes, ensuring the efficient use of resources, and achieving desired mechanical characteristics in the manufactured components.

IV. CONCLUSION

The UTS values associated with different infill percentages are critical in understanding the material's mechanical behavior, thereby facilitating informed decisions in 3D printing processes and component design. These findings contribute significantly to the broader discourse on optimizing 3D printing parameters and underscore the importance of infill density as a determinant of mechanical properties in 3D printed components.

In the comprehensive exploration of 3D printing technologies and their impact on material characteristics, it's essential to note that, besides the examined factors such as infill density, patterns, material types, and printing options, other influential variables were not within the scope of this investigation. Factors like ambient conditions, specific printer settings, and variations in filament quality can significantly influence the outcomes. Acknowledging these unexplored facets adds a layer of complexity to the broader understanding of 3D printing processes. Future research endeavors may consider delving into these unexplored factors to establish a more comprehensive and nuanced comprehension of the interplay between diverse variables, enabling a more refined optimization of 3D printing technologies and their applications.

In conclusion, integrating mechanical design, code generation, 3D printing, and the subsequent testing of components offers a dynamic and transformative learning experience for students in technical fields such as mechanical engineering. Notably, post-experiment feedback from students indicated a substantial improvement in satisfaction and knowledge of the subject matter. They expressed a keen interest in participating in similar projects and investigations in the future. This positive response highlights the educational value of such hands-on experiences, reinforcing the idea that practical applications complement theoretical knowledge and foster a deeper understanding of engineering principles. This not only equips students for future challenges but also nurtures a passion for continuous exploration and innovation in their academic and professional journeys.

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Learning in New Ways: E-Learning in the Fashion and Textile Industry

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Abstract - The fashion and textile industry is rapidly evolving, driven by technological advancements and changing consumer preferences. To keep pace with these changes, traditional learning methods are being replaced by innovative approaches, with e-learning emerging as a key educational tool. E-learning in this industry can include online courses on design, manufacturing, materials, technology, sustainability, marketing, business management, and other relevant topics. These courses may include video lessons, text materials, interactive simulations, practice assignments, discussion forums, and other electronic resources. This approach to training allows employees and individuals in this industry to follow new trends, improve their skills, follow technological innovations and remain competitive in the market. Also, e-learning can help spread knowledge about sustainability in the fashion industry, as this topic has become extremely important in recent years. Therefore, this paper will deal with the topic of the impact of e-learning in the fashion and textile industry.

Keywords: e-learning, textile industry, fashion industry, technology

I. INTRODUCTION

Electronic learning, often known as e-learning, is the evolution of traditional education via the use of electronic technology to facilitate online access to educational materials. This cutting-edge educational model is also starting to play a significant role in the textile sector, positively altering how people learn and grow in this fast-paced business. E-learning has shown itself to be an essential instrument for the textile industry's adaptive training of staff members, designers, engineers, and other specialists. This kind of learning offers rapid and effective access to knowledge about the newest materials, industrial processes, fashion trends, and sustainable practices thanks to the ongoing advancements in technology [1,2].

The potential of e-learning to lower geographical barriers and offer worldwide access to the most recent information and skills is indicative of its significance in the textile industry. Regardless of their geographical location, workers in the textile business have the chance to advance their skills, which promotes the sharing of technical advances and ideas across borders. These breakthroughs fundamentally alter the way textiles are studied, created, manufactured, and disseminated, putting the sector on a road toward sustainable growth. The textile industry is moving toward more ecologically friendly practices, and e-learning offers a platform for learning about new, sustainable materials and production techniques [2,3].

In the following parts, we will explore how e-learning specifically affects education in the textile industry and what concrete innovations it brings to the working environment of experts in this dynamic field.

II. TYPES OF E-LEARNING

Educational scientists have classified many e-learning kinds and paradigms based on factors including learning style, delivery method, educational technologies, and online course platforms, considering the wide definition of e-learning. The forms of e-learning that are now in use are as follows:

A. Computer-Managed Learning (CML)

An educational method called Computer-Managed Learning (CML), often referred to as Computer-Based Training (CBT), makes use of a computer to oversee and control the learning process. This e-learning strategy automates and streamlines the educational process via the use of technology and software. A Computer-Managed Learning system is a management tool so it isn't a computer-based learning system that delivers course materials to the students. That being stated, certain CML apps are currently made to transmit course content because of the World Wide Web (WWW). Computer-managed learning programs, on the other hand, are primarily intended to help large groups of learners, teachers and administration staff [4,5].

B. Computer-Assisted Instruction (CAI)

The term "Computer-Assisted Instruction" (CAI) describes remediation or instruction that is given using a computer. You can get a lot of instructional computer applications from computer retailers,

textbook publishers, and the internet. Interactive computer applications may visually represent ideas using eye-catching animation, audio, and demonstration. They let students work independently or in groups to solve problems while moving forward at their speed. Students can immediately determine whether their response is right thanks to computers' instant feedback. Should the response be inaccurate, the software instructs learners on how to properly respond to the question [5,6].

C. *Synchronous Online Learning*

Synchronized Online Learning is a form of e-learning in which educational content is delivered in real-time, allowing participants to simultaneously participate in activities such as lessons, discussions or workshops. This type of online learning simulates the experience of traditional classroom learning, where the teacher and students interact in real time, even though they may be physically located in different places. Synchronized Online Learning can include online courses and workshops. Online courses typically have a structure that includes video lessons, reading materials, assignments, tests, and other educational resources, while online workshops are often designed as interactive sessions that allow participants to work on specific skills, solve problems, or apply concepts in real time [5,7].

D. *Asynchronous Online Learning (D – Distance Learning)*

Asynchronous Online Learning (D - Distance Learning) is a model of e-learning where participants access educational material, resources, and activities at a time that suits their schedules. Unlike synchronous online learning where interaction takes place in real time, asynchronous learning allows students the flexibility to access materials whenever they want. Learners access the online platform whenever they want and have access to a variety of educational resources, including video lessons, readings, assignments, and tests. They take responsibility for their learning, progressing through materials and assignments independently. Communication and discussions usually take place via forums, e-mail or other digital means of communication. Learners have the flexibility to adapt learning to their own schedule and pace, following the materials whenever it suits them [5,7].

E. *Fixed e-learning*

Fixed e-learning can refer to the concept of eLearning that involves a fixed or predefined learning experience. This term is often used in the context of courses or training modules that have a predetermined content, schedule and structure, and participants follow a well-defined learning path [5,8].

F. *Adaptive e-learning*

Adaptive e-learning is an approach to e-learning that uses personalized strategies to adapt to the individual needs, knowledge level and learning styles of each individual. This e-learning model uses technology and learning data to tailor the learning experience to the specific characteristics of each participant. The purpose of this e-learning is to create student-driven instructional techniques by measuring characteristics such as skills, student performance, and goals. Artificial intelligence is significant in knowledge management and is the main module of adaptive eLearning systems. Additionally, AI helps instructional materials pinpoint and highlight areas in which students still need to grow [5,9].

G. *Linear e-learning*

Linear e-learning is an approach to e-learning where participants move through educational material or a course in a linear or predefined sequence. This e-learning model often involves a course structure where modules, lessons or sections are laid out in a fixed sequence and participants follow that sequence to complete the training. Information is sent from sender to recipient using linear communication, which is based on human-computer interaction. The information's sequence, timing, and speed of reception are determined by the sender. Furthermore, the recipient does not reply to the sender. As a result, teachers and students are unable to communicate with one another using this online learning platform. For instance, linear e-learning is the distribution of educational content to students through radio and television shows [5,10].

H. *Interactive Online Learning*

Interactive Online Learning is an approach to e-learning that emphasizes active participation, engagement and interaction of participants during the learning process. This type of e-learning includes various interactive elements and tools to create a dynamic and engaging learning experience. With interactive e-learning, participants may communicate in both directions by sending and receiving messages. Based on the delivered and received messages, educators and students can modify their methods of instruction. Because it allows professors and students to communicate with one another, interactive e-learning is more popular than sequential e-learning. Forums, instant chat, and discussion boards are a few examples [5,11].

I. Individual Online Learning

Individual Online Learning refers to an approach to e-learning where each participant independently accesses, studies, and progresses through educational material. This type of e-learning focuses on personalizing the learning experience, adapting the learning pace and content to the individual needs, interests, and speed of each participant. This kind of online education has long been used in traditional classroom settings. When learning on their own, students study the course materials alone without the assistance of teachers or classmates. Since it only stresses individual learning, it is inappropriate for improving students' communication and collaboration abilities [5].

J. Collaborative Online Learning

Collaborative Online Learning is an approach to e-learning in which participants are actively involved in joint learning and work on tasks through online platforms. This type of e-learning encourages collaboration, interaction, and knowledge sharing between participants, creating a shared learning experience. Through group formation, each learner must take into account the advantages and disadvantages of each other. This component strengthens the student's critical thinking, collaboration, and communication abilities. The idea behind collaborative e-learning is that knowledge is enhanced by student interaction [5].

III. E-LEARNING IN THE FASHION AND TEXTILE INDUSTRY

E-learning in the fashion and textile industry refers to the use of online educational methods and technologies to deliver training and learning experiences related to the fashion and textile sector. This approach leverages digital platforms, multimedia content, and interactive tools to provide education and skills development in various aspects of the industry, including design, production, marketing, retail, etc.

Figure 1. E-learning in the fashion and textile industry [22]

Here are some key aspects of e-learning in the fashion and textile industry:

A. Online Courses

Courses and modules on design concepts, creative processes, and fashion and textile trends may be found on e-learning sites. Through online modules, participants may learn about textile design, fashion illustration, and other creative areas. The principles of fashion illustration and drawing are frequently covered in e-learning programs. Participants gain a grasp of measurements, stances, and clothing details as well as how to convert their creative ideas into paper. Textile design is another topic included in courses, where students learn about various fabric kinds, surface design methods, and patterns. It is possible to create and work with textile designs using digital technologies. Developing design concepts and mood boards are common topics covered in design courses. Participants gain the ability to coherently express their design concepts both verbally and graphically [12, 13].

There are also online courses on technical skills in the textile industry that provide training in the practical aspects of textile production and processing. These courses cover basic and advanced sewing techniques, including making different stitches, handling different types of fabrics, and adapting to different projects as well as operating different sewing machines. It also includes tailoring training where students gain the skills needed to make patterns and adjust designs. These courses offer an insight into weaving and knitting techniques, from basic to specific techniques used in textile production. As well as many other techniques of dyeing materials and their processing such as washing, ironing, and other methods that improve the quality and appearance of textiles [12, 13].

B. Online Workshops

Online textile workshops provide participants with the opportunity to develop creativity, acquire pattern and fabric design skills, and engage in the process of creating textile designs. Workshops and courses represent two different approaches to education. Workshops are often aimed at the practical acquisition of skills through interactive exercises, are short-term and usually gather a smaller number of participants for greater individual engagement. The focus of the workshop is on the rapid acquisition of specific skills that can be immediately applied in practice. Workshops focus on practical skills and interactive learning, while courses provide a deeper understanding of the material. This difference allows participants to choose between a quick training with a specific focus, such as a workshop, or a more comprehensive

program with a wider coverage of material, such as a course. Participants learn the basics of pattern design, from traditional to contemporary approaches. Workshops focus on understanding proportions, repeating and combining pattern elements. With an emphasis on sustainability, some workshops may include elements of sustainable practices in textile design, including the use of environmentally friendly materials. Workshops can also include aspects of working with clients, understanding market trends and adapting designs to the needs of the target audience. Through challenges and project work, participants apply their new skills in real situations, developing a portfolio and gaining practical experience [14, 15].

C. Digital Fashion Shows

Digital fashion shows represent an innovative approach to presenting collections and current fashion trends through digital platforms. This form of fashion display combines fashion and technology, adapting to the modern digital age. Instead of traditional catwalks, digital fashion shows use visual and technical elements to create a unique experience. This way of informing about currently popular fashion trends and activities is available to the public, where everyone can be informed on their own without going to a fashion show. One of the key features of digital fashion shows is the ability to access them from the comfort of your own home through online platforms. Viewers can explore the collections through high-quality photos, videos, and often interactive elements. This approach allows brands to reach a global audience without geographic restrictions [16, 17].

This new fashion show format enables faster access to collections, reduces the environmental impact of travel for traditional shows, and provides an opportunity for designers and brands to experiment with creative expression. Digital fashion shows are not only a response to contemporary challenges, but also a platform for exploring new horizons in the fashion industry [16, 17].

Fashion shows can now be followed on social networks, such as Instagram, YouTube, Facebook, Twitter, etc., and through them, you can be informed individually, in addition to fashion shows, about current activities in the textile world and supplement your knowledge. Fashion shows can also be followed through the official Digital Fashion Week platform.

D. Use of Augmented Reality (AR) and Virtual Reality (VR)

Students can learn through authentic experiences, accessing virtual fashion shows, online courses, and workshops through VR technology. This form of learning enables not only the study of the latest trends; but also interactive participation in the processes of designing and experimenting with textiles. The application of AR contributes to hands-on learning through virtual clothing fitting, and interactive learning materials, and allows students to create unique virtual design workshops. In addition, VR technology allows textile engineering students to walk through factories and production lines through virtual tours, giving them a deeper understanding of manufacturing processes. Textile designers can use VR to experiment with fabric patterns and textures before moving to physical production, while industrial workers can use AR for training on the production line. The combination of these technologies also facilitates the evaluation of student work and allows professors to monitor progress through virtual reality [18].

All these applications of AR and VR technologies provide a dynamic and innovative environment for e-learning in the fashion and textile industry, while improving students' and professionals' understanding of materials, techniques and learning processes [18].

E. Distance Learning Platforms

Distance learning platforms in the textile and fashion industry have become a key part of e-learning, providing flexibility and adaptability to learning. These platforms allow students to access a variety of educational resources and tools regardless of geographic location or work schedule. Collaboration and social interaction are integrated through discussion forums and other communication channels, allowing students to share experiences, ask questions, and collaborate with instructors and peers. Virtual workshops and projects further enhance the hands-on experience, allowing students to practice their skills in a safe online environment. Level adjustment and personalized resources help students learn at their pace and needs. Progress tracking systems provide instructors with insight into student success through grades, tests, and assignments. The mobile accessibility of these platforms allows students to access materials and resources even while on the move, contributing to their flexibility and adaptability. All these features make distance learning platforms key players in supporting e-learning in the textile and fashion industry, providing an efficient and affordable path for the professional development of students in this dynamic industry [19 - 21].

Distance learning platforms in the textile and fashion industry may depend on current offers and trends, these are some platforms: Google Classroom,

Coursera, edX, Udemy, FutureLearn, OpenSesame etc.

IV. CONCLUSION

E-learning in the textile industry is a key aspect of the professional development of participants in this dynamic field. Through distance learning platforms like Coursera, edX, and others, students can a variety of courses, virtual workshops, and interactive materials. The application of augmented reality (AR) and virtual reality (VR) further enhances the learning experience, enabling hands-on training and experimentation in a virtual environment. Flexibility, mobile accessibility, and customized resources make e-learning a key factor in supporting education in the textile industry, enabling participants to follow the latest trends, improve skills, and remain competitive in the labor market. Overall, this digital transformation of learning brings innovations that shape the future of education in the textile sector.

E-learning in the textile industry is revolutionizing the traditional approach to education, providing participants with the opportunity for interactive learning through virtual workshops, trying on textiles through AR technology, and following the latest trends. These digital innovations not only support the acquisition of knowledge but also encourage creativity and practical application of skills. Through mobile accessibility and distance learning platforms, e-learning is becoming a key factor in advancing professional development in the textile industry, creating an inclusive environment for learners worldwide.

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One Approach to Web Application Development to Support Library Business Processes

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Abstract - The motivation for this work is to create a solution that would facilitate and speed up the work of the staff, administration and members of the library, but also the work of the library itself as a business system as a whole. Software solutions used on the web previously mostly consisted of a few static documents that provided users with feedback only in the form of text and images. In the meantime, such solutions have evolved into complex distributed systems whose content and generation are influenced by the users themselves through their activity. Considering the above said, the primary goal is the design of a web application with a quality user interface, a normalized and well-structured database using current technologies.
Assuming that future users will access the application on different devices, it is necessary for the application to meet the criteria of responsive design, i.e. adaptation to screens of different sizes.
At the end of the work, adequate conclusions will be drawn which will summarize the overall performance and advantages of the application and the possibilities of further development.

I. INTRODUCTION

Librarianship is essentially a discipline that operates in the field of library organization, categorization and classification of titles, book publishing, and library membership records. In addition to books, a library's holdings can also include other types of content such as images or photographs, historical records or documents, and other data in analog or digital form. With the introduction of computers and other technological innovations in the library's work process, the procedure of searching for members (by first and last name or a unique identifier), books (by title, author, genre,...) or library records and archives has been greatly facilitated for employees and members. (regulation of membership fees, book loan history, etc.). In the continuation of the work, a solution will be presented that represents a potential replacement for the traditional information system of the library.

A web application is application software that resides on a web server. Compared to native applications that can only function on the specific operating system or device for which they are intended, web applications run from a web browser and are independent of the operating system or type of device through which the end user accesses the application. Web applications can usually be seen divided into three layers: the presentation layer, the business logic layer, and the data layer. The presentation layer, to put it simply, includes all the components that make up the user interface. The main goal of the business logic layer is to process user requests and send results. The procedure is generally as follows: the necessary data is retrieved from the data layer, encoded into HTML or other required form, and then sent. Defining and developing the business logic layer is done using appropriate programming languages. The data layer stores the data necessary to respond to user requests, as well as the very results of user requests. Database management systems are mainly used for storing and working with data [1][2].

The following technologies were used for the realization of a web application that would satisfy the above-mentioned functionalities of the library:

- ASP.NET,
- HTML, CSS, Bootstrap for creating user interface and responsive design,
- programming language C# for developing the middle layer of the application, i.e. the layer of business logic,
- structured query language SQL for database manipulation.

ASP.NET is a Microsoft product that represents a platform for developing web applications. ASP.NET is a Microsoft product that represents a platform for developing web applications.This platform initially included the use of Microsoft technologies and programming languages supported on the Microsoft .NET platform, as well as execution

on Microsoft operating systems. The C# programming language is one of the most commonly used languages on the ASP.NET platform. The C# programming language is one of the most commonly used languages on the ASP.NET platform. Among the many programming models provided by the ASP.NET platform, ASP.NET Web Pages was used for the purposes of this application, which allows combining HTML with code that is executed on the server [3].

During the development of the application, the following software and programming environments were used:

- https://app.creately.com/ to create a usage diagram,
- https://online.visual-paradigm.com/ for sequence diagram design,
- SAP PowerDesigner (trial version) for physical database model design and generation SQL code for database objects design,
- Microsoft SQL Server Management Studio 2018 as a database management system,
- Microsoft Visual Studio 2022 in which the application is fully written.

The application development process took place in several stages: analysis of user requirements and their presentation, creation of a database model, design of the user interface, development of the middle layer of the application, and application testing and elimination of possible errors or undesirable effects.

II. DEVELOPMENT OF SOLUTION

A. User requirements

The first step in the process of developing a software solution is to record the requirements that the process should fulfill. A set of requirements arises as a result of an analysis carried out in order to understand the needs of the software user, that is, the customer or the orderer [4].

Users can use the proposed solution from five different perspectives, ie. through five different roles with different permissions and privileges:

- **Library administrator -** a person who, if necessary, can act on the library database by adding, changing and deleting titles, authors, publishers, members, etc. Also, the administrator has the option to assign the appropriate role to other users;
- **Director of the library -** has identical privileges as an administrator, except for the privilege of assigning roles;
- **Librarian -** in addition to enrolling/subscribing members, recording titles, authors or publishers, the librarian is the only person who is allowed to issue books for reading to library users;
- **Library member/user -** persons to whom the librarian can issue a book for reading;
- **Guest -** application user who only has an overview of the library's literary collection (catalogue) and the option of deactivating the user account in case they are not satisfied with the services provided by the application.

User requirements will also be graphically represented through use case diagrams and sequence diagrams.

Considering that all software systems have users from the external environment, during the process of realizing the software solution, it is necessary to determine the boundaries of the system and precisely define how the interaction between the system and the user takes place. The use case is precisely the description of the procedure of that interaction. Graphic representation and documentation of user interaction with the system for the purpose of achieving user request is called use case diagram [4][5]. The use case diagram in Figure 1 presents the previously described user requirements.

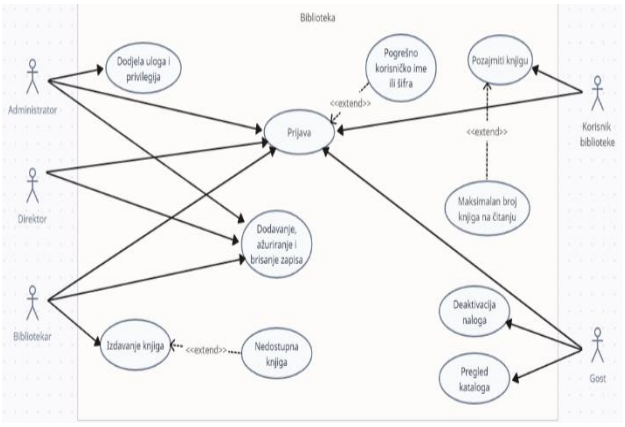

Figure 1. Use case diagram

Unlike the previous type of diagram, the sequence diagram describes the activities that take place between objects within the system. Typically, a sequence diagram captures the behavior of a single scenario. The diagram shows a number of example

objects and the messages that are passed between these objects within the use case [6].

In this case, however, the timing of the execution of the given activity must also be taken into account, for example, in order for the administrator to perform an action, he must first log in to his account, in order for the login to be considered successful, the correct data must be entered (username and password) and the like. The following diagram represents the activity of issuing a book to a library member by a librarian.

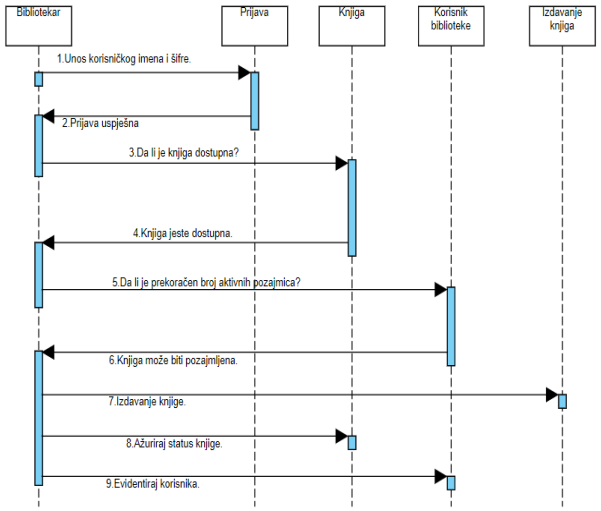

Figure 2. Sequence diagram

B. *Databese development*

Before the actual realization of the database, we must first go through the system modeling process.

A model is an approximate representation of a system or process that serves to understand the system, and to change or manage it. Modeling is the process of using a model instead of a real system, which should enable the creation of a clear and realistic representation of the system [7].

The basic procedures leading to the formation of the model are [8]:

- classification of objects: observation of individual objects that make up the system;
- classification of relationships: observing relationships between individual objects;
- abstraction of objects: neglecting less important properties of objects and retaining only relevant ones;
- abstraction of relations: highlighting only those relations between objects that will be key for the functioning of the system as a whole.

The modeling process takes place in parallel with the analysis of user requirements, so that the model can be modified if necessary in order to preserve its accuracy and completeness [9].

Based on all of the above said , we can highlight the key features of the objects that make up the library system and define the connections between them.

All users of the application, regardless of role, have personal data: first name, last name, contact data and login data. For authors, only their name is important, as well as names when we talk about publishers. The books that make up the library have a title, the genre they belong to, the language in which they are written, the number of pages, and information about the author and publisher. In addition, library staff have the option to assign each book a corresponding image.

The scheme in Figure 3 presents the basic properties of the objects that make up the library system and the relationships between them. It can be noticed that the *Knjiga_Izdavanje* table establishes links between library members and titles that are issued for reading.

Using SAP PowerDesigner (a trial version), one of the many CASE tools whose purpose is to automate some stages in the development of a software solution [10], we create a physical model of the database whose generated code we will execute in the SQLQuery window of the Microsoft SQL Server Management database management system.

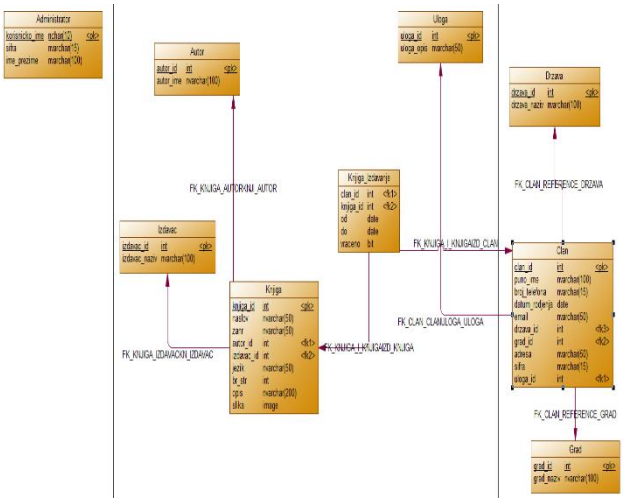

Figure 3. Database model in SAP PowerDesigner

C. *User interface design*

The next step in the development of the solution is the design of the user interface. The user interface of the application is mainly based on HTML forms consisting different types of text boxes (text, number, date or email), text areas, drop-down menus, links and buttons, as can be seen in Figure No 4, which shows the application user registration form.

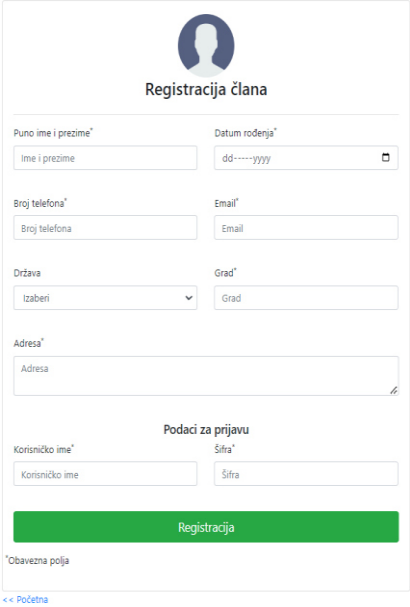

Figure 4. User interface

Figure No.5 shows a preview of the code that describes the form from picture no.4.

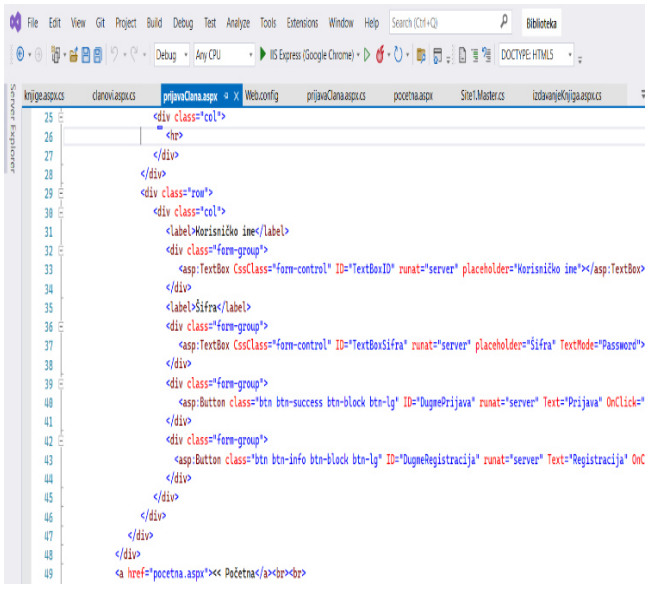

Figure 5. Example of HTML code

The home page, the most important part of which is the navigation menu, has a fairly simple design and is understandable to the user. That the page, as well as the application as a whole, is responsive and adaptable to the screen of the device from which the user accesses the application can be seen below:

Figure 6. The home page of the application on the Google Chrome browser

while by reducing the size of the window or accessing the application on a device with a smaller screen, the application itself is adjusted:

Figure 7. Responsiveness of the application

D. *Development of the middle layer of the application*

The middle layer of the application is developed using the C# programming language in the Microsoft Visual Studio 2022 environment, with the inevitable use of the SQL query language. Searching, adding, modifying or deleting records (members, books, authors,...) from the library database is actually an implementation of the SELECT, INSERT, UPDATE and DELETE commands from the SQL language. In this step, the quality and stable structure of the database, which was created in one of the previous steps, must come to the fore. Even with proper use of the application, downtime or anomalies may occur if database modeling is not performed correctly. The

quality of the base is primarily reflected in the preservation of two types of integrity:

- identification - it is prohibited to enter two identical records in the table, or to put it simply, there cannot be two users of the application with the same username or similar;
- referential - e.g. we cannot delete a member of the library who took books for reading, because by doing so we damage the library's documentation and archives, etc.

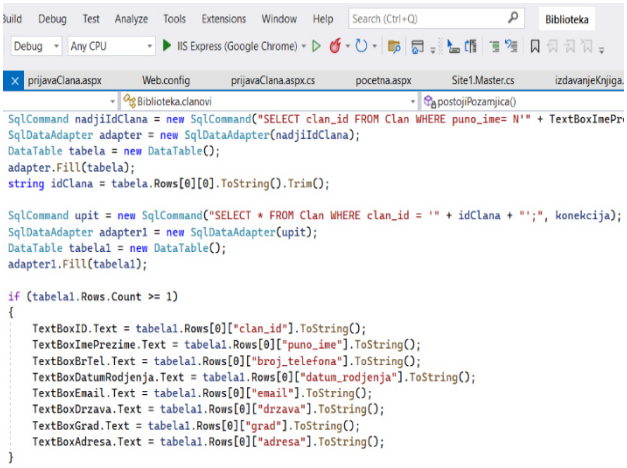

Figure 8. Example of C# code with the implementation of the SQL statement SELECT

III. CONCLUSION

This proposal of a solution for IT support within the business systems of libraries was created as a result of the expansion of functionality and the continuous development of the project assignment for the second cycle of studies at the Faculty of Philosophy of the University of East Sarajevo.

The application offers a wide range of possibilities to the management, administrative staff of the library and ultimately to the librarians themselves. When we talk about users who access the application as an ordinary member or user of the library, there are noticeable possibilities and potential for further development of the application in terms of expanding the user's powers, for example: book reservation option, membership fee regulation or similar.

It is important to point out that the application itself is not strictly limited to a specific type of library. The application in its full extent can be used both by school and college libraries whose membership consists mainly of students, as well as by classic city libraries or bookstores, and other organizations engaged in a related activity.

The application also meets all the criteria of responsive design and can be accessed from different devices without affecting the quality of the user interface.

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A Qualitative Study on Onboarding in a Small Software Company

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Abstract - The dynamics of the market and the great fluctuation of workers have a significant impact on the work of software companies. This is very important for small software companies that have limited resources and struggle to survive in the competitive market. Onboarding, defined as the process of introducing and preparing new employees for effective work in the company, has been recognized as important for the overall business performance of small software companies. In this paper, a qualitative study on onboarding practice in a local small software company is presented. Reflexive thematic analysis was used for analyzing data, resulting in a thematic framework that presents themes important for onboarding practice in the company. The validity of the research, recommendations for practitioners from industry, and further research directions are discussed.

I. INTRODUCTION

The growth of the information technology (IT) industry puts more and more demands on educating and involving IT novices in industrial settings. It has been widely recognized that the success of IT and software companies is tightly related to their employees who possess knowledge and skills to perform all processes [1], pointing out the importance of efficient knowledge management (KM) practice. The main driving forces of a modern industry that stress the importance of KM are [2]: (1) Structural change – knowledge becomes a main resource instead of capital and work, resulting in structural changes in companies, (2) Globalisation – changes in the division of labour result in local and global competition and internationalized learning process, and (3) Information and Communication Technologies (ICT) – more efficient exchange of information with reduced costs of transactions.

The importance of KM for contemporary companies introduced terms such as Knowledge Work (activity based on cognitive skills assuming creativity) and Knowledge Worker (a person that performs knowledge work) [3,4,5]. According to Cortada [3] the common characteristics of knowledge work are: (1) it relies on a body of related information that are collected, applied, and built on the previous actions, (2) it is supported by new technologies, and (3) it is especially important for organizations and environments where the complexity of work is important, or the size of work or organization grows. Further, Arthur et al. [4] recognized collaboration as the main characteristic of knowledge work, while individuals, communities, organizations, and industries are distinguished as interdependent participants in knowledge work, each with particular interests. According to Kogut and Zander [6] the organizational knowledge of the firm is something that is observable and includes all assets that describes the firm, which can be replicated within the organization but cannot be easily used by other firms.

Since software organizations are typical representatives of organizations with knowledge work, KM becomes very important for them [7]. Therefore, one of the main challenges for software companies is to effectively involve new people in their organization and to retain experienced workers who possess knowledge about processes, products, technology, and organizational issues [8].

Small software companies, representing over 85% of all companies in the software industry, significantly contribute to economies all around the world [9,10]. Through literature review Tuape and Ayalew [10] identified 14 factors affecting software development in small software companies, among which 11 relate to human factors, while 3 relate to technical factors. Human-related factors are recognized as the most critical and are organized into three groups: organizational factors, business environment, and governance. Organizational climate supported by knowledge management practice has been recognized as a crucial factor for employees' work behavior and the organizational and business success of small software companies [11].

Onboarding is one of the most important and challenging processes in knowledge-based organizations, enabling them to quickly socialize and

make productive new employees. Through onboarding, as a process of organizational socialization, new employees adjust to their new surroundings by quickly learning the necessary behaviors, attitudes, and skills [12]. This becomes even more important because new employees are the most underutilized assets, that can contribute with fresh ideas, expertise, knowledge, perspectives, and personal contacts [13]. Knowledge management strategy and organizational knowledge are essential for effective onboarding and retaining employees on a long term [8].

Based on the above discussion, focusing on human factors in the context of the organization is very important for the overall business performance of small software companies. Onboarding is recognized as a very important practice for the fast and efficient involvement of new employees in business processes in small software companies. The objective of this paper is to inquire about onboarding practices in a local small software company by using qualitative research methods, and to propose some recommendations for managers of software companies.

II. Related Work

This section will present some of the recently published studies related to onboarding in software and IT organizations and companies.

Ju et al. [14] conducted exploratory qualitative study to inquire onboarding tasks and strategies in software development teams. The study was based on interviewing 32 developers and 15 engineering managers that onboard new developers in their teams. Interviews' findings were tested with surveys. Coding of interviews and development of study findings was done by using constructivist grounded theory [15]. Through data analysis the following themes related to tasks were identified: learning, confidence building, and socialization. In addition, the following onboarding strategies were identified: (1) Simple-Complex - the task's complexity is gradually increased by managers, (2) Priority-First – priority of tasks is the most important during assigning tasks to developers, and (3) Exploration-Based – under-defined and uncertain tasks are assigned to new developers.

Brødsjø et al. [8] used a qualitative case study method [16] to examine onboarding process and knowledge sharing with new employees in the IT department of a public organization in Norway. The focus of the research was on various knowledge management initiatives and the influence of organizational culture on knowledge sharing practice. Empirical data were collected through online semi-structured interviews. The recorded interviews were transcribed verbatim and analyzed. The findings suggest the following: new employees should receive specific training based on their roles, early productivity during onboarding process is increased, and new employees are overloaded with general knowledge about the organization. Based on the findings, the authors proposed several knowledge management initiatives (introduction of knowledge sharing platforms, use of communities of practice, capturing and documenting knowledge, competence management, mentoring and coaching, collaboration technologies, etc.) as a support for onboarding process.

Sharma and Stol [17] explored the link between onboarding of new employees and their turnover intention. The authors proposed a theoretical model based on management and psychological literature, in which they inquire about links between onboarding activities, onboarding success, organizational fit, and turnover intentions. The model was tested with a cross-sectional survey instrument that resulted in 102 complete responses. Based on the study findings, the authors point out that all IT organizations should develop efficient onboarding strategies and practices based on full support for new employees, which will increase the retention rate of IT professionals.

Buchan et al. [18] conducted an interview-based study to inquire about common onboarding activities in Agile software development teams, as well as literature synthesis to identify onboarding goals. Totally, 24 onboarding techniques were identified through interviews, while the most frequently used onboarding techniques in agile teams are: mentoring, online communities, peer support, and team socializing. Three categories of onboarding techniques were identified through interviews: working with people, working with artefacts, and undertaking an activity. Through literature synthesis, 11 onboarding goas were identified, and identified techniques were mapped to identified goals. In addition, the most important organizational effort categories related to onboarding were identified: socialization opportunities, access to high quality knowledge artefacts, access to formal training, proactive feedback and knowledge sharing, and provide psychological safety to experiment and learn.

III. A Qualitative Study

This section presents experience related to onboarding and knowledge transfer practice in a small local software company. For that purpose, a qualitative case study based on an interview with the company manager and inductive thematic analysis for data analysis was designed. This study is prepared as a pilot study within a larger qualitative study aimed at inquiring about the state of the practice in local software companies. The case study methodology was selected because it is focused on the real context and dynamic interactions while allowing researchers to select the most appropriate methods for collecting and analyzing data [19]. The aim of this study is to revealed onboarding practice and knowledge transfer practice from the view of the employer in a local software company, as well as to practically check technical and methodological issues for conducting a larger qualitative study [20].

A. Methods

For collecting data about the practice, a semi-structured in-depth interview [21] with the company manager that has over 20 years in the IT industry was used. This type of interview enables to get more deeper insight int the inquired practice by using main questions proposed in the interview guide, as well as follow-up questions that are used for directing interview flow based on the answers on the previous questions. The interview was transcribed into unstructured text suitable for qualitative analysis. Data analysis was performed by using reflexive thematic analysis [22].

Steps in conducting a study with the focus on researchers performing specific steps are presented in Fig. 1. The main aim in including two researchers (the first and the third authors) to independently analyze interview through initial coding is to reduce subjectivity in data analysis and to increase the validity of the study findings. Phases in thematic analysis are rendered as light grey rectangles in Fig. 1, while other steps in qualitative study are rendered as white rectangles.

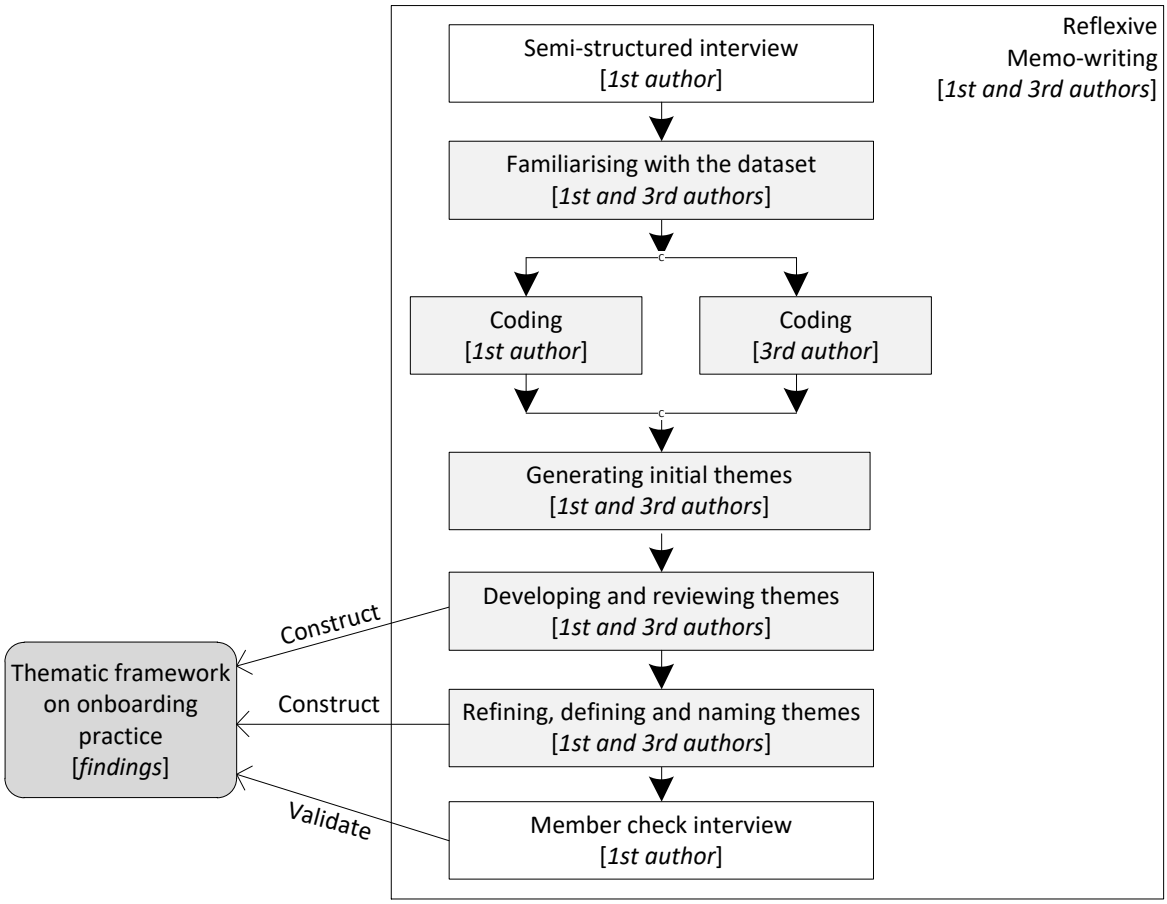

Figure 1. Steps in the realization of a qualitative study

Initial themes development, their refinement, and development of final themes were performed through joint work of the authors that perform coding. All codes were compared and discussed, and initial themes that present the most important and general topics about onboarding practice are constructed. Memos, as an essential part of constructing findings in qualitative data analysis, were written throughout the whole process, starting with interviewing, and pursuing through all steps of coding and constructing findings [23]. Memos relate to the development of themes and thematic framework (theoretical memos), and to the research process itself (methodological memos).

B. Findings

Study findings are developed and represented as a thematic framework with themes identified through reflexive thematic analysis. A thematic framework with identified themes and their relations is presented in Fig. 2.

The main theme in the developed framework is *Onboarding process*, which is connected with all other themes: *Objectives*, *People*, *Prerequisites*,

Work position, *Knowledge management*, *Tools and methods*, *Outputs*, and *Shortcomings*. In addition, some relations were identified between some other themes, like between *People* and *Prerequisites*, *Prerequisites* and *Work position*, *Work position* and *Knowledge management*, and *Knowledge management* and *Tools and methods*.

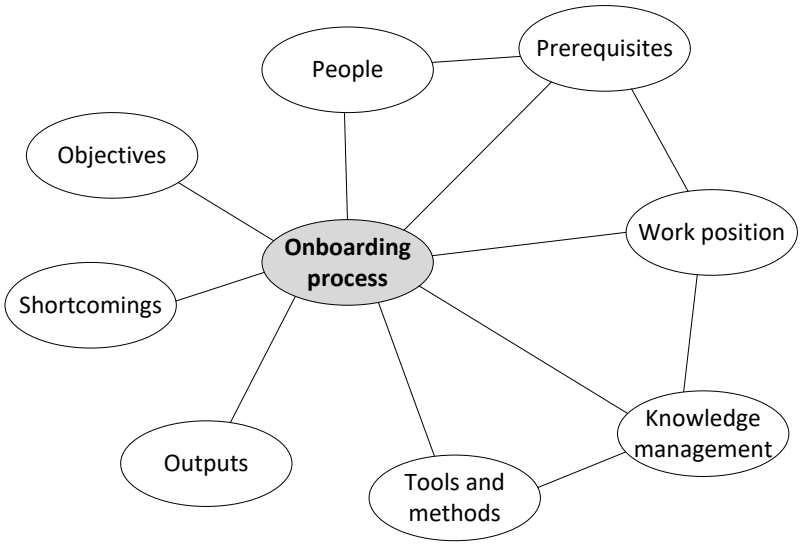

Figure 2. Thematic framework on onboarding practice

All candidates for working engagement in the company should pass *Onboarding process*. The process contains the following steps: getting to know overall organization and culture of the company, introduction to team in which a candidate will work, introduction to technical platform, and introduction to projects in which a candidate will be involved. Before starting the onboarding process, a candidate should satisfy *Prerequisites* proposed by human resource service, which includes passing psychological test, checking suitability for position profile, and signing the contract. The *Outputs* of the process are either termination of the contract if the candidate fails to satisfy all requirements regarding organizational culture and work position, or incorporation of the candidate in work if it satisfies previously stated requirements. In some cases, new ideas and solutions from candidates may be adopted and incorporated in organizational culture and working practice. *Objectives* of the onboarding process are: adapting to work and life in the company, getting to know the internal organization, avoiding harming the company work and culture, solving problematic situations, and saving time of existing employees and resources.

Onboarding is usually tailored to specific working positions in the company, which is represented with theme *Work position* that is connected with onboarding process. Determination of work position includes working profile (technical, technological, and organizational issues) and psychological profile that must be met by the candidate.

Knowledge management is also connected with onboarding process, as well as to work position, which assumes categorization of knowledge for each particular work position. Knowledge management is on elementary level and includes documenting critical issues in projects and finding solutions in previous projects.

Tools and methods is another theme important for the onboarding process, which includes the use of documents for presenting the organizational culture of the company, documents for describing tools and procedures for work, and documents with problems' descriptions. Another method used in onboarding is mentoring, which is tailored for each candidate. And finally, the most important issue is that all candidates are included in real projects and get real simple tasks during the onboarding process.

Two groups of People are involved in onboarding process. The first group includes candidates who signed a contract, which may be beginners without experience in the industry and experienced candidates who have industrial experience but also worked in companies with different organizational cultures. Beginners easily adapt to organizational culture, but experienced candidates are better with technical issues. Experienced candidates have more problems in adopting organizational culture since they already have acquired habits

C. Discussion of Validity

The validity of the study and the findings assume ensuring credibility of the constructed findings by using some common techniques as proposed by Creswell and Miller [24]. In this study, the following techniques to increase credibility and validity of the study are used: thick and rich description of used methods and findings, independent coding of transcribed interview by two researchers and joint construction of the findings, and member check interview with the interviewee. Through member check interview, constructed findings are discussed and refined through joint work with the interviewee. These techniques increase descriptive and interpretative validity as proposed by Maxwell [25].

Generalizability (transferability) of the study findings is hard to claim because the findings are grounded in the data collected in only one company and cannot be extended or applied in other organizations [25]. However, this is not the intention of this study. Generalizability can be achieved through a more comprehensive study that includes a larger number of selected experts from similar organizations, leading to the development of a more general findings or even theory about the onboarding practice.

D. Recommendations for Industrial Practice

Based on the findings of the study, the following recommendations for the practitioners from industry can be proposed:

- Requirements or prerequisites for all work positions should be carefully prepared, including both technical and non-technical aspects of the work. Adequate company employees should be included in that work, but external experts should also be hired as needed (psychologists, economists, engineers of other profiles, etc.)
- Onboarding process should be tightly connected with the real projects in the company, which positively affects the engagement and motivation of new candidates. This assumes the engagement of the company staff working on that project in onboarding activities.
- Use of knowledge management methods and tools might positively affect onboarding process, especially if it can be applied to all work positions in companies.

E. Implications

The presented study design and findings can provide valuable guidelines for designing and implementing similar qualitative studies on human-centered practice in small software companies.

In addition, findings can be used as a basis for inquiring about human-related issues and knowledge management issues in the software industry and including them in the education of IT and software engineers.

IV. CONCLUSIONS

This qualitative study presents themes identified in onboarding practice in a local small software company. The study findings are rendered as a thematic framework created through interpretative and reflexive thematic analysis of an in-depth interview with the company manager.

The presented thematic framework systematizes knowledge of onboarding practice in the selected company and can be used as a basis for the identification of potential improvements in the onboarding practice.

A more detailed analysis that includes the use of other sources of data in the company is possible further research direction that will improve and extend the presented thematic framework. This direction will include both quantitative and qualitative data, and therefore it will require mixed methods in further research.

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Web Development Trends in E-Learning

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Abstract - With the world becoming increasingly connected, the development of web technologies is playing a key role in shaping the field of education. The growth of e-learning has led to constant advances in technology, and this article examines the key trends that are transforming the landscape of online education. These trends are essential for educators, decision-makers, and technologists who want to improve the availability and quality of education. From the integration of web technologies to the use of multimedia elements, the development of web technologies is redefining traditional educational models and providing new opportunities for students. This paper explores topics such as responsive design, cross-browser compatibility, single-page application development, e-learning security measures, as well as emerging technologies such as progressive web applications, voice user interfaces, and the use of JavaScript frameworks for developing interactive content. In addition, the paper explores the ethical and security aspects of digital education, highlighting the importance of establishing ethical guidelines and strengthening security measures to create a responsible and fair learning environment.

INTRODUCTION

In an era of increasing connectivity, the role of web technologies in shaping the education landscape cannot be overstated. Over the past few years, the popularity of e-learning has surged, and the COVID-19 pandemic has only accelerated this trend. Consequently, the development of web technologies in education has become indispensable for educators, decision-makers, and technologists aiming to enhance the accessibility and quality of education.

This article delves into the pivotal trends reshaping online education. From seamlessly integrating web technologies to incorporating multimedia elements, the evolution of web technologies is not merely redefining traditional educational models but also presenting fresh opportunities for students. The exploration encompasses a spectrum of topics, ranging from responsive design, cross-browser compatibility, and single-page application development to security measures in e-learning. It also delves into emerging technologies such as progressive web applications, voice user interfaces, and the utilization of JavaScript frameworks for crafting interactive content.

Moreover, the paper delves into the ethical and security dimensions of digital education. Emphasizing the establishment of ethical guidelines and the fortification of security measures, it underscores the need to create a responsible and equitable learning environment. Clearly, the development of web technologies in education holds immense significance, poised to elevate the quality of education and broaden access for a diverse population.

CURRENT LANDSCAPE OF WEB DEVELOPMENT IN E-LEARNING

A. Responsive Design and Cross-Browser Compatibility

Website design is a crucial point in a website development process. It involves the arrangement of content into graphical models that can be used as a basis for a coding a site [1]. Responsive Design emerges as a technical solution that mitigates the issue, since a website dynamically adapts to the width of the device in which is being visualized [2]. Creating responsive design includes tailoring the page layout resolution of the device, resizing the images automatically to they fit on the screen, adapt size of buttons and links to touch interfaces where the mouse pointer is replaced by the user’s finger, use intelligently features in mobile devices [3].

The One of the prominent trends in web development influencing online education is the emphasis on responsive design. As users access educational content on various devices, from desktops to smartphones and tablets, ensuring a seamless experience across different screen sizes is imperative.

Additionally, the importance of cross-browser compatibility cannot be overlooked, as learners may use different browsers to access educational platforms.

B. Integration of Progressive Web Applications (PWAs)

Progressive Web Apps (PWA) is a new web technology advocated by Google as a novel way to develop as they promise to combine web technologies’ ease of development with the versatility of native apps [4].

Furthermore, PWA was enhanced with some technologies that allow for native-like behavior in a mobile device, while still functioning in a web browser [5].

The integration of Progressive Web Apps (PWAs) in E-Learning has brought about a significant transformation. By combining the strengths of web and mobile applications, PWAs offer offline capabilities, push notifications, and faster loading times. This has a profound

impact on user engagement and accessibility in e-learning platforms.

PWAs enable learners to engage in interactive and immersive learning experiences, navigate seamlessly across different devices, and access personalized content and recommendations. Furthermore, PWAs enhance accessibility by providing flexible access to educational materials and ensuring compatibility across various user devices.

II. THE ROLE OF JAVASCRIPT FRAMEWORK

A. Single Page Applications (SPAs)

A single page application (SPA) is a web application that uses only one HTML web page as a shell for all the application's web pages and whose end-user interactions are implemented by using JavaScript, HTML, and CSS. Most of the SPA development is done on the front end as opposed to traditional web applications that rely heavily on web server interactions and that reload new web pages whenever navigation occurs. SPAs resemble native applications in their behavior and development, but they run inside a browser process as opposed to native applications, which run in their own process [6].

JavaScript frameworks have revolutionized e-learning platforms, particularly through the development of Single Page Applications (SPAs).

SPAs offer a dynamic and immersive user experience by loading content asynchronously, minimizing page reloads, and enhancing interactivity. These advancements have significantly transformed the way users engage with online education.

Learners can seamlessly navigate through different sections of the platform, access content quickly, and interact with interactive elements in real-time. The use of SPAs has contributed to a more fluid and engaging learning experience in modern e-learning platforms.

B. Interactive Content with Vue.js

Vue.js is renowned for its simplicity and flexibility, making it an ideal choice for creating dynamic and responsive user interfaces. When applied to the development of interactive content, Vue.js empowers educators to craft engaging materials that go beyond static presentations [7].

The framework facilitates the seamless integration of interactive elements, such as quizzes, simulations, and collaborative exercises, fostering an immersive and participatory learning environment.

III. EMERGING TRENDS IN WEB DEVELOPMENT FOR E-LEARNING

A. Voice User Interface (VUI)

A Voice User Interface is what a person interacts with when communicating with a spoken language application. The elements of VUI include prompts, grammars and dialog logic. The prompts or system messages are all the recordings or synthesized speech played to the user during the dialog. Grammars define the possible things callers can say in response to each prompt. The system can understand only those words, sentences, or phrases that are included in the grammar. The dialog logic defines the actions taken by the system [8].

In the realm of e-learning, user interaction has evolved beyond traditional interfaces, prompting the exploration of innovative solutions to enhance engagement.

Voice User Interface (VUI) stands out as a pioneering approach, leveraging the natural means of human communication. Unlike conventional interfaces that rely on graphical elements, VUI enables users to interact with e-learning platforms using spoken language. Common examples of VUI include virtual assistants.

Examples: Amazon’s Alexa, Apple’s Siri, Google Assistant, Microsoft’s Cortana.

B. Gamification in E-Learning Interfaces

Gamification is a buzzword that has appeared in a few different fields in the last couple of years, including learning. The term does not imply the design of games, but the usage of game elements, game mechanics and game thinking in non-game contexts. Kapp defined gamification for learning as usage of game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning and solve problems [9].

The integration of gamification principles in E-Learning interfaces transforms the educational experience by introducing game elements to drive engagement and motivation.

Learners earn points and badges for completing tasks, engage in friendly competition through leaderboards, and track their progress visually with progress bars. Gamification leverages intrinsic human motivators, creating an interactive and enjoyable learning environment that fosters achievement and collaboration.

IV. FUTURE PERSPECTIVES AND CONSIDERATIONS

A. Ethical Considerations in E-Learning Technologies

Navigating the ethical landscape of E-Learning technologies requires a thoughtful approach to data privacy, algorithmic biases, and inclusivity. In the digital age, the governance of E-Learning technologies necessitates a soft ethics approach, emphasizing the thoughtful consideration of these factors [10]. This involves ensuring fair and unbiased AI algorithms, securing user data, and promoting digital accessibility, aligning with the critical analysis of schools and schooling in the digital age [11].

Moreover, ethical considerations extend beyond technological aspects to encompass the overall digital

learning environment underscores the importance of ethical guidelines in guiding the development and deployment of digital learning environments [12]. This approach fosters a responsible and equitable learning environment, contributing to the overarching goal of ethical E-Learning practices.

B. Cybersecurity Measures for E-Learning Platforms

In the rapidly evolving educational landscape, the role of E-Learning platforms is increasingly pivotal, necessitating a robust framework of cybersecurity measures to address emerging threats. Secure authentication protocols stand out as foundational elements, serving to fortify defenses against unauthorized access and potential threats. The importance of prioritizing the protection of sensitive learner information cannot be overstated, and comprehensive strategies are essential to mitigate the ever-present risk of data breaches. As highlighted by Pfleeger, proactive approach, including routine security audits and user awareness programs, contributes significantly to enhancing the overall cybersecurity posture of E-Learning platforms [13].

V. CONCLUSION

In this paper, we have explored the key trends in the development of web technologies that impact the field of e-learning. From responsive design to single-page application development, these trends have transformed traditional educational models and provided new opportunities for learners. The integration of progressive web applications, voice user interfaces, and the use of JavaScript frameworks to develop interactive content are also presented as new technologies that enhance the quality of e-learning.

Additionally, the work highlighted the importance of ethical guidelines and security measures in digital education. Data security and privacy are pivotal factors in digital education and establishing ethical guidelines and strengthening security measures are necessary to create a responsible and fair learning environment.

In conclusion, the development of web technologies in the field of education holds great potential to improve the quality of education and provide access to education for a wider population. However, it is crucial that ethical and security standards are followed to ensure that these technologies are used in a responsible manner. As observed, the development of web technologies in the field of education is highly significant and has substantial potential to enhance the quality of education and broaden access for a wider population.

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Scientific-Educational Application of Laser Alignment in Developing Engineering Students' Skills

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Abstract - The application of laser alignment in engineering student education provides high precision and flexibility, facilitating the rapid acquisition of key machine alignment skills. This approach not only shapes students' profound understanding of alignment techniques but also facilitates knowledge transfer between theory and industrial practice. The integration of laser alignment into the curriculum contributes to the development of practical skills, preparing students for the dynamic and technologically advanced environment of industrial facilities.

I. INTRODUCTION

In the introduction of the scientific paper on the use of machinery alignment software in industry for the purpose of student education, we explore key aspects of applying digital technologies in the process of educating future engineers. The technical progress in the industry demands increasingly sophisticated methods of maintenance and adjustment of machinery, with alignment playing a crucial role in effective operation and system longevity. This study focuses on the integration of software tools into educational programs to enable students to gain a deep understanding of alignment techniques, utilizing authentic simulations and virtual laboratory exercises.

The objective of this research is to analyze the benefits of using machinery alignment software in an educational context, investigating how this technology can enhance the learning process and prepare students for the challenges of modern industrial facilities. Additionally, we consider how this innovation can facilitate the transfer of knowledge between the academic sphere and industrial practices, creating a bridge between theory and the real world.

Through the lens of this research, we uncover potential obstacles and challenges faced by educational institutions in the implementation of machinery alignment software, exploring strategies for effectively overcoming these challenges. Through a deeper understanding of this field, we aim to contribute to the improvement of pedagogical methods in mechanical engineering, laying the groundwork for better preparing students for the dynamic and technologically advanced environment of industrial practice.

Furthermore, beyond facilitating the practical implementation of machinery alignment concepts, machinery alignment software plays a pivotal role in enriching students' experiences through interactive simulations and virtual exercises. The integration of these tools into the curriculum provides students with the opportunity to experiment with various alignment scenarios, simulating real industrial situations. This approach enables students to gain practical experience in controlled conditions, enhancing their understanding of machinery alignment concepts [1].

The software also allows personalized learning, adapting to individual student needs. The ability to access resources at any time enables students to learn at their own pace, exploring and reviewing materials according to their specific requirements. This flexibility supports diverse learning styles and provides additional support for students in their academic progression.

Moreover, machinery alignment software often provides insights into real-time machine performance data, further improving students' understanding of the impact of precise alignment on system efficiency and reliability. Through the analysis of this data, students can develop analytical skills and make informed decisions regarding machine maintenance [2]. The sole impact of misalignment can lead to a myriad of issues that occur in industrial machinery [3].

Ultimately, the use of machinery alignment software in education provides students with the opportunity to acquire practical knowledge directly applicable in an industrial setting, enhancing their competitive advantage in the job market.

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II. MATERIALS AND METHODS

The method of laser alignment of industrial machinery represents a highly precise and efficient approach to achieving optimal alignment of machine components. This technique utilizes laser devices to measure and adjust the relative positions and angles between machine parts. Here are the key aspects of laser alignment [4]-[7]:

Principle of Operation:

Laser alignment relies on the emission of laser beams to precisely measure distances and angles between different points on the machine. These devices generate laser beams directed towards target points, and sensors or cameras register the reflected rays.

Measurement Precision:

Laser technology enables high measurement precision, crucial for achieving optimal alignment. In many cases, laser alignment can detect deviations in millimeters or even micrometers, allowing for very precise adjustments.

Various Types of Laser Alignment:

There are different types of laser alignment, including axial, radial, and tangential alignment. Each variant focuses on a specific aspect of alignment to achieve optimal machine geometry.

Real-Time Monitoring and Adjustment:

Laser alignment often allows real-time monitoring, meaning operators can immediately see results and make corrections while the alignment process is still ongoing. This reduces the time needed for adjustments and increases efficiency.

Utilization of Computers and Software:

Laser alignment often involves the use of computers and specialized software for data analysis. These tools provide detailed information about deviations, facilitate result interpretation, and offer guidelines for precise corrections.

Application in Various Industries:

The laser alignment method is applied in various industries, including manufacturing, energy, aviation, and precision mechanics. Its versatility makes it an efficient solution for different types of machinery.

Training of Personnel:

To successfully implement laser alignment, training of personnel is crucial. Operators need to be proficient in handling laser devices, interpreting results, and implementing corrective measures.

The laser alignment method represents a sophisticated technique that significantly contributes to increasing the accuracy and efficiency of industrial machinery. Its ability to provide highly precise measurements and instant adjustments makes it essential for achieving optimal performance in mechanical systems.

Laser machine alignment is a precise procedure that requires careful execution of steps to achieve optimal alignment. Here are the sequential steps for laser machine alignment:

1. Prepare the working surface:

Clean and prepare the working surface to ensure the stability of the machine. Remove any obstacles that might interfere with the alignment process.

2. Set up the laser:

Position the laser device at one end of the machine. If possible, use rotating lasers to cover multiple measurement points.

3. Place target points:

Set up target points on other parts of the machine. Target points can be reflectors, prisms, or other elements that reflect laser beams.

4. Take initial measurements:

Perform initial measurements to determine the current state of machine alignment. This serves as a reference point for further corrections.

5. Rotate the machine:

Rotate the machine so that the laser beam passes over the target points along its path. This allows the collection of data on relative deviations.

6. Data analysis:

Use specialized software or instruments to analyze the data obtained during the machine rotation. Identify deviations and areas that require correction.

7. Adjustment and correction:

Based on the analysis, adjust the machine settings to correct deviations. This may involve shifting or adjusting relevant machine components.

8. Remeasurement:

After making corrections, re-measure to confirm that deviations have been minimized. The correction process can be repeated as needed.

9. Documentation and report:

Record measurement results, corrections made, and any other relevant information. This report can serve as a reference for future maintenance.

III. RESULTS AND DISCUSSION

The application of laser alignment methods in an educational context provides valuable insights into the effectiveness of this technique in developing practical engineering skills among students. Results show that the precision and repeatability achieved through laser alignment contribute to consistent measurements, offering students a realistic experience in controlled settings. This method accelerates learning by allowing students to quickly grasp key alignment skills without the need for physical interaction with actual machinery. The flexibility and adaptability of laser alignment software enable experimentation with various alignment scenarios, accommodating diverse learning styles. Moreover, the method facilitates the transfer of knowledge between academia and industry, bridging the gap between theory and practical application. Overall, the integration of laser alignment methods in education not only shapes students' understanding of machine alignment but also prepares them for successful entry into the industrial sector, fostering the development of crucial practical skills.

Figure 1 shows the process of analyzing the compatibility of the machine in the Easy Laser program.

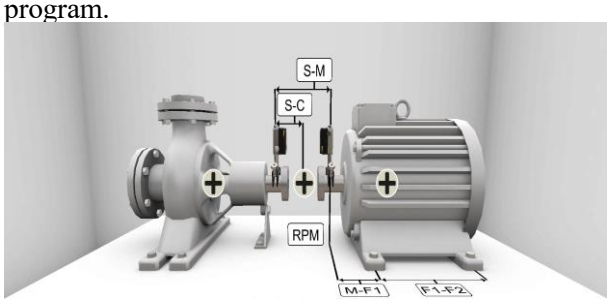

Figure 1. Setting the initial parameters of the machines

In addition to the geometric dimensions shown in Figure 1, it is necessary to define the appropriate number of revolutions of the drive shaft of the machine.

Figure 2 shows the measured misalignment in the vertical direction before the engine centering process.

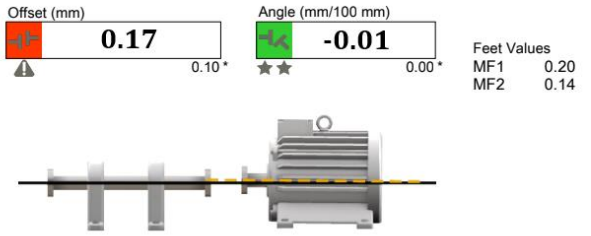

Figure 2. Measured values before the machine alignment in vertical direction

Figure 3 shows the measured values after the shaft axis alignment process in vertical direction.

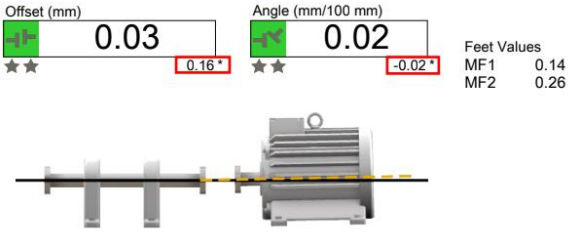

Figure 3. Measured values after the machine alignment in vertical direction

Figure 4 shows the measured misalignment in the horizontal direction before the engine centering process.

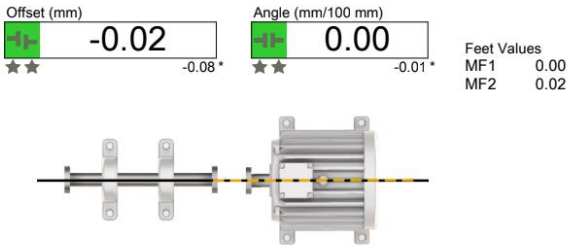

Figure 4. Measured values before the machine alignment in horizontal direction

Figure 5 shows the measured misalignment in the horizontal direction after the engine centering process.

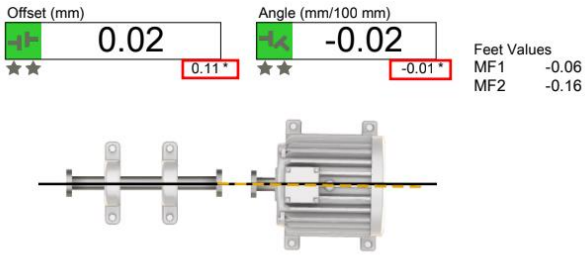

Figure 5. Measured values before the machine alignment in horizontal direction

IV. CONCLUSION

The application of laser alignment methods in engineering student education represents an exceptionally effective approach to developing practical skills. Research findings highlight a high degree of precision and repeatability in this process, providing students with a consistently controlled learning experience. The rapid acquisition of key alignment skills without physical interaction with real machinery contributes to accelerated learning, while the flexibility of laser software tailors the experience to diverse learning styles. Furthermore, the method facilitates knowledge transfer between academia and industry, serving as a bridge between theory and practical application. The integration of laser alignment methods into the educational curriculum not only shapes students' understanding of machinery alignment but also prepares them for successful entry into the industrial sector, contributing to the development of crucial practical skills needed for the challenges of contemporary engineering. Education in the field of laser alignment through practical examples significantly impacts university students' education on various levels. By applying theory to practice, students can directly employ their theoretical knowledge in real-world situations, enhancing their understanding of concepts and facilitating the integration of theory and practice. Furthermore, working on practical examples fosters the development of analytical skills and critical thinking among students, enabling them to identify the causes of laser alignment and propose solutions. The interactive learning approach provided by working on real-life situations encourages student engagement and active participation in the learning process. Additionally, addressing disagreement cases prepares students for future professional challenges by offering them practical experience that will prove valuable in their careers. Finally, the multidisciplinary approach often required in resolving disagreement issues allows students to integrate knowledge from various fields and comprehend the complexity of real-life scenarios.

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Improving User Experience Aspect at a Preschool Website – a Case Study

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Abstract - This paper presents results of a project that has the aim to improve user experience aspect of a preschool web portal, addressing graphical and functional elements. This project is applied at Preschool instution Zrenjanin, Serbia. Comparison between previous and new solution will be presented, with description of user interface and implementation. Additional comparison is made by using automated tool for user experience measurements, based on common metrics.

I. INTRODUCTION

User experience is one of the most important aspects which should be addressed in modern web site development. Contemporary approaches clearly make distinction between user interface (UI) and user experience (UX) as a broader term. Starting point of every web site development is definition of the purpose, goals and target user groups, which represent the basis for selection of user experience elements, i.e. graphical and functional elements and their integration. Obviously, different purposes and target groups require quite diverse graphical and functional styles of data representation, navigation, manipulation [1] etc.

This paper presents results of a project particularly conducted in aim to enhance user experience at official web site of Preschool institution Zrenjanin, Serbia (available at www.predskolskazr.edu.rs). Having user experience in focus, descriptive analysis of previous and new solution of the website will be presented, as well as comparison of experimental results in automated measurements of both version of the website (old – currently being used and the new one – under finalization). This way refinement of user experience is judged – has it been achieved with the new version of web site?

The rest of this paper is organized as follows: second section explains background, with introducing the concept of user experience and basic aspects covered within this concept. Third section provides brief analysis of previously published papers related to user experience at websites. Section four contributes with the proposed research methodology, section five presents the developed web site solutions (old and new) and section six provides results and discussion on automated measurement of user experience level of both solutions. Final section outlines the aims, results and future work that could be conducted for this website and generally, in this research area.

II. BACKGROUND

According to [1], ISO 9241 standard [2] defines key terms related to user experience as a common concept:

- "Usability: An extension in which a system, product or service can be used by specific users to achieve determined goals with effectiveness, efficiency and satisfaction in the defined context of use.
- User Experience (UX): Extends the concept of usability (effectiveness, efficiency and satisfaction) to the perception and responses resulting from the use and/or anticipated use of a product, system or service." [1]

User experience of software has certain relevant aspects that should be addressed during website development - planning, implementation and testing. In systematic review [3], user experience definition, relevant aspects and dimensions, as well as aspects that affect user experience were addressed and analyzed from papers published within appropriate scientific events or journals. Regarding user experience definition in the context of software, only 2% of the research sample provided answers to that research question, while 53% of all analyzed papers were related to aspects and factors affecting user experience.

ISO standards define relevant characteristics of software quality as a product (Figure 1) and in use (Figure 2).

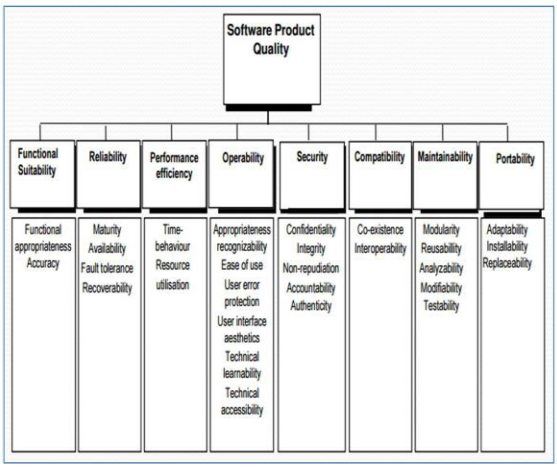

Figure 1. Aspects of software product quality, as per ISO standards (ISO/IEC 9126, ISO/IEC 25010:2011)

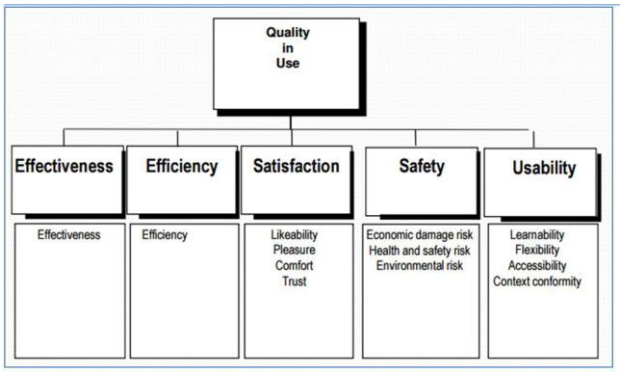

Figure 2. . Aspects of software product quality in use, as per ISO standards (ISO/IEC 9126, ISO/IEC 25010:2011)

III. RELATED WORK

Recent research results are related to user experience evaluation of particular types of web sites, having different user experience requirements and appropriate evaluations, according to their purpose, such as: a) "information driven websites" having main goal to provide relevant content to users [2]; b) "transactional business-oriented", such as e-Commerce, e-Banking, travel etc [2], related to presenting news [4].

Methods for evaluation of user experience aspect of web sites have been addressed in systematic review [1]. Dominant methods for user experience evaluation determined in [1] include: user testing, expert evaluation, automated evaluation and data mining. In [2] an empirical research has been conducted by using online surveys with users of news website within the exploration of relevant characteristics of news website design. In these online surveys, particular attention has been set to user satisfaction and psychometrics measure of trust.

Google has developed a system for evaluation of user experience metrics and it is named Web Vitals [5]. Three key aspects are performance at load i.e. load and paint speed (LCP – largest contentful paint), speed of answering to user actions (FID – first input delay) and visual stability of user interface elements positions in the user interface, after load (CLS – cumulative layout shift).

Table I presents classification of obtained and analyzed results, regarding aspects affecting user experience, as per systematic review [3].

TABLE I. RELEVANT ASPECTS, CATEGORIES AND DIMENSIONS OF USER EXPERIENCE DESIGN [3]

UX Aspect	Aspect Category	Dimension
Branding	Brand	Brand Experience (BX)
Everyday Operations	Brand	Brand Experience (BX)
Marketing	Brand	Brand Experience (BX)
Business Communications	Brand	Brand Experience (BX)
Context of use	Context	Brand Experience (BX)
Spatio-Temporal	Context	Brand Experience (BX)
User Journey	Context	Brand Experience (BX)
Cultural	Context	User Experience (UX)
Emotional	Hedonic	User Experience (UX)
Hedonic	Hedonic	User Experience (UX)
Trustworthiness	Hedonic	User Experience (UX)
Aesthetics	Hedonic	User Experience (UX)
Fun	Hedonic	User Experience (UX)
Privacy	Hedonic	User Experience (UX)
Sensual	Hedonic	User Experience (UX)
Usability	Pragmatic	User Experience (UX)
Functionality	Pragmatic	User Experience (UX)
Usefulness	Pragmatic	User Experience (UX)
Platform Technology	Development Technology	Technology Experience (TX)
Infrastructure	Hardware	Technology Experience (TX)
Service Response time	Operation	Technology Experience (TX)
Visual Attractiveness	UXD	Technology Experience (TX)

User experience of web portals could be presented in with levels of features [6] – accessibility, relevancy, usability, personalization and persuasiveness, as presented at figure 3.

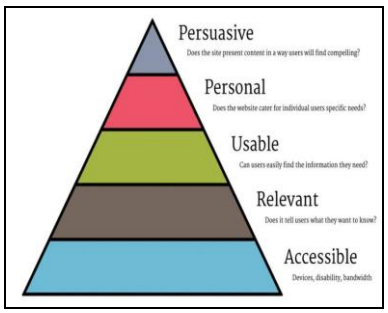

Figure 3. User experience and personalization [6]

According to [7], user experience design of web sites is based on definition of web site objectives and user needs, which lead to definition of content requirements and functional specifications, as well

as information architecture. Relevant aspect of user experience is interaction, navigation, interface and visual design. All relevant aspects of user experience design are presented at figure 4.

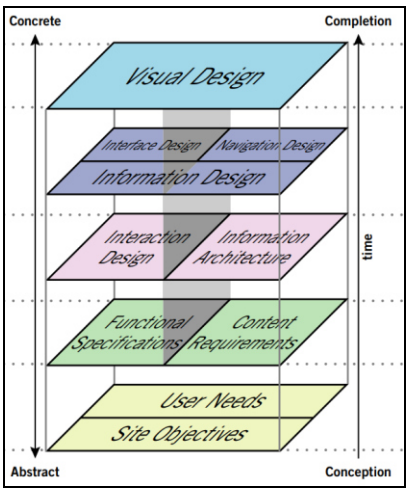

Figure 4. Elements of user experience design [7]

IV. Research Methodology

This paper aim is to present results of a case study based on comparison of features of previous (old) and new website of Preschool institution Zrenjanin, Serbia.

Currently, in this case study there is official web site of Preschool institution Zrenjanin, Serbia reachable at: www.predskolskazr.edu.rs. Previously, old web site could be reached at web site url: www.predskolskazr.edu.rs.

After establishing new web site to be ready for public presentation, old web site was shifted into a subfolder and now it could be reached at: https://www.predskolskazr.edu.rs/StariSajt/index.php New web site is reachable at: https://www.predskolskazr.edu.rs/ which redirects automatically to: https://www.predskolskazr.edu.rs/NoviSajt/index.php

The comparison is made with two methods:

1. Descriptive – by presenting relevant features in tabular presentation of comparison of old and new web site characteristics;
2. Automated – by using web-based tool GTMetrix, that enables evaluation of web sites from the aspect of user experience – evaluation results of old and new web site will be presented as images representing screen shots from GTMEtrix application results.

V. Case Study – Empirical Sample

Empirical sample in this case study is related to old and new web site of Preschool institution Zrenjanin, Serbia.

Both versions of web site are based on PHP and MySQL database (without using any frameworks), hosted at the same hosting server and they both have:

1. Presentation part – presenting content included in web site by using CMS – presented with figure 5 and figure 6 for new web site, as well as Figure 8 and Figure 9 for old web site,
2. CMS (Content Management System) – separate module that enables entering texts and multimedia elements, needed to be presented in the presentation part – presented with figure 7 for new web site and figure 10 for old web site.

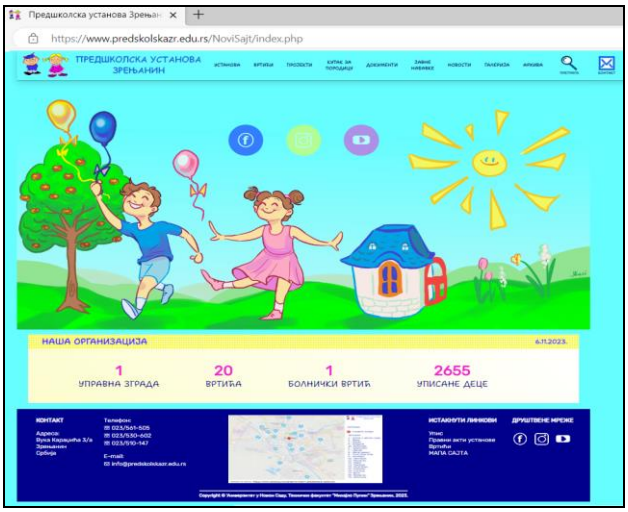

Figure 5. Home page of new web site of Preschool institution

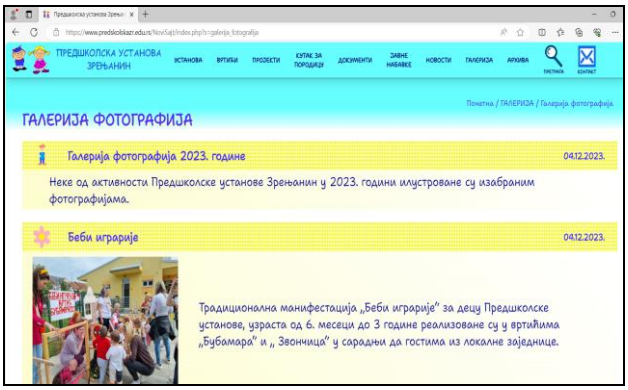

Figure 6. Particular page at new web site of Preschool Institution Zrenjanin, Serbia

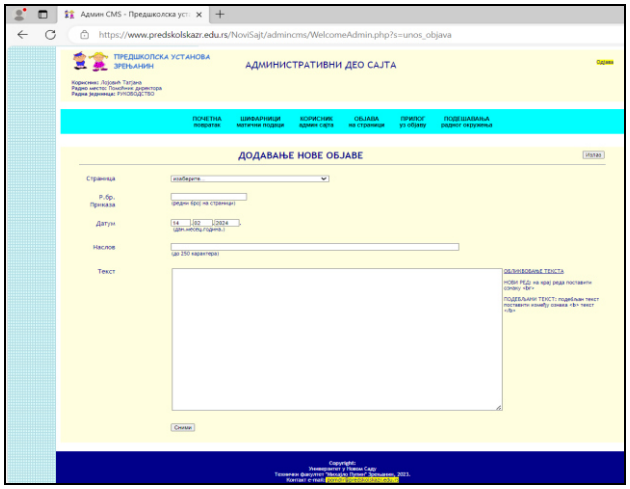

Figure 7. CMS system of the new web site of Preschool institution Zrenjanin

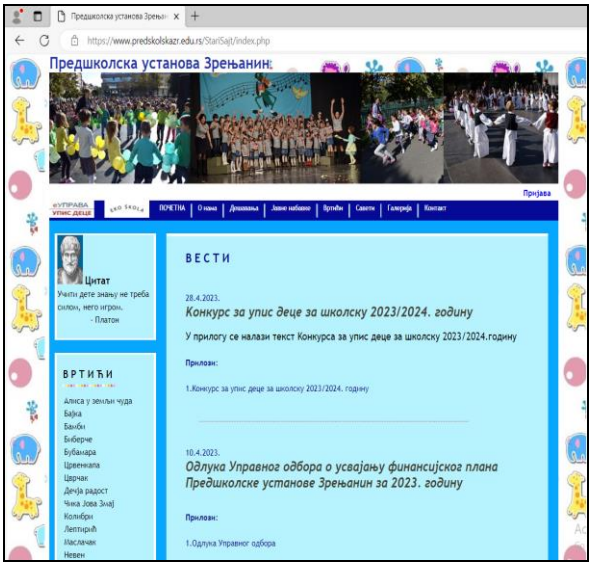

Figure 8. Home page of old web site of Preschool institution Zrenjanin, Serbia

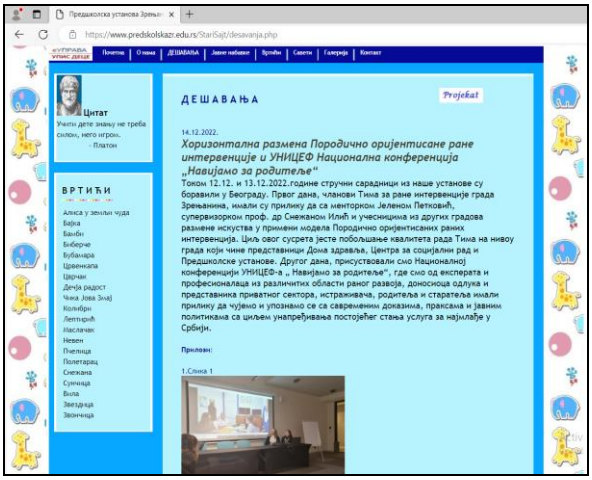

Figure 9. Particular page of old web site of Preschool institution Zrenjanin, Serbia

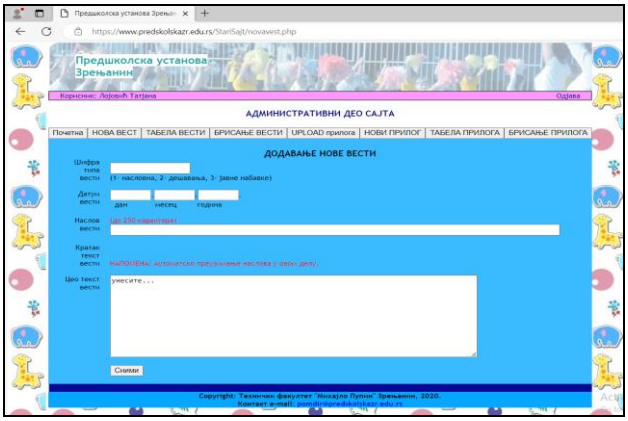

Figure 10. CMS system of old web site of Preschool institution Zrenjanin, Serbia

VI. RESULTS

A. *Descriptive Analysis Results*

In the descriptive analysis comparison of relevant features regarding user experience will be conducted and presented in the form of table. Relevant features are selected and integrated from previously presented figures 1-4 and Table I. This integration is presented in Table II and used for analysis of old and new web site.

TABLE II. COMPARATIVE DESCRIPTIVE ANALYSIS OF USER EXPERIENCE-RELATED FEATURES OF OLD AND NEW WEB SITE OF PRESCHOOL INSTITUTION ZRENJANIN, SERBIA

FEATURE	Old web site	New web site
Content	Short content, some menu items are missing	Complete content having all menu items and sub-items aligned with similar web sites of preschool institutions
Functions – usability	*Basic multimedia:* Plain texts, documents for download, images with small and large versions	*Multiple multimedia types:* Texts, images, google maps, Youtube video *Presentation elements:* Presentation of content, search, archive filtering, contact data, footer with map of all institution buildings, important links, site map, social networks links, *Additional visual effects*: animated icons, transition of elements when mouse over
Software Architecture	Multi page	Single page
Interaction	No transitions	Transitions in interaction with icons at menu and icons next to news titles
Navigation	Side and upper simple menu without submenu items, no site map or search	Menu with submenus, site map, search, archive filtering
Interface design	Neutral colors, serious design	Cartoonish elements, light colors, cheerful design
Accessibility	Only web version	Designed for both web and mobile version (structure

		based on divs and css classes, not tables)
Visual attractiveness	Dominant "sad" shade of blue color	Dominant "light" blue color and yellow color, cartoonish style, icons, visual effects of animations and transitions
Performance	Slow loading – multi page, all news since start of the web site use (from many years)	Fast loading – single page, max 10 news per page (last 10 news are presented, the rest are in the archive)
Learnability	Simple structure of menus, intuitive	Simple structure of news and menus, intuitive, standard options at usual locations in header and footer

B. Automated Evaluation Results

Results of automated analysis of user experience of old and new web site are presented at following figures - they represent screen shots from the GTMetrix tool applied to both versions of Preschool institution web site.

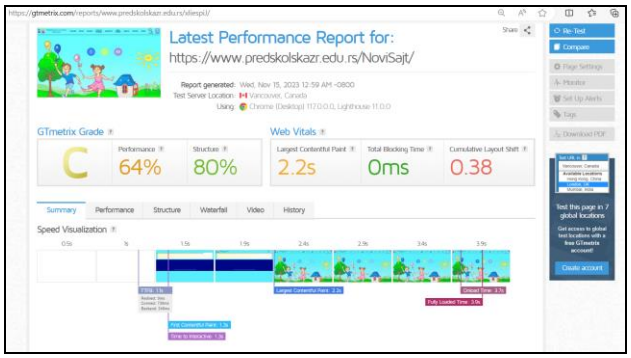

Figure 11. GTMetrix results, after applied to new web site url

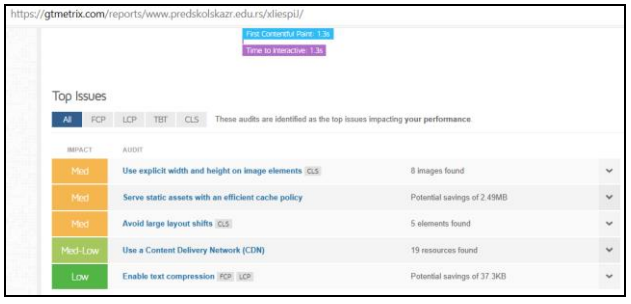

Figure 12. User experience issues detected with using GTMEtrix tool upon new web site

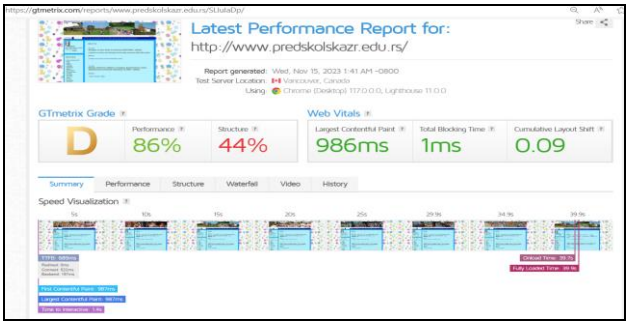

Figure 13. GTMetrix results, after applied to old web site url

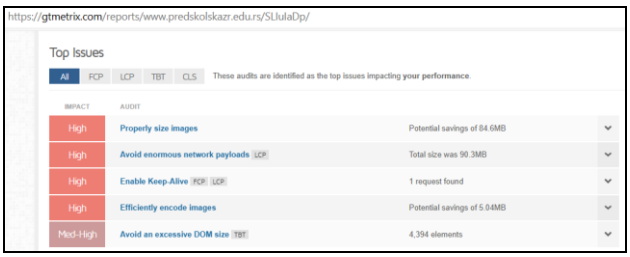

Figure 14. User Experience issues detected by GTMetrix tool, upon old web site

C. Discussion About Results

According to descriptive presentation of old and new web site comparison, it could be concluded that new web site has improved user experience in all aspects. Content is more complete, having all necessary pages related to menus and submenu items, aligned with similar web portal of preschool institutions. New web site included more multimedia types (added are – google maps and YouTube video), more functions (added are: search, archive, footer with important links and site map, as well as social network links), additional visual effects – animations and transitions. Single page architecture of new web site enables faster loading and better suitability to maintenance and content expansion. Interaction at new web site is modern, with transitions that appear when having mouse move over the icons. Navigation is enhanced having search, site map and archive filtering available. User interface is better designed, having more cheerful colors of blue and yellow, as well as cartoonish style at first page and having multiple icons manually created in cartoonish style, which brings cheerful feelings. Accessibility is improved having the structure suitable for mobile version (having divs and css classes as main structural and design elements). Visual attractiveness is enhanced by selection of colors, cartoonish style of home page and icons, visual effects of animations and transitions. Performance is enhanced by using single page architecture and restriction of top 10 last news

presented per page (the rest are available in the archive page with filtering). Learnability is supported by organization of elements intuitively (standard options positioned as typical user of a website is used to – in header, main content and in footer).

After comparing results of automated evaluation of both old and new web site, by using GTMetrix, it could be concluded that general grade for new web site is C, while old web site received grade D. New web site had 64% for performance, while 80% in the structure aspect. Old web site received 86% for performance, while only 44% in the structure aspect. Having web vitals considered, Largest contentful paint is for new web site 2.2s, while old web site have 985ms, Total blocking time for new web site is 0ms, while 1 ms for old web site and Cumulative layout shift is for new website 0,38, while for old is 0.09. GTMetrix presented particular issues which, if resolved, would enable better results for Web Vitals. For example, in the new website, some of the issues are considered as medium impact, such as: the use of explicit width and height of image elements, use of static assets, large layout shifts. In old web site, some issues are considered as with the high impact, such as: image size, encoding of images, network payloads.

VII. CONCLUSION

Aim of this paper was to present results of user experience improvements for the particular case of Preschool institution Zrenjanin, Serbia.

The introductory part of this paper introduced background for software quality in ISO standards, as well as related work, having presented both professional and scientific results in user experience evaluation models and application of evaluations.

The main contribution of this paper is related to an evaluation model that was used with this case study for comparison of old and new web site regarding user experience aspects. This evaluation model, that was proposed in this paper, was created as integration of important features of user experience from several other evaluation models. The proposed evaluation model is a basis for descriptive presentation of important features. It has been used to compare new and old web site of Preschool institution Zrenjanin, Serbia.

Second important result is related to automated evaluation of old and new web site of Preschool institution Zrenjanin, Serbia, performed by using GTMetrix tool. In both cases, old and new web site were evaluated according to Web Vitals metrics, but also GTMetrix tool provided additional features results, such as performance and structure and it also provided list of particular items that could be enhanced and the estimation of the impact of these items on overall GTMetrix score.

Having concerned results of manual (descriptive) and automated evaluation of user experience quality of old and new web site of Preschool institution Zrenjanin, Serbia, it could be concluded that new web site has brought improvements in all relevant aspects of user experience. Of course, there are still some items to be improved in new web site, such as finishing the mobile version of the new web site and finalizing presentational and CMS functions, to the full usability level.

ACKNOWLEDGEMENTS

This paper presents results from the project entitled “Improvement of graphical and functional aspect of user experience at Preschool institution Zrenjanin official web site (www.predskolskazr.edu.rs)”, which was conducted during year 2023 in cooperation between Technical Faculty “Mihajlo Pupin” Zrenjanin, affiliated to University of Novi Sad, Serbia and Preschool institution Zrenjanin, Serbia.

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Artificial Intelligence in Online Learning

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Abstract - Artificial intelligence (AI) is rapidly transforming the way we learn, and online learning is no exception. AI is being used to create more personalized, engaging, and effective online learning experiences for students of all ages. AI is also being used to automate many of the tasks that are traditionally performed by teachers, such as grading assignments, providing feedback, and answering questions. This paper deals with main characteristics of AI online learning and tends to predict future benefits. In addition to that, AI itself is used to extract main features in online learning supported by AI and make predictions. Predictions on same matter are made by humans and these predictions are compared. It is concluded that AI assumes and predict high levels of knowledge retention and understanding, which is in contrast to human predictions. On the other hand, humans assume and predict high levels of engagement and motivation which is in contrast to AI predictions.

I. INTRODUCTION

The rapid advancement of artificial intelligence (AI) is transforming various aspects of our lives, and education is no exception. Within online learning platforms, AI is emerging as a promising solution, with possibility to change the ways of teaching and learning. This paper deals with possible AI interactions and benefits in online learning in near future.

From the beginnings of personalized learning concepts, which were developed to fulfill individual needs in the learning process, AI emerged as a powerful learning associate. Nowadays AI learning systems can:

- **Personalize learning experiences.** By analysis of data and learning patterns, AI algorithms can produce individualized learning steps, beneficial to different learning styles, and suggest learning materials and other learning content [1].
- **Enhance engagement and interaction.** AI learning assistants and chatbots can answer questions in real-time, providing personalized support. By gamification and simulations AI learning systems can increase learner's interaction, which results in turning of passive learning into active one [2].
- **Automate administrative tasks.** Grading student's work is elaborate and time-expensive task. Furthermore, providing feedback, and scheduling assessments are just adding to this task list causing great stress for teachers. AI can automate these tedious tasks, so teacher can focus on higher-value activities [3].
- **Deliver adaptive assessments.** Even today, AI learning assistants can adjust to each student's personal learning level which includes level if knowledge understanding. This is an opportunity to develop systems which are capable to guide learner through learning process [4].

There are many technical difficulties when embedding AI learning tools to learning process. Also, there are many ethical considerations such as data privacy. To add on that, there are many concerns regarding creativity, social skills and bias of AI learning tools.

This paper will examine current state of AI learning tools when applied in real-life education process, especially learning process, with the main goal of assessing AI capabilities in learning environments in near future.

The paper is structured as follows: After short introduction given in this subsection, subsection II gives literature review in order to get an insight to the subject of online AI learning tools. Some review papers are investigated in this subsection. Subsection III deals with future prediction of AI in online learning. Lastly, subsection IV gives some discussion and final conclusion.

II. CURRENT STATE OF AI IN ONLINE LEARNING

Today, there is an opportunity to change online learning experience by including AI learning tools in this process. The online learning, which was once considered to be rather predetermined and static learning experience driven by non-dynamic algorithms, has a likely chance to change and become dynamic, changing and tailored to learner's needs. In order to have an insight to today's AI's capabilities in online learning, an insight into the

literature sources that deal with the subject of the application of AI tools in online learning is needed.

In [5], 12 papers dealing with the application of AI in online learning were analyzed. This review is of great importance for this paper, because an integrated insight to various problems regarding AI applications in online learning systems is given. Next lines summarize most valuable results from [5].

Hardware\software platforms for distance online learning supported by AI are an indispensable element of such systems. Second indispensable element is AI mechanism applied to online learning process. So, a decision-making intelligent distance online education has been proposed. These systems are often cloud-based, and provide "human-computer interaction window" in order to visualize decision-making scheme. First experimental results prove that cloud-based decision-making, visual systems are effective.

Next article reviewed in [5] deals with privacy issues such as "the risk of privacy disclosure of location, social network and trajectory of end users in the education system". Algorithms for privacy protection are proposed, which proved usable.

There are also literature sources which deals with slow data processing of intelligent education systems, so that "huge transmitted information by students, teachers and administrators is merged using the Bayesian model for integrating educational resources in the digital cloud to create a distance education database that supports the system with data". Transmitting speed of data and data connectivity in general are huge problem in online systems. The solution predicts the development of hardware\software networks that are capable to deal with data transmitting speed, connectivity and data integration from various sources.

It is also important to study the pattern recognition methods of personalized adaptive learning in online education. In the sense of personalization, learner's characteristic models are created in order to identify learning patterns, interactive behavior and online social patterns.

Method of mobile intelligent education system based on distributed hash table has been also proposed. This method "combines the chord system based on distributed hash table and vector space model to form a resource discovery mechanism, and solve the similarity between query and location resource vectors by establishing the vector relationship between them."

Furthermore, an "industrial" usability of AI based learning systems are analyzed, as well as the problems of low coverage of teaching resource recommendation results, long running time of the platform and low accuracy of resource recommendation in traditional methods.

Intelligent teaching modes are evaluated in further works of multiple researchers. In this investigations "an effect evaluation index system including five indexes of basic quality, teaching attitude, teaching method, teaching ability and teaching effect is constructed".

In [6] four researching questions are proposed:

RQ1: Which approaches are used for education analysis and development using AI?

RQ2: Which machine learning or deep learning classifier is frequently used?

RQ3: What is the primary feature engineering technique used in analyzing education?

RQ4: What are the major sources of data for educational analysis?

A set of 35 research paper has been thoroughly investigated in [6] which led to recommendations for development of AI-based online learning systems which further led to important implications. There is a need for larger and standardized dataset as well as preprocessing of data and handling small datasets. Some challenges in providing fair and reliable ratings are observed, as well as the temporal nature of indicators. Further implications are alternative classification and feature engineering, limited exploration of deep learning algorithms, understanding dynamic student performance, importance of class balance of training sets and enhancing education by machine learning methods.

In summary, the important points that determine the state of today's application of AI in online education concern:

1. Data privacy.
2. Data transmitting speed and connectivity issues.
3. Personalized online learning.
4. Training datasets and applied machine learning methods.

These points are crucial for estimation of AI online learning platforms, as well as for future development.

III. FUTURE OF AI ONLINE LEARNING

By literature analysis it is expected that key benefits of AI online learning platforms are: Increased engagement, improved learning outcomes, reduced teacher workload and increased

accessibility. One glimpse to the future is exploration of current AI based online platforms such as:

1. **EdApp**: This is mobile-first platform, has AI-powered course creation tools, personalized learning paths, gamified learning, micro-learning modules and content library [7].

2. **MindTap**: Integrates with online textbooks and courseware, has adaptive learning modules, personalized study plans, adaptive assessments, real-time analytics [8].

3. **McGraw Hill Connect:** Includes adaptive learning quizzes and activities, personalized feedback, data-driven insights for instructors, virtual labs and simulations, as well as mobile access [9].

4. **Blackboard Learn:** Includes built-in LMS platform with adaptive learning components, personalized recommendations, AI-powered grading tools and mobile application [10].

5. **Smart Sparrow:** Focuses on STEM education, adopts adaptive labs and simulations, personalized reports for instructors and real-time student performance tracking [11].

These platforms are used for high-education online learning, but some of them are used for corporate training and are domain oriented (medicine, economy, etc). By insight to these platforms it is obvious that AI is not used in its full potential. Also, there are no obvious standards for inclusion of AI based learning platforms to the broader system of education.

One simple experiment is to ask AI chatbot to define key features regarding potential improvement in student learning in future, when AI online learning is used. Such one "opinion" is generated as courtesy of Google Bard chatbot [12]. Following key attributes were selected:

- Personalized learning,
- Engagement and motivation,
- Knowledge retention and understanding and
- Teacher efficiency and effectiveness.

Graph on Fig. 1 represents AI's opinion on potential improvement in student learning with AI in 2024 to 2030 period.

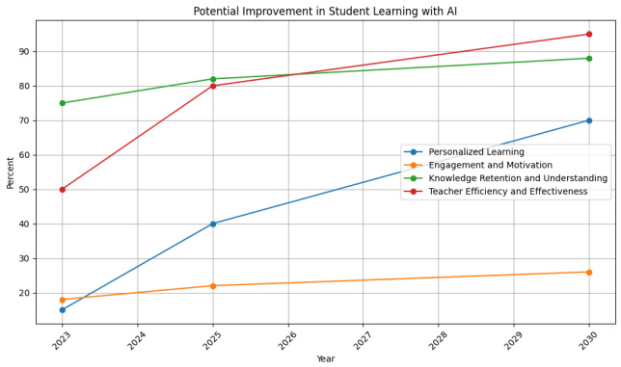

Figure 1. AI predictions

As can be seen from Fig. 1, personalized learning and teacher efficiency and effectiveness are to make greatest improvement, while knowledge retention and understanding, as well as engagement and motivation are to make minor improvement. AI considers that current levels of knowledge retention and understanding are currently relatively high, while engagement and motivation are currently relatively low. In contrast, empirical yet subjective author's opinion on same subject is given on Fig. 2.

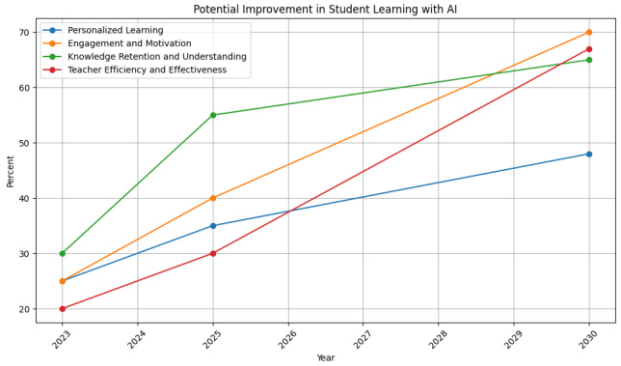

Figure 2. Human predictions

As can be seen from Fig. 2, author's opinion differs from AI opinion: starting levels are considered lower, while potential improvements are also considered to be lower.

IV. Discussion and Conclusion

Artificial intelligence is indeed powerful tool when embedded in online learning system. However, AI inclusion to online learning is yet to be fully explored and applied. Currently, there is no great number of systems that uses AI as prime mechanism for online AI learning platforms. As stated before, main concerns are related to: Data privacy, data transmitting speed and connectivity issues, personalized learning, training datasets and applied machine learning methods.

This paper investigates current state of AI in online learning in order to predict potential future

improvements in student learning and facilitating the work of teachers in online learning. Although literary sources and overview papers were consulted, the prediction of the future in this matter was left to the AI itself, which distinguished four essential parameters (features): Personalized learning, engagement and motivation, knowledge retention and understanding, as well as teacher efficiency and effectiveness. These features are in agreement with the previous knowledge, although their number may be significantly higher and variable. AI's predictions are given in Fig.1, while predictions on same matter by authors are given in Fig. 2. AI predicts substantial growth of personalized learning and teacher efficiency, while human predictions differ. Namely, AI assumes that current state of knowledge retention and understanding is pretty high and predict mild growth, while human conception of current state of knowledge retention and understanding is not so "bright". This is probably due to real-life empirical experience where knowledge retention and understanding are often questionable. This human prediction versus AI prediction also differ on the matter of engagement and motivation: while AI assumes these levels to be currently low, as well as low growth, human prediction assumes that engagement and motivation are main factor in knowledge retention and understanding. This time "dark" AI prediction is opposed by "bright" human prediction. These differences in prediction can be attributed to the lack of a concept of the mutual influence of parameters that inevitably exists, and AI is not "aware" of it.

As for the future work, it would be important to examine in detail the role and possibilities of AI chatbots in the learning process, both online and offline. This would provide significant insight into the development of learning methods, as well as new concepts on this matter.

ACKNOWLEDGMENT

This research is financially supported by Ministry of Education and Science of the Republic of Serbia under the project number TR32044 "The development of software tools for business process analysis and improvement", 2011-2023.

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Microlearning in Technical Education: Didactic Aspects and the Possibility of Practical Application in Elementary School

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Abstract - This paper discusses the didactic aspects of microlearning and its possible applications in technical education in primary schools. We examine the impact of the fundamental elements of microlearning and analyse how they can effectively contribute to improving the results of teaching techniques and technology in elementary schools. The goal is to clarify the theoretical foundations of microlearning in the context of this subject, which will support and encourage teachers to apply this innovative method effectively in their teaching practice.

I. INTRODUCTION

The challenge of the current education system is that students often encounter obstacles within traditional learning methods, struggling to foster rapid learning and encourage creative thinking. Microlearning introduces a new approach to instruction that involves breaking down knowledge and information into concise segments and delivering them to students. This method aims to simplify learning subjects, making them more understandable and memorable over a lasting period.

Modern education faces the challenges of adapting to technological innovations and social changes. These changes also affect the teaching of technique and technology in elementary school. For the efficiency of the teaching process, more and more attention is consecrating to new approaches to education. One of those innovative approaches is microlearning, whose application in the teaching subject of techniques and technology can have a major influence on the learning process.

Microlearning arises as a response to the need for an adaptable and focused form of learning in the modern digital environment. In this research, we focus on the theoretical framework of microlearning in the context of teaching the subject of techniques and technologies. Our goal is to understand the fundamental characteristics of microlearning and explore how this approach can effectively contribute to the increase of teaching outcomes in the technology field.

Micro-learning represents a practical innovation in the realm of lifelong learning. It takes pragmatic as it aligns with contemporary information and communication models, effortlessly accommodating individual learning requirements, particularly in informal learning settings. The term "innovation" is applicable because it introduces a novel approach to crafting and structuring learning experiences. This includes the delivery of content in small, digestible steps and units, besides the organization of content through collaborative creation and utilization via social interaction. (Giurgiu, 2017)

We can find many studies on this topic. The research of Mohammer and ad. focuses on the application of microlearning teaching techniques in the context of ICT subjects within primary school education (Mohammed, Wakil, & Nawroly, 2018) After testing both scoring groups, the microlearning group showed about 18% better learning than the traditional group. We can conclude that using microlearning techniques can improve the effectiveness and efficiency of learning. Also, knowledge can remain memorable for a lasting period.

The Fagerstrøm, Gulliksen, and Grønli study illustrates that a mobile application enables participants to engage in the microlearning program irrespective of time and location. Compared to traditional learning programs, typically conducted through presentations at meetings for educating healthcare professionals, the utilization of mobile learning and microlearning has the potential to augment participation in the learning initiative (Fagerstrøm, Gulliksen, & Grønli, 2016).

Also is interesting Goschlberger's view is that individuals who engage in microlearning often concentrate on achieving cognitive goals at lower

levels, primarily focused on processes of memory and understanding (Göschlberger & Göschlberger, 2017). That should be especially considered when preparing micro-lessons.

Through the analysis of the key elements of microlearning, we will explore how this innovative method can be adapted to the specifics of the teaching subject of techniques and technologies, exploring potentials, challenges and expected benefits. With this research, we aim to contribute to the theoretical understanding of microlearning in the specific context of teaching technical and technological disciplines, with the hope that the results of this research will provide guidelines for improving practice in the field of technical and technological education.

II. THEORETICAL FRAMEWORK

A. Defining Microlearning

While the definition of microlearning may lack a universally agreed-upon definition, certain interpretations are noteworthy. Hug (2010) characterizes microlearning based on time, specifically defining it as ranging "from one second up to more than an hour" (p. 3). Hug and Friesen (2005) conceptualise microlearning as a learning process occurring in incremental steps, aiming to reshape traditional notions of education beyond established frameworks. Langreiter and Bolka (2005) identify microlearning as the "progressive fragmentation of both information sources and learning units" (p. 1). Schafer (1999) draws a connection between microlearning and technology, highlighting how computer technology inherently mirrors microlearning through its modular and adaptable nature. Langreiter and Bolka (2006, p. 79) describe microlearning as a concept that represents the growing phenomenon of the continuous breakdown of information sources and learning units, particularly in dynamic fields characterized by swift advancements and a consistently elevated level of transformation.

As per Simonson et al. (2018), microlearning is essentially a term denoting an instructional approach that advocates for learning in brief segments, facilitated through diverse platforms. It involves the delivery of concise learning content, typically lasting only a few minutes and easily accessible via mobile devices (Palmer & Blake, 2018). The notion of "Micro-Learning" (ML) has consistently been underscored as an efficient learning strategy across various learning scenarios (Khong & Kabilan, 2020). Particularly, microlearning has garnered attention as a promising approach within work-based learning contexts (Leong et al., 2020). Microlearning (also written as micro-learning) is a learning delivery approach in which learning tasks are broken into tiny content designs. Microlearning is also defined as training delivered in bits, simultaneously giving learners the freedom to control what they are learning (Fox, 2016). Lastly, Job and Ogalo (2012) gave a detailed definition of the microlearning concept: Microlearning is based on the idea of developing small chunks of learning content and flexible technologies that can enable learners to access them more easily in specific moments and conditions of the day, for example during breaks or while on the move.

The rise in popularity of microlearning can be caused by its user-friendly nature and its adaptability to various delivery methods. Its convenience appeals to individuals with busy schedules who seek to acquire new information. Moreover, microlearning is cost-effective and seamlessly integrates with other learning modalities. The primary objective of microlearning is to present information in a manner that enhances retention and facilitates practical application in daily life.

B. Key Features Of Microlearning

Microlearning is a pedagogical approach in education that focuses on providing short, specific and targeted educational content. This method involves delivering information or skills in small and carefully designed segments, often tailored to the needs of the individual learner. A key feature of microlearning is its emphasis on efficiency, accessibility and speed, thus responding to the modern challenges of learning in the digital age.

Microlearning can use a variety of formats, including short video lessons, interactive exercises, quizzes, infographics, or other compact educational resources (Kulhanek & Mandato, 2022). This method allows students to quickly access specific information or skills, often through digital platforms or mobile devices. Individuals engaged in microlearning often concentrate on achieving cognitive objectives at the lower levels, primarily centred around the processes of remembering and understanding (Göschlberger & Göschlberger, 2017).

The microlearning goals include improving information retention, facilitating the learning process through small steps, and adapting instruction to individual student needs. Microlearning is often applied in formal and informal education, providing an effective way of learning that is easily integrated into everyday life. Features of microlearning:

- ***Short duration***: Microlearning is characterized by an extremely short duration,

usually lasting only a few minutes. This feature enables fast and efficient delivery of information.

- ***Focus on Specificity****:* Each microteaching segment has a clearly defined purpose and focuses on a specific information, skill or concept. This approach allows for precise targeting of learning.
- ***Adaptability:*** Microlearning is adaptable to individual student needs. Students can access micro-lessons according to their own pace and needs.
- ***Digital Accessibility:*** Often delivered through digital platforms, allowing students to access content through various devices such as smartphones, tablets or computers.
- ***Interactivity:*** Microlearning can include interactive elements, such as quizzes, discussions or mini-tasks, which increase student engagement.
- ***Rapid Transfer of Knowledge***: Thanks to its brevity and focus, microlearning facilitates the rapid transfer of knowledge, which is especially useful in situations where immediate information acquisition is required.
- ***Modularity:*** Micro-lessons often have a modular structure, which allows easy combining and adaptation to different topics and student needs.
- ***Availability on the Move:*** Mobility is a key feature of microlearning, allowing learners to access content whenever and wherever they want.
- ***Immediate Application:*** Information imparted through microlearning is usually practical and applicable immediately after learning, encouraging the practical application of newly acquired knowledge.
- ***Encouraging Continuous Learning:*** Microlearning promotes the idea of continuous learning, where information is consumed in small chunks over time, supporting long-term knowledge acquisition**.**

C. Application Of Microlearning In Formal Education

Microlearning, although often associated with informal forms of learning, is increasingly finding its place and application in formal education. Here are some examples of how can be integrated into a formal educational context:

- ***Supplementary Materials***: Micro-lessons or micro-modules can be served as supplementary units within formal curricula. These materials can provide additional resources for students to deepen their understanding of specific topics.
- ***Blended Learning***: Integrating microlearning with traditional teaching methods within a blended learning model can create a comprehensive learning experience. This allows students to access short, focused materials through digital means while maintaining interaction with teachers and peers in the class.
- ***Tailoring for Individual Needs:*** Microlearning enables learning to be adapted to the individual needs of students. Teachers may recommend specific micro-modules based on each individual's ability, interest or learning pace.
- ***Recapitulation of Materials:*** Microlearning can be used to reactivate previously covered materials or to prepare for new lessons. This allows students to quickly recap key concepts or skills before moving on to the next phase of learning.
- ***Formative Evaluation:*** Micro-modules can serve as a tool for formative evaluation. Through interactive tasks or quizzes, teachers can monitor student progress and adjust further lesson plans according to identified needs.
- ***Flexibility of the Teaching Process:*** using microlearning, teachers get more flexibility in organising teaching activities. Students can access materials at their own time and pace, which increases the adaptability of formal education.

Integrating microlearning into the formal education system requires careful planning and coordination, but it can significantly enrich the student experience and improve teaching effectiveness.

D. Differences Between Microlearning And Traditional Teaching

The differences between microlearning and the traditional approach to education include several key aspects shown in Table 1

TABLE I: Differences between traditional learning approaches and microlearning

Parameter	***Microlearning***	***Traditional learning***
Time Duration	Short duration, usually measured in minutes.	It usually takes place over longer periods, such as classes or workshops that last for hours.
Focus on Specificity	It focuses on one clear concept, skill or piece of information	It can cover a wider range of material during one teaching period.
Format of Materials	It is often delivered through short video lessons, interactive quizzes, or similar compact formats.	It uses a variety of formats such as lectures, workshops, group discussions, and exercises.
Customization and Personalization	Flexible and tailored to individual needs, allowing students to access content at their own pace.	Less flexible, it often follows a pre-defined schedule.
Targeted Information Transfer	It focuses on the effective transfer of specific information or skills	It can have a wider range of goals, including deeper understanding and critical thinking.
Interactivity	It often includes interactive elements such as quizzes, discussions and mini-tasks.	It can also be interactive but does not necessarily have the same degree of interactivity as microlearning.
Location Apply	It allows access anywhere, especially via mobile devices	It often takes place in physical classrooms or educational institutions.
Learning Style	It encourages fast, fragmented learning	It can provide deeper, continuous learning over longer sessions.

E. A Critical View Of Microlearning

Microlearning brings many advantages and disadvantages in the educational context, and some of them are shown in Table 2.

TABLE II: Advantages and disadvantages of microlearning

Advantages	**Deficiency**
Fast learning	Lack of Depth
Adaptability	Lack of context
Focus on Specifics	Limit for Complex Topics
Efficiency	Potential for Knowledge Fragmentation
Mobility	The problem of maintaining attention
Interaction	Dependence on Technology
Encouraging Independent Learning	Absence of Live Interaction
Easier Progress Tracking	Difficulties in Evaluation
Reduction of Information Load	Possible Loss of Motivation
Practical Application	Limitation for Practical Application
Ecological conscience	
Blended learning	

III. TECHNIQUE AND TECHNOLOGY TEACHING

A. The Importance Of Technique And Technology In Modern Education

The subject of techniques and technology in elementary schools plays an important role in modern education, and here are some key reasons why this subject is important:

- ***Development of technical skills***: The subject of techniques and technology provides students with the opportunity to develop various technical skills, including working with tools, software, programming and the like. These skills are essential in today's society, where technology plays a key role in all spheres of life.
- ***Innovation and creativity***: Through this subject, students learn how to apply their creative abilities in solving problems. Developing innovation becomes an important learning to deal with the challenges of the future.
- ***Applied knowledge:*** Technique and technology provide an opportunity to apply theoretical knowledge to practical situations. This helps students see the practical application of what they are learning, which often improves their understanding of the material.
- ***Preparation for the world of work***: Modern society increasingly requires a workforce with technical skills. The subject of engineering and technology can prepare students for future professional challenges and a labour market that increasingly requires technologically literate individuals.
- ***Interdisciplinarity:*** This subject often integrates different disciplines such as mathematics, science, engineering, art and others. This encourages interdisciplinary thinking, which is principal in solving complex problems.
- ***Digital Literacy:*** The subject of techniques and technology plays a key role in the development of digital literacy. Students acquire skills in handling digital tools, understanding basic programming principles and general digital ethics.
- ***Developing teamwork:*** Projects and tasks within the subjects of techniques and technology often encourage teamwork. Students learn how to effectively collaborate,

communicate and share responsibilities, skills that are essential in the work environment.

- ***Problem Solving:*** Engineering and technology encourage the development of problem-solving skills. Students learn how to identify, analyze and solve different types of problems through the application of technical principles.
- ***Global connectivity:*** Modern technologies enable global connectivity. Through this course, students can develop an awareness of global challenges and opportunities related to technology, as well as an understanding of different cultures and perspectives.
- ***Industry Connection:*** Collaboration with industry, entrepreneurs and experts in the field of engineering and technology can provide students with real insights into the professional world, expectations and innovations.

In essence, the outcomes of techniques and technology play a key role in preparing students for life in modern society, providing them with practical skills, creativity, problem-solving and the ability to adapt to technological changes.

B. Challenges in Teaching Techniques and Technology

Although the subject of technique and technology brings numerous advantages, there are also several challenges in teaching this subject. Some of the key challenges in teaching engineering and technology include:

- ***Lack of equipment and resources:*** Some teachers and schools may not have enough equipment or resources to provide hands-on experience to students, especially with the latest technologies and tools.
- ***Rapidly changing technology:*** Technology is changing rapidly, and teachers must keep up with the latest trends to keep the material relevant. This can be challenging, especially in schools with limited financial resources.
- ***Different technical abilities of students:*** Students have different levels of technical literacy and ability. Some students may already possess certain skills, while others may be at a beginner level. Finding the right pace and approach for all students can be a challenge.
- ***Safety and maintenance of tools:*** The use of tools and equipment in the classroom carries a risk of injury. Teachers must be careful in providing a safe learning environment while teaching the safe use of tools.
- ***Interdisciplinarity and integration:*** Sometimes it is challenging to integrate technical and technological concepts into other subjects and vice versa. Achieving a balance between interdisciplinarity and maintaining a focus on core skills can be difficult.
- ***Responsibility and ethical aspects of technology:*** Teaching about the responsible use of technology and understanding the ethical issues involved in technological processes is an additional challenge.
- ***Adapting to diverse learners:*** Teachers must adapt teaching methods to meet different learning styles and individual needs of students.
- ***Studying innovations in teaching***: Staying informed about the latest pedagogical methods, technologies and teaching tools can be a challenge, and some teachers may not have enough time or resources for regular training.
- ***Gender imbalance:*** Traditionally, it is assumed that engineering and technology subjects are more directed towards men. The challenge is to motivate and support female students to become interested and involved in these subjects.
- ***Evaluation and assessment of practical skills:*** Evaluating students' practical skills can be challenging. How to properly assess applied skills and understanding of concepts can be a question that requires special attention.

Improving the teaching of technique and technology requires solving these challenges, the joint work of teachers, the support of school administrations and the constant training of teachers.

C. Current Teaching Methods In The Teaching Of Techniques And Technologies

Teaching methods in the field of techniques and technologies include different approaches that encourage the development of technical skills, creativity, innovation and practical application of knowledge. Here are some teaching methods in this area so far:

- ***Project-oriented teaching:*** This method involves setting a task or project that students must solve by applying technical skills and knowledge. Working on projects encourages

teamwork, problem-solving and the application of theory in practice.

- ***Workshops and hands-on exercises:*** These methods include hands-on exercises where students have the opportunity to work directly with tools, materials or technologies. This can include prototyping, programming, working with electronics, and the like.
- ***Learning through games:*** The use of games, simulations and educational activities can increase student engagement. These methods often combine fun with the acquisition of technical skills and knowledge.
- ***Demonstrations and Presentations***: Teachers can use demonstrations to illustrate certain concepts, techniques or processes. These demonstrations can be followed by discussions or workshops.
- ***Blended learning***: Integration of traditional teaching methods with online resources enables learning flexibility. Students can access materials online, participate in discussions, and do assignments outside of the classroom.
- ***Learning through case studies***: Analysis of real situations, projects or problems in industry or society can be used for learning. This method encourages the practical application of knowledge in real contexts.
- ***Problem Solving Work***: This method involves setting up problems that students must solve using their technical skills. Work on solving problems encourages critical thinking and the application of theoretical knowledge in practice.
- ***Mentoring and practical projects***: Working with mentors or in real industrial settings provides students with the opportunity to gain hands-on experience and real-world applications of techniques and technologies.
- ***Innovative technologies***: The use of modern technologies, such as virtual reality (VR) or simulations, can enhance the learning experience and enable realistic simulations of certain processes.
- ***Combination of theory and practice***: Integration of theoretical knowledge with practical exercises is often used to give students a complete picture of certain technical concepts.

These approaches often combine different methods to accommodate different learning styles and achieve optimal results in developing students' technical skills.

IV. MICRO-LEARNING IN THE TEACHING OF TECHNIQUES AND TECHNOLOGIES

A. Adapting Microlearning To Subject Specifics

Adapting microlearning to the specifics of the subject of techniques and technologies requires careful integration of the characteristics of this subject with the principles of microlearning. Here are some strategies that can be implemented:

- ***Focus on practical skills:*** Techniques and technology often require practical skills. Microlearning can be focused on specific skills such as working with tools, programming, designing, and the like. Each micro-lesson can be focused on a specific skill or step in the process.
- ***Short and focused modules:*** Microlearning is characterized by short and focused lessons. When adapted to the subject of techniques and technology, this may mean targeting specific concepts, tools or techniques in each micro-lesson.
- ***Interactive elements:*** Including interactive elements like simulations, virtual workshops or quizzes can improve student engagement. These elements can provide an opportunity to apply theoretical concepts in a virtual environment.
- ***Demonstrations and step-by-step tutorials***: Microlearning in techniques and technology can use video demonstrations or step-by-step tutorials to allow students to visually follow procedures. This is especially useful for learning practical skills.
- ***Project-oriented content:*** Micro-courses can be structured as mini-projects where students apply techniques and technologies to solve a specific problem or challenge. This enables the application of knowledge in real situations.
- ***Incremental progress:*** Breaking down complex technological or technical concepts into smaller, easily understood parts allows for incremental progress. Each micro-lesson can cover one part of a broader concept.
- ***Virtual laboratories:*** If available, virtual laboratories can provide an opportunity for experimentation and practice without the need for physical laboratory facilities. This is especially useful in an online environment.

- ***Practical tasks and mini-problems:*** Including practical tasks or mini-problems in each micro-lesson allows students to immediately apply what they have learned. It supports the process of active learning.
- ***Flexibility and accessibility:*** Microlearning in techniques and technology should be flexible and accessible. Students should be given access to micro-modules whenever they need it, and the modules themselves should be adaptable to different learning rates.

Adapting microlearning to the specifics of the subjects of techniques and technologies means finding a balance between theoretical concepts and practical application, which supports effective learning and the development of concrete skills.

B. Examples Of Successful Application Of Microlearning In The Field Of Technique And Technology

The successful application of microlearning in the field of engineering and technology can be seen through various examples that emphasize the effectiveness of this method. Here are some examples:

- ***Online Programming Courses:*** Platforms like Codecademy provide micro-lessons and exercises to learn programming. Each lesson covers a specific programming functionality or concept. Students go through a small set of exercises to immediately apply what they have learned.
- ***Virtual Simulation Lab for techniques and technology:*** Schools use virtual simulations, like Labster, to provide hands-on experience to students. Each simulation focuses on a specific experiment or laboratory procedure. Students have the opportunity to virtually handle tools and equipment.
- ***Graphic Design Mini-Projects:*** Online graphic design courses often offer micro-modules that cover specific aspects of design, such as using certain tools or techniques. Students can complete mini-projects that demonstrate their understanding and application of those skills.
- ***3D Modeling Courses:*** 3D modelling courses often use microlearning to cover specific modelling, texturing or animation techniques. Students practice these techniques through shorter, focused lessons.
- ***Electronic Books***: Micro-lessons in electronic books are often used to explain basic electronic concepts. Examples include steps for assembling electronic circuits or solving problems in electronics.

These examples illustrate how microlearning can be tailored to the specific needs and characteristics of a technique and technology subject, allowing students to acquire knowledge and skills in efficient, focused steps.

C. Potential Benefits And Challenges Of Introducing Microlearning Into The Teaching Of Techniques And Technology

The potential benefits of introducing microlearning into techniques and technology teaching:

- ***Practical application of knowledge:*** Microlearning allows students to immediately apply specific knowledge and skills, often through practical tasks or exercises.
- ***Learning flexibility:*** Students can access micro-modules whenever they want, adjust the pace of learning to their needs and study in places that suit them.
- ***Effectiveness of teaching***: Focused micro-lessons enable precisely directed learning, which increases the efficiency of teaching and enables faster progress.
- ***Personalization of learning***: The ability to personalize microlearning allows teachers to adapt materials and tasks according to the specifics of each student.
- ***Continuous evaluation:*** Through microlearning quizzes and tests, teachers can continuously monitor student progress and provide prompt feedback.
- ***Support for independent learning:*** Microlearning encourages independence in learning, developing students' independent research and knowledge acquisition skills.
- ***Practical Results Monitoring***: Monitoring and analyzing student results in microlearning provides teachers with insight into areas where students are successful or where they may be struggling.

Challenges in introducing microlearning in the field of techniques and technologies:

- ***Equipment and technical resources:*** Some practical skills require specific equipment and resources that may not be available to all students, which may limit the implementation of microlearning.
- ***Need for hands-on experience***: While microlearning can provide theoretical understanding, practical skills often require real-world work experience that

microlearning may not be able to fully replace.

- ***Lack of real-time interaction:*** The virtual aspect of microlearning can limit the actual interaction of students with teachers and peers, which is sometimes crucial for certain aspects of techniques and technologies.
- ***Need for real-time instruction:*** Some complex topics may require additional real-time instruction, which microlearning may not adequately provide.
- ***Adapting to learner diversity:*** Different learning styles and ability levels may necessitate additional adaptability in micro-modules to meet individual learner needs.
- ***Need for motivation:*** Self-directed learning through microlearning can cause challenges in student motivation, especially if there is a lack of interactivity or direct support.
- ***Safety aspects:*** In the field of techniques and technologies, special attention must be paid to safety aspects, to ensure that students use tools and equipment correctly.
- ***Practical Skills Evaluation:*** Assessing practical skills through microlearning can be challenging. Finding effective ways to evaluate actual technical ability may require additional attention.
- ***Cultural aspects:*** Different cultural perspectives can affect the understanding of certain technical or technological concepts, therefore care must be taken to adapt the material to a diverse context.

Despite the challenges, adequately planned and adapted microlearning can bring significant benefits to students in the field of techniques and technologies. It is important to consider these factors when implementing to maximize the benefits of microlearning.

V. CONCLUSION

Modern education is constantly evolving to meet the challenges of today's digital age. Following this trend, the use of innovations in the teaching of techniques and technology becomes a key element of effective learning. The focus of this research paper was the didactic aspect of microlearning in the teaching of technique and technology and its potential to improve the teaching of techniques and technologies. Microlearning is an innovative approach to education that emphasizes accessibility and efficiency through small, focused units of content.

Introducing microlearning into the subject of techniques and technologies brings with it several potential benefits and challenges. Despite the challenges, properly implemented microlearning can provide significant benefits, enabling students to quickly acquire and apply skills and knowledge in the field of techniques and technologies.

Based on the key findings about the potential benefits and challenges of introducing microlearning in the field of techniques and technologies, certain implications for practice in the field of education can be identified. Here are some suggested implications:

- ***Development of Practical Skills through Micro-Modules***: Practical skills, which often require interaction with real tools and equipment, can be developed through micro-modules focused on specific aspects of techniques and technologies. These modules should have practical exercises and tasks to enable students to apply theory in practice.
- ***Individualized Approach to Learning:*** Teachers should adapt micro-modules to suit different learning styles, ability levels and interests of students. Personalization of content and tasks can increase student engagement and contribute to a better understanding of the material.
- ***Combination of Virtual and Physical Resources***: Integration of virtual simulations and resources with real learning experiences can provide comprehensive learning. This may include the use of online simulations along with laboratory exercises and projects in real-world settings.
- ***Increasing Motivation through Interactivity:*** Introducing interactive elements in micro-modules, such as virtual workshops, quizzes and mini-games, can increase student motivation. Interactivity adds to the dynamism of learning and can improve engagement.
- ***Adaptability and Sensitivity to Diversity:*** Adaptability of materials according to the school's technical resources or students' access to technology can strengthen the implementation of microlearning. In addition, teachers should be aware of cultural diversity to adapt the content and context of the material.
- ***Monitoring and Feedback:*** Through the implementation of microlearning, teachers should regularly monitor student progress through quizzes, tests and analysis of results. Prompt feedback can help students understand their strengths and weaknesses.

- ***Support for Independent Learning:*** The development of independent learning skills should be emphasized in microlearning. Teachers can provide guidance and resources to support students in independent research and learning.
- ***Teacher Training for Effective Use of Technology***: Teachers should be trained in how to effectively use technology and integrate it into teaching. This includes the use of microlearning platforms, virtual tools and other digital resources.

Implementation of these implications in practice can help achieve better success of microlearning in the field of techniques and technology, thus ensuring optimal learning and development of relevant skills.

Further research on the topic of microlearning in the field of techniques and technologies can explore different aspects to deepen the understanding of this innovative learning method. Here are some suggestions for further research: The effectiveness of microlearning in the development of specific technical skills, adapting microlearning to different levels of students, the impact of a combination of virtual and physical resources on learning, the role of interactivity in improving student motivation and engagement, etc. Further research in any of these directions can contribute to a broader understanding of how to effectively apply microlearning in the field of engineering and technology, thus improving the learning experience and the development of student's skills.

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Enhancing Educational Processes: Contemporary Communication in Web Design Teaching

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Abstract – Learning is a positive permanent change in behavior occurs through an effective teaching process. Centre of effective teaching and learning are the teacher, and they should be fully equipped for this duty. The paper examines the innovative teaching methods for effective teaching and learning in web design course.

Key words: web design, IT, innovation, teaching methods, teaching trends and innovative teaching method, action research.

I. INTRODUCTION

Education is a veritable instrument for effecting positive change in citizens' behavior, inculcating the correct type of values, attitudes, communication skills, and life-long skills, as well as raising intellectual capital for national sustainable development. In the 21st century, information and knowledge stand out as very important and vital elements of advancement in an information era. These goals are attainable through effective classroom interaction between the teacher and the learner through the process of teaching and learning. Teaching, which is the primary function of a teacher, entails giving instruction and imparting knowledge, facts, skills, attitudes, interests, and aptitudes [1]. The teacher imparts to the learner through the process of teaching. The teaching is an activity, consisting of a set of conscious and deliberate actions and programmes planned and directed towards inducing learning. The product of these efforts is learning. Learning as a concept has varied definitions due to various theories of learning that define it from different perspectives. Learning is the positive, permanent change in behavior due to experience and practice gained that enables the learner to face later situations differently. According to Ambrose et al learning is "a process that leads to change, which occurs as a result of experience and increases the potential for improved performance and future learning" [2]. The change in the learner may happen at the level of knowledge, attitude, or behavior. As a result of learning, learners come to see concepts, ideas, and the world differently. Quality teaching is that transforms students' perceptions and the way they go about applying their knowledge to real-world problems. Many researchers applied Teaching techniques to assess their effects.

The research revealed that many students need to absorb the course content to the expected level if the teaching is traditional [3]. Hence, improving the existing teaching-learning methods and teaching with new innovative methods has become imperative. The use of innovative teaching methods by teachers also helps to enhance the performance of students of diversity [4]. Technology[1] and its rapid progress create an intellectual environment where each student can progress depending on their intellectual abilities, motivation, and knowledge. The research (Ganyaupfu, 2013) about the teacher-student interactive method shows that direct teaching efficiently transfers knowledge, but more is needed for deeper understanding, problem-solving, and creativity. The focus of innovative education is based on the trust that every student can learn and be successful in life. [5] Claimed that innovative teaching methods provide more experience and help students tackle work-related problems. [6] identifies five components of effective teaching: knowledge of the subject matter, ability to help students with their work, presenting subject matter appropriately, motivating students to excel, and firmness/fairness in preparing marking guides and grading examinations. The quality of education can only be enhanced by the adoption of innovative teaching practices in order to make the content rest as well as to motivate the learners. In addition, teachers should consider themselves facilitators, guides, and co-learners in the education process. The world of modern living and modern science implies a free exchange of ideas, thoughts, and communication without limits and restrictions. Free thought expressed publicly and through electronic communication systems will enable the rapid

[1] Technology is the science of ways of working in any work process.

progress of science and e-society. The paper examines effective teaching and learning, teaching methods, teaching techniques, teaching strategy, trends in teaching methods, innovative methods and applicability in teaching, conclusions, and recommendations. In this paper, we share our research findings on the use of non-traditional ways of teaching and learning, which can support colleagues in other secondary schools and colleges to move towards less traditional teaching.

II. ACTION RESEARCH

Action research is an approach to educational research commonly used by educational practitioners and professionals to examine and ultimately improve their pedagogy and practice. In this way, action research represents an extension of the reflection and critical self-reflection that the teacher applies daily in his classroom.

In a traditional textbook, the text carries the main semantic load, accompanied by illustrations (pictures, diagrams, tables, etc.). The clear advantage of e-books is that they are accompanied by text with sound and video. Multimedia[2] means presenting educational material in an exciting, dynamic form and engineering structures, devices, and elements - as moving three-dimensional objects, thus fully revealing their design and principle of operation.

Action research offers one route to more intentional, substantive, and critical thinking that can be documented and analyzed to improve educator practice. Action research generates knowledge around research in practical educational contexts and enables educators to learn through their activities.

A. Defining the research question

In the daily educational process, many questions often arise from teachers and students regarding how students could learn better. In this research, the goal is to show the progress of students in terms of interaction during class if modern communication using Information technology - IT technology is applied in teaching. Activity and interaction are highlighted as an important part of research when teaching through classical education lessons about education in which the focus is placed on the use of modern IT technology for communication during classes.

B. Strategy for overcoming the problem and implementing the planned activities

One professor is involved in conducting the research, and the students in Secondary Municipal Technical School - SOTU "Gjorgi Naumov" - Bitola from the third (third) year, aged 16-17, are included as respondents. The total number of students is 66, of which 13 are girls, and 53 are boys. The examination was conducted at the beginning of the school year, in the period from mid-September to the end of October. It was made based on two classes, with 33 students each, who are from the same major - "Electrical technician for computer technology and automation" in the subject "Editing of web pages" with a representation of two hours per week, during which the thematic unit of IT technologies was processed HyperText Markup Language)-HTML." [7] Most teachers are eager to embrace new technologies because they have seen the excitement and motivation of their students increase when they do. With technological standards becoming an integral part of student's education, teachers are more enthusiastic than ever to learn new technologies and methods. During the teaching, the course of progress was monitored about the interaction of the students during the lesson. Below are shown how the planned activities were carried out.

C. First method for teaching class

First, a lesson was conducted in which the traditional approach to learning of the students prevailed. Each student was assigned written material for the lessons taught in that approach while the research on this way of holding a lesson lasted. The introduction of the lesson started by asking questions from the previous lesson. Since the research focuses on measuring interactivity, four questions were asked in this case.

TABLE I. RECALL THE PREVIOUS LESSON – WITH SHORT ORAL QUESTIONS

	1 question	**2 question**	**3 question**	**4 question**
Reported	14	22	18	20
Answered	2	2	2	2

A written record was kept for each activity of the students. The method of practical work was

[2] Information for the perception of which we use multiple senses at the same time because they use different media through which they are spread (set consisting of text, sound, graphics, video and animations)

implemented so that the students were assigned a task containing elements of the new subject. Each student creates a solution to the task.

TABLE II. TASK IMPLEMENTED THROUGH WRITTEN FORM

	Task
Reply sent	46
Correct answer	30

Again, the direction is set towards measuring interactivity so that each student who successfully or partially solves the given task is recorded in written form. In the previously described way, two classes were held, which resulted in poor results according to the measurements of interaction and knowledge of the students.

D. A second method for a lesson

We receive the largest number of impressions of reality with the sense of sight.

When it comes to the implementation of teaching and the application of visual teaching aids[3], both static (slides, photos, drawings, maps) and dynamic (film, tutorial[4]) teaching aids are applicable.

Therefore, the next method on which the research was carried out is visual teaching aids, where the use of computer applications[5] led this method to achieve greater interest and interaction among students and acquire high-quality knowledge. The planned activities were carried out through an interactive presentation shown on a projector. The lesson's introduction started with a tutorial on how to use a simple computer application, through which short questions were asked to recall the concepts from the previous lesson.

• Reminder from a previous lesson – with questions through an interactive presentation

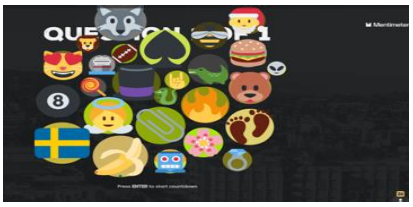

Figure 1. Start of the interactive presentation

[3] Visibility is one of the components of the learning system, which can help students better assimilate the material studied at a higher level.
[4] method of knowledge transfer and can be used as part of the learning process.
[5] a type of software that allows a user to do one or more things

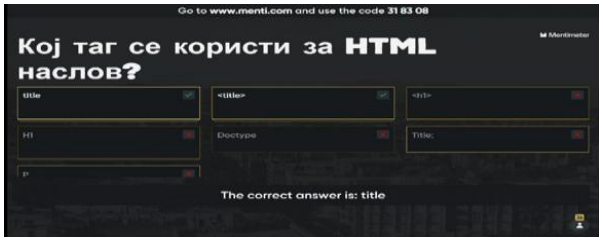

Figure 2. Question and answer display

Figure 3. Correct answers according to speed

Through the application, the students were asked several questions, which they answered in real-time. At the same time, an electronic record was kept in the application itself so that the results of the student's answers were directly monitored in the presentation shown on a projector. On average, a large part of the present students gave an answer to each of the questions asked.

During the explanation, the main movement through the lesson is dictated by the presentation, which is complemented by short interactive questions throughout the lesson. The main concepts defined in the current lesson's objectives were primarily presented using the brainstorming technique and answering short questions.

• Interaction with – brainstorming

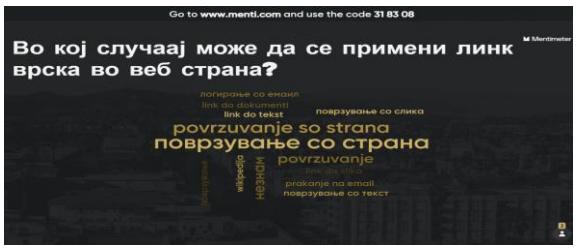

Figure 4. Question and answer display

The technique was carried out through the computer application, where questions were asked about a particular element that was the subject of study in the lesson, and each student had the opportunity to give a variety of opinions about its meaning, use, etc., thus, to a large extent, the students were active in the hour.

The method of practical work was implemented so that the students were assigned a task containing elements of the new subject. For this purpose, the students were given instructions for using a computer application through which the task should be solved, which created an individual way of working among the students. After the students finished solving the task, they sent their answers, and through the application, the students could immediately see if they had made a mistake in any part of the task.

• Task carried out in electronic form

Figure 5. Display a partially correct answer

The records[6] of the achieved results of the students' solutions were displayed through the application on a projector, where everyone could see the correct answer to the task. The student's involvement in this activity was at a high level. In the previously described way, two classes were held, which resulted in very good results according to the measurements of interaction and knowledge of the students.

E. A third way for a lesson

The learning process can be seen from a very entertaining aspect so that learning will be turned into a game, characteristic of games as an integral element in the learning process. Games are ideal in teaching because the basis of the lesson is based on play. In this way, the planned activities were carried out through the students' group work so that the students were divided into groups at the beginning of the lesson. Group work will allow each member to engage in the assigned activity and contribute to the group's progress to achieve better results [8]. The teaching included the use of an interactive presentation that was shown on a projector. Since, in this way, the emphasis was placed on introducing games into the learning process, the lesson began by pointing out instructions for using a simple computer game, which we used to recall the concepts from the previous lesson.

Each group was assigned a clue according to which they created a mind map in real-time so that their every activity was kept an electronic record directly in the application itself. The results of each group were followed by the interactive presentation, which was shown on a projector.

• Reminder from a previous lesson with a game – mind map.

Figure 6. Correctly answered mind map

Organizing learning as a competition encouraged motivation to achieve better results among students. Visible progress motivates students by showing them how far they have come and where they need to go. Involvement in the assigned activity was at a high level. The results of the groups' answers were directly monitored during the presentation. It allowed the students to increase their activity more and more during the lesson.

After the main concepts outlined in the objectives of the current lesson were highlighted and explained, another short game followed ed, for which the students were instructed on the game's rules. The game comprises cubes placed in a matrix, where half of the cubes contain HTML elements while the other half contains an explanation of those elements. The task of the game was to find the matching pairs. Upon joining the computer game, each group received a matrix with all the dice, in which the arrangement of the dice was placed in a different, undefined order. With great concentration, the students focused on their problems for the group to achieve a better result in the shortest possible time.

[6] keeping records of persons or conditions.

• Game interaction – matrix

Figure 7. Correctly completed game die

The game proved very effective because it notified the students in real time when a mistake was made, thus achieving the effect of learning from mistakes. In this activity, all groups completed the game, and there was maximum interaction among the students, monitored electronically through the computer game application.

The method of practical work was carried out through a computer game - a puzzle so that each group was electronically assigned a task containing elements of the new subject. By joining the computer game, the students were given the same task, but the puzzle pieces were placed in a different order in each group.

- A task carried out through a game – a puzzle

Figure 8. Start a puzzle task/game

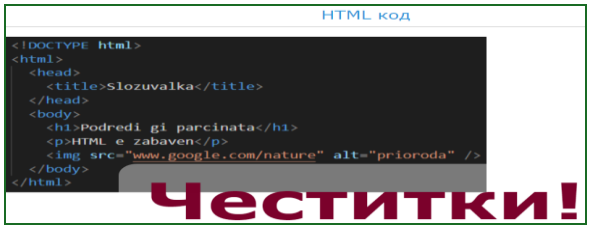

Figure 9. Correctly completed puzzle

The results of the students were shown in the interactive presentation. The game proved very effective because it notified the students of a mistake made in real-time. In this activity, there was maximum interaction among the students, although not all of them managed to assemble the puzzle successfully. In the previously described way, two classes were held, which, according to the measurements of interaction and knowledge of the students, resulted in very good results.

F. Initial and final survey results

The following shows the results of the anonymous survey that was conducted before the changes from the action research were introduced, that is, before the introduction of modern methods of communication in teaching, as well as the results of the survey that was conducted after the application of modern methods of communication using IT technology in teaching.

- How often are you interactive during the lesson?

Figure 10. Through the frontal way(left) Through a new way(right)

- How often do you have the opportunity to express your opinion, ask, or discuss during the lesson?

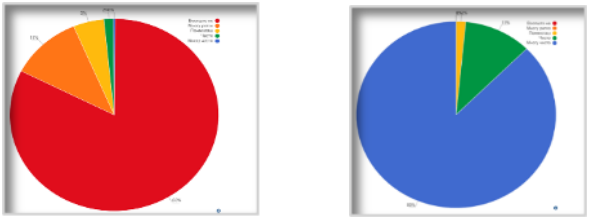

Figure 11. Before changes (left) After changes (right)

- How much do you think you are using your facilities?

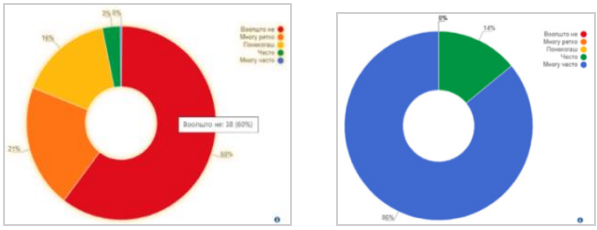

Figure 12. Before changes (left) After changes (right)

- Do you think you are learning other additional skills in addition to the material provided for the lesson?

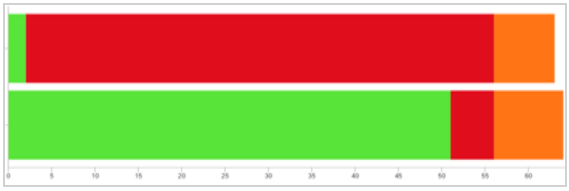

Figure 13. Before changes and after changes

- Does cooperation between students improve?

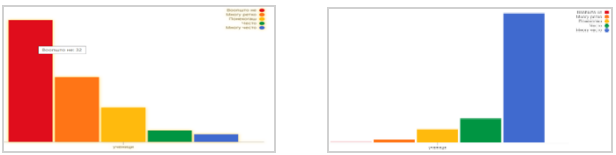

Figure 14. Through the frontal way Through the new way

From the results, we can see that the introduction of modern methods of communication in teaching has a positive effect on the students according to the comparison made at the beginning and end of the measurement.

III. REFLECTION

The process of reflection, as one of the most important parts of the action research process, is of crucial importance for developing the professionalism of teachers because learning from own and shared experience is the most effective. The objectives of the research question have been achieved, as it has been confirmed that by applying modern methods using IT technology in teaching, a much greater interaction, involvement, and cooperation of students was achieved during the lessons, as well as an increase in the achieved knowledge at the end of the current a lesson. The positive experience from this action research is a motive for me to introduce some of the mentioned modern methods in my practice, and I recommend that this way of conducting a lesson be accepted by other professors. Before that, it can be concluded that this research led to adopting the desired change and, thus, to the problem's solution. This research was helpful in creating new experiences, gaining knowledge, and learning exciting and modern methods of communication that can be applied in teaching.

IV. CONCLUSION

Education pedagogy has undergone many changes during the last two decades. Many institutes are still following traditional teaching methods; however, several institutes have adopted innovative approaches to teaching and learning. Teachers play a vital role in students' success, so the teacher must take a step towards accepting modern teaching methods. In short, the inclusion of contemporary teaching methods at this time is necessary because it opposes the idea of traditional forms of repetition and memorization of the curriculum for the education of students. To develop decision-making skills, problem-solving skills, and critical thinking ability, modern teaching methods are paramount. Finally, to provide quality education, there should be a combination of a qualified teacher and innovative teaching methods. Innovation is a continuous process, and faculty members are applying innovative ways to enhance the quality of education to develop creativity, empower people, and ultimately achieve the human development index of our country.

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Empowering Learning through PBL and Scrum in Computer Science Education

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Abstract - This paper presents the results of research with students of the third year of computer science at Subotica Tech. This study aimed to highlight the benefits of incorporating project-based learning and Scrum methodology into teaching practices. This was done to provide a comprehensive understanding of how these approaches significantly contribute to supporting student learning. The results show that the students had a higher level of participation and motivation, as well as a higher perception of their progress and learning success. Project-based learning and Scrum also allowed students to participate in the learning process, acquire practical knowledge and skills, and encourage teamwork.

I. INTRODUCTION

Learning is defined as an active process of understanding and development of knowledge and skills corresponding to the project-based learning concept (PBL). Project-based learning is a process of recognizing the problems of the real world in the environment, exploring, and proposing potential solutions with the aim of gaining a better understanding and solving of the problem. PBL has been shown to be an effective method to improve critical thinking skills and improve student knowledge retention [1].

As the complexity of the project increases, efficient project management methods are also needed. One of the methods that has been proven to be effective in the management of complex projects is Scrum. Scrum is an agile methodology used in software engineering to develop products. It is based on teamwork, continuous assessment and an improvement, and iterative approach. Scrum helps teams work quickly and effectively on projects, provide high-quality results, and adapt to changes during the project. This requires the participation of all team members, flexibility, and rapid adaptation to client requirements [2].

This paper presents the results of a case study of third-year computer science students from the Subotica Tech in Subotica. The paper emphasizes the advantages of using PBL and Scrum methodologies in education and provides a clear understanding of the importance of these methods in supporting student learning. By incorporating both approaches into the education system, students have the opportunity to develop technical skills, creativity and teamwork, which are essential skills for future success.

II. LITERATURE OVERVIEW

Project-Based Learning is an educational approach that emphasizes active collaboration through project work in the real world. This method has been proven effective in incorporating students into their learning, improving critical thinking skills, and increasing their knowledge retention [3, 4]. PBL is also in line with the principles of 21st-century learning, which emphasize the development of skills such as collaboration, communication, and problem solving [5]. As the complexity of projects increases, the need for tools that can assist in project management also increases. One such tool is Scrum. The use of Scrum in education has been applied in various educational settings, including elementary and secondary schools [6, 7], as well as higher education institutions [8]. These studies have shown that implementing Scrum in education can improve student engagement, motivation, and collaboration, as well as enhance student performance and outcomes. Authors in [9] found that the use of PBL and Scrum in a master's program in industrial engineering and management improved student performance and outcomes. The authors of the study [10] examined how project-based teaching affects students' attitudes towards STEM. As a result of their research, they found that taking at least one PBL-based course during the first four semesters influenced students' perceptions of their STEM skills, the value of attending STEM courses, and their desire to work in STEM fields later.

The traditional method of teaching may no longer be sufficient to meet current demands, particularly in the field of the Internet of Things (IoT), as concluded by the authors in [11]. Their research relates to an introductory programming course in JavaScript. The

results demonstrate that PBL and Scrum enable students to address tasks, make progress in learning, achieve better results in project development, and foster creativity.

In [12] the authors carried out research within an engineering program at the University of Minho, Portugal. The research design was based on an explorative quantitative and qualitative approach. Implementing Scrum in PBL teams helps students to keep the project running smoothly and draws greater awareness on how to manage the project and teams in a more effective way. The results show that task assignment, performance monitoring, visual management and regular feedback were considered the main advantages of using Scrum in PBL teams, which had a positive impact on student performance.

III. METHODOLOGY

The research was conducted during the winter semester of the 2022/23 academic year in Subotica Tech - College of Applied Sciences. The participants were third-year computer science students who were enrolled in the course "Agile Approach in Software Development".

In this research, the Student Engagement Instrument (SEI) was used to measure the degree of motivation, interest, participation, and activity of students. SEI is a widely used tool in student engagement research [13]. It typically consists of a questionnaire containing questions related to various dimensions of student engagement, such as motivation, participation in activities, attitudes toward school and teachers, etc. The results obtained from the questionnaire are used to identify issues and improve strategies to increase student participation.

SEI was administered to all students enrolled in the course, both at the beginning and at the end of the semester. The methodology for this research involved the following steps:

1. Recruitment of participants: the study involved 40 third-year computer science students from Subotica Tech. Permission was obtained from all students who participated in the research, and measures were taken to protect their privacy.

2. Project assignment: students' task was to develop an Android application for learning the English language. They used the Java programming language and Android Studio as their integrated development environment (IDE).

3. Implementation of Scrum methodology: during the first four weeks of the course, students were introduced to the fundamental principles of the Scrum methodology. Following an assessment of their knowledge of Scrum, students were assigned a project task. They were required to work on the project while applying Scrum methodology, which included the use of sprints, daily stand-up meetings, and retrospectives. They had a total of 9 weeks for project development, divided into 3 sprints, each lasting 3 weeks.

4. Data collection: data was collected throughout the semester using SEI, which assesses students' cognitive, behavioral, and emotional engagement.

IV. RESEARCH FINDINGS

To evaluate the level of student engagement before implementing project-based learning with the Scrum methodology, a pre-test was conducted using SEI. A Likert scale of 1 to 5 was used, where 1 represented 'not motivated at all' and 5 indicated 'very motivated'. The pre-test consisted of the following questions:

1. How enthusiastic are you about completing the tasks given during lectures?

2. How confident are you in understanding the material taught in class?

3. How often do you think your classmates and teachers appreciate what you say in class?

4. How often do you think what you learn in class is useful in the real world?

5. How often do you think you can use what you learn in class in other subjects or for your future job?

6. How often do you think you can work well with your classmates?

7. How often do you think you can take charge of your own learning?

8. How often do you feel that you can set goals for yourself and achieve them during your learning?

Based on the results (Fig. 1), it appears that students generally feel that they understand what is being taught in class (Q2). They also think their contributions in class discussions are valued fairly often (Q3). However, they do not feel very motivated to do assignments (Q1) or see how what they are learning connects to real-life situations (Q5). Additionally, they do not think they can use what they learn in class for other subjects or future jobs very often (Q4, Q5). Working together with classmates (Q6) and setting and achieving goals in class (Q8) also happen less often.

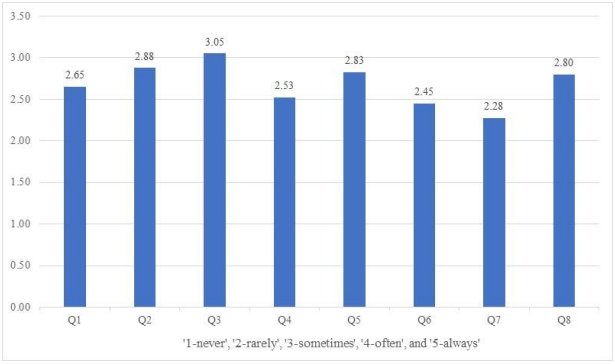

Figure 1. The results of the pre-test

The responses gathered during the pre-test offered valuable initial insights into student engagement levels prior to the introduction of project-based learning with Scrum. These measurements are essential to compare changes in student engagement after the implementation of the new teaching approach.

At the end of the semester, when the project was completed, the students responded to questions related to three areas: cognitive, behavioral, and emotional participation.

The questions related to the cognitive engagement were as follows:

1. I can explain the main ideas of the project I worked on to others.
2. I can apply what I learned in new situations.
3. I can connect the project to other concepts that I have learned during my studies.
4. I can use critical thinking skills to solve problems related to the project.
5. I can reflect on my own learning process during the project.
6. I can assess the quality of project results.
7. I can generate new ideas related to the project.
8. I can see the value of the project I am working on for my future career.

A Likert scale ranging from 1 (‘strongly disagree’) to 5 (‘strongly agree’) was used, and the results are presented in Fig. 2.

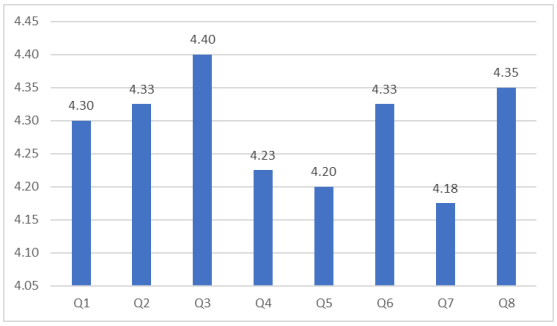

Figure 2. Results of cognitive engagement

These questions aimed to assess various aspects of cognitive participation related to students' ability to understand, apply, and connect their learning to practical contexts and their future careers. The results provide insight into the impact of project-based learning with Scrum on students' cognitive engagement.

The post-test results for questions related to cognitive engagement are positive. For the first question, most of the students reported having a high level of understanding and the ability to effectively communicate their thoughts. Regarding the second question, the students expressed a strong ability to transfer their knowledge to real-world contexts and think critically and creatively when faced with new challenges. On the third question, the students demonstrated a deep understanding of the subject matter and the ability to integrate new information with existing knowledge. Results for the fourth question were positive, with students reporting a strong ability for critical and creative thinking when addressing project-related issues.

For the fifth question, the students reported a high level of self-awareness and the ability to understand their own learning style and strengths. Regarding the sixth question, the students demonstrated the ability to evaluate project success and understand the importance of quality control. Responses to the seventh question indicated a high level of creativity and the ability to think outside the box. Finally, for the eighth question, the students showed a strong understanding of the practical application of what they learned and the ability to connect their projects with real-world scenarios.

The questions related to engagement during project work were as follows.

1. I attended all project meetings and actively participated.
2. I completed all assigned project tasks on time.
3. I collaborated well with members of my team to complete the project on time.

4. I got help when needed and provided help when requested by other team members.
5. I took the initiative to improve the project and its outcome.
6. I provided constructive feedback to members of my team.
7. I followed the Scrum methodology throughout the project.
8. I was willing to take on additional responsibilities as needed.

A Likert scale ranging from 1 ('strongly disagree') to 5 ('strongly agree') was used, and the results are presented in Fig. 3.

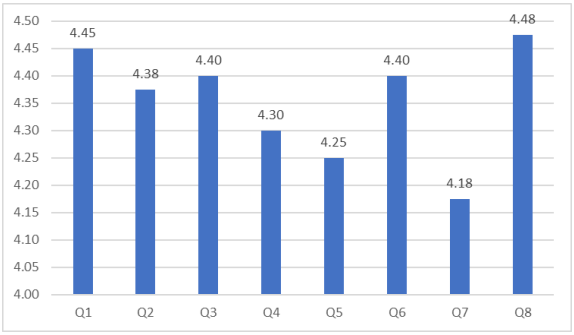

Figure 3. Results of engagement during project

These questions aimed to assess students' behavior engagement during project work, including their attendance, task completion, collaboration, initiative, feedback, devotion to Scrum methodology, and willingness to take on additional responsibilities. The results suggest that the students actively engaged in project-based learning with Scrum, as they reported high levels of participation, task completion, teamwork, and devotion to agile practices. These findings support the effectiveness of Scrum project-based learning in promoting behavioral engagement among students.

The following questions were designed to assess students' emotional involvement during project-based learning with Scrum:

1. I felt motivated to work on the project.
2. I felt a sense of accomplishment when I completed the tasks assigned to the project.
3. I felt involved in the success of the project and connected to it.
4. I was proud of my work contributing to the project.
5. I felt that the project was meaningful and worth the effort.
6. I felt a sense of belonging and connection with my team members.
7. I felt satisfaction with the final outcome of the project.

A Likert scale ranging from 1 ('strongly disagree') to 5 ('strongly agree') was used, and the results are presented in Fig. 4.

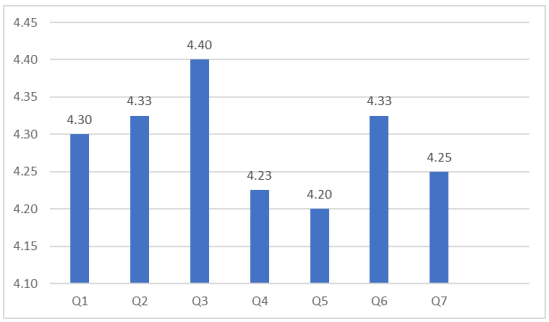

Figure 4. Results of emotional engagement during project

The results show that a significant majority of students experienced a high level of emotional engagement in the project. The students reported feeling motivated to work on the project (Q1), indicating that the Scrum project-based learning approach was successful in maintaining their enthusiasm and interest. The sense of achievement was evident (Q2) as the students expressed a feeling of their contributions to the project and satisfaction with the result (Q4). Emotional connection to the project was strong, with students feeling involved in its success and finding the project meaningful and worth their effort (Q3, Q7). A sense of belonging and connection with team members was also evident (Q6), highlighting the positive team dynamics and collaboration fostered by the project-based learning approach.

These findings indicate that students not only actively participated in project work but also had a deep emotional connection to the projects they worked on. This emotional involvement is a significant indicator of Scrum the success of project-based learning, as it suggests that students found the learning experience meaningful and fulfilling.

The results of the SEI post-test are highly encouraging, suggesting that students have positive attitudes and a deep understanding of key concepts and skills related to project-based learning.

V. CONCLUSIONS

The results of this research clearly demonstrate that the students significantly increased their participation, as measured by the SEI. The students expressed a high level of satisfaction with the project

tasks, saying that it allowed them to deepen their knowledge and gain self-confidence that can help them in their future professional practice. They also mentioned being satisfied with the opportunity to work in teams and to rely on other team members when faced with challenging problems. Furthermore, the students reported a sense of responsibility for their own learning and were able to set and achieve goals within the project framework.

The post-test results indicate that project-based learning with the implementation of the Scrum methodology was effective in improving student engagement and learning outcomes. This aligns with the earlier findings that the students were not only actively involved in the project work, but also felt a strong emotional connection to their projects.

Based on these results, it is clear that the use of project-based learning and Scrum methodology in education can have a significant impact on supporting student learning. These methodologies enable students to actively engage in the learning process, acquire practical knowledge and skills, and practice teamwork. The study results indicate that students who used PBL and Scrum had higher levels of engagement and motivation, as well as a greater perception of their progress and learning success.

The advantages of using PBL and Scrum in education include:

1. Active participation of students in the learning process.
2. Acquisition of practical knowledge and skills.
3. Promotion of teamwork.
4. Increased levels of engagement and motivation.
5. Enhanced student perception of their progress and learning success.

The results imply that integrating project-based learning with Scrum methodology into the educational process could be an effective way to improve student engagement and prepare them for their future careers. This approach not only fosters practical skills but also encourages a deeper understanding of course material and its real-world applications, contributing to more motivated and confident students.

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Standards and Procedures for Quality Assurance of Study Programs on the Example of the Higher School of Applied Studies

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Abstract - This paper describes the standards and procedures for ensuring the quality of study programs on the example of the higher school of applied studies, which through the Statute, and by the Law on Higher Education, has introduced and implemented a quality assurance system. The backbone of the quality assurance system is the Rulebook on standards and procedures for ensuring and improving the quality of work, self-evaluation of the Technical College of Applied Studies in Zrenjanin, and self-evaluation of study programs. It was assumed that the same, general act elaborates in more detail the standards and procedure for ensuring the quality of study programs and that it is harmonized with the requirements of the Rulebook on standards for self-evaluation and assessment of the quality of higher education institutions and study programs, but also with the principles and goals of the National Qualifications Framework. Based on the analyzed standards and quality assurance procedures of study programs, it can be considered that the prescribed indicators of the quality of study programs take into account the specifics of the position of the observed higher school of applied studies in the higher education system of the Republic of Serbia; whereby they are the same and aligned with the goals and principles of the National Framework of Qualifications for the appropriate level of education. The practical application of the analyzed standards and quality assurance procedures of study programs can represent an important factor in improving the quality of the work of the observed higher school of applied studies and thus for its tighter inclusion in the EU streams of higher education.

I. INTRODUCTION

The Law on Higher Education defines the method and procedure of accreditation of study programs in higher education institutions in the Republic of Serbia [1]. The National Entity for Accreditation and Quality Assurance in Higher Education (NEAQA), as the supreme authority in higher education, prescribes standards for accreditation and consequently, quality requirements, which the study program must fulfill imperatively [1,2].

To provide the most detailed guidelines for the preparation of documentation for the accreditation of study programs of the first and second degree of study, NEAQA prescribes different Instructions for the preparation of documentation for the accreditation of the study program of the first and second degree of higher education, which define the parameters of ensuring (as well as control and improvement) the quality of the study program, and the same are binding for all higher education institutions (regardless of the ownership structure) [3].

The Standards for the accreditation of study programs of the first and second degree of study [2] and the corresponding Instructions for the preparation of documentation for the accreditation of the study program of the first and second degree of higher education [3] must also be applied in applied studies, whereby they respect the specificities of higher schools of applied studies, academies of applied (professional) studies about academic studies [1,2,3].

Higher schools of applied studies, through the quality assurance system, apply mechanisms of quality control and improvement, to ensure the prerequisites prescribed by the standards (in terms of quality) that are required for the successful completion of the process of accreditation of study programs [1,4].

This paper presents the standards and procedures for ensuring the quality of study programs on the example of the higher school of applied studies, which through the Statute [5], and by the Law on Higher Education [1], has introduced and applies a quality assurance system. The backbone of the quality assurance system is the Rulebook on standards and procedures for ensuring and improving the quality of work, self-evaluation of the Technical College of Applied Studies in Zrenjanin, and self-evaluation of study programs [6]. It was

assumed that the same, general act [6] elaborates in more detail the standards and procedure for ensuring the quality of study programs [2] and that while respecting the specificity of the position and business of the observed s of applied studies in the system of higher education in the Republic of Serbia. The paper also assumed that the prescribed standards and the quality assurance procedure of study programs are aligned with the requirements of the Rulebook on standards for self-evaluation and quality assessment of higher education institutions and study programs [7] as imperative prerequisites in terms of quality assurance.

II. PRESENTATION OF THE STANDARDS AND PROCEDURES FOR QUALITY ASSURANCE OF STUDY PROGRAMS ON THE EXAMPLE OF ONE HIGHER SCHOOL OF APPLIED STUDIES

Rulebook on standards and procedures for ensuring and improving the quality of work, self-evaluation of the Technical College of Applied Studies in Zrenjanin, and self-evaluation of study programs [6] (Rulebook) forms an integral part of the quality assurance system in the observed college of applied studies.

Standard 4 - Standards and procedures for ensuring the quality of study programs, of the same Rulebook [6] define the following elements in more detail:

- Quality standards of study programs.
- Procedures for ensuring the quality of study programs.

The data obtained by Standard 4 [6] is used by the observed higher school of applied studies for:

- Checking and improving the quality of current accredited study programs.
- Ensuring the quality of study programs planned for accreditation.

A. Quality standards of study programs

Each study program is a set of interconnected and coordinated elements, which includes: clearly defined goals; structure, and content; student enrollment policy and procedure; learning methods and ways of checking knowledge; and learning outcomes (qualifications and competencies of students) [6], i.e. basic quality indicators.

The quality standards of the study program are [6]:

- Clearly defined goals of the study program and their alignment with those goals.
- Alignment of study program objectives with the basic objectives and tasks of the observed college of applied studies, i.e. the integrity of the quality assurance system.
- Structure of the study program in a way that ensures an optimal balance between academic-general education, and professional and professional-applicative disciplines.
- The study program ensures the acquisition of general and professional knowledge, professional skills, and abilities.
- The study program prepares students for lifelong learning.
- The study program encourages the construction of critical and unbiased perspectives in considering the strategic challenges facing society.
- The study program ensures the training of students for the practical application of knowledge and skills, for a creative way of thinking, as well as for monitoring professional achievements.
- The study program ensures the efficiency and rationality of the educational process.
- The study program is flexible and open to the application of innovative teaching methods and all learning styles.
- The study program provides an adequate workload for the student.
- The study program allows for vertical and horizontal mobility.
- The study program provides wide opportunities for employment, further education, and personal development of students.

1) Preparation and adoption of the study program

Subjects of preparation of study programs, method, and procedure of preparation and adoption of the same are defined by the Statute [5] and other general acts of the observed higher school of applied studies.

2) Availability of information about the study program

The higher school of applied studies is obliged to make available to students and the public all information about accredited study programs, about the conditions and methods of their realization, as well as about the conditions for acquiring

professional titles [6]. The information must be regularly updated in printed and/or electronic form [6].

3) Evaluation of the quality of study programs

The quality of study programs is assessed based on qualitative and quantitative indicators [6].

Qualitative indicators of the study program are [6]:

- Student's ability to engage in the work process and creative application of general special knowledge and skills.
- The ability of students for a creative way of thinking.
- Competence and motivation of students to follow the achievements of science and profession.
- The capacity of students for lifelong learning.
- Student's ability to understand social relations and contemporary trends, to research phenomena and problems, and to make creative proposals for solving them.
- The ability of students for active involvement in community life.
- The ability of students for independence and teamwork.
- The possibility of employment, professional advancement, and further education.

Quantitative indicators of the study program are [6]:

- The average duration of studies.
- Broj i procenat svršenih studenata u odnosu na broj studenata upisanih u prvu godinu studija iste školske godine.

B. Procedures for ensuring the quality of study programs

Procedures for ensuring and improving the quality of study programs are [6]:

- Regular monitoring and checking of goals, structure, and content of study programs.
- Regular monitoring and checking of the total workload of students and the workload of students in mastering individual subjects.
- Collecting information about the quality of study programs from internal and external users of the quality assurance system.
- Modernizing the curriculum and ensuring its comparability with the curricula of the corresponding domestic and foreign higher education institutions.

1) Determination of qualitative indicators

Qualitative indicators of the study program are determined by examining the opinions of the following subjects about the quality of the study program [6]:

- Students who attend accredited study programs in the observed higher school of applied studies.
- Teaching staff who are employed in the observed higher school of applied studies.
- Employers who employ graduate students.
- Graduated students who are employed or those who are on the records of the National Employment Service.

The opinion of students about the quality of current study programs is determined through an anonymous survey of students, which is conducted at least once a year [1,6]. The content of the survey list, the sample of respondents, the method and procedure of conducting the survey, and processing and presenting the results, are standardized and form an integral part of the Rulebook [6].

2) Determination of quantitative indicators

Quantitative indicators of the study program are determined based on data from official records, according to the established procedure [6]. The data includes:

- The average duration of studies.
- The number and percentage of graduated students about the number of students enrolled in the first year of study in the same academic year.
- Passing exams by the teacher and by study program.

3) Consideration and analysis of data on the quality of study programs and measures to improve quality

The Quality Assurance Committee summarizes, analyzes, and considers the collected data on the quality of all study programs and prepares an annual report based on this [6].

The annual report on the quality of study programs contains the findings and opinions of the Quality Assurance Committee regarding the quality of study programs as well as proposals for improving their quality [6]. The report is submitted to the Teaching and Professional Council for consideration [6]. The Teaching and Professional Council of the observed higher school of applied studies considers the report and establishes

proposals for the modernization of study programs [6], i.e. for the final improvement of quality.

III. ANALYSIS OF STANDARDS AND PROCEDURES FOR QUALITY ASSURANCE OF STUDY PROGRAMS ON THE EXAMPLE OF ONE HIGHER SCHOOL OF APPLIED STUDIES

The analysis of the presented standards and procedures for ensuring the quality of study programs showed that the quality standards of study programs are elaborated in great detail and are applicable in practice. The quality standards are aligned with the descriptors of the appropriate level of qualifications according to the Law on the National Qualifications Framework [8].

The data, which is obtained by assessing the quality of current accredited study programs, can be used for the Report on Self-Assessment of the Quality of Study Programs and the improvement of its quality. The data can also represent one of the starting points for making a decision on the re-accreditation of the currently accredited study program or for its cancellation.

Standardized data on the quality of an accredited study program can be used in the process of planning an innovative/new study program for which documentation for accreditation will be prepared.

The data obtained from the evaluation of the quality of accredited study programs can also be used in the process of preparing documentation for self-evaluation of the institution as well as for the accreditation of the institution (with appropriate interpretation).

The results of the performed analysis showed that the observed school of applied studies has introduced a very organized and comprehensive quality assurance system. The quality assurance system contains standardized procedures for evaluation and assessment of the quality of study programs.

Procedures for ensuring and improving the quality of study programs in the observed university of applied studies are aligned with the Law on Higher Education [1] but also with the requirements of the Rulebook for self-evaluation and evaluation of the quality of higher education institutions and study programs [7].

t can be considered that the practical application of the analyzed standards and procedures for ensuring the quality of study programs can represent an important factor in improving the quality of the work of the observed higher school of applied studies and thus for its tighter inclusion in the EU streams of higher education.

Data obtained through standardized quality assurance procedures can be very simply interpreted and used in the process of accreditation of study programs, but also in the accreditation of the observed higher school of applied studies, which consequently facilitates and speeds up the work of internal bodies, which deals with the preparation of documentation for accreditation.

IV. CONCLUSION

The presented standards and procedures for ensuring the quality of study programs applied in the observed higher school of applied studies form an integral part of the quality assurance system.

The prescribed parameters for determining, evaluating, and ensuring the quality of the study program are aligned with the requirements of the Law on Higher Education, [7]; Rulebook on standards for self-evaluation and quality assessment of higher education institutions and study programs. The prescribed quality assurance parameters of study programs take into account the specifics of the position and way of working of the observed higher school of applied studies in the higher education system of the Republic of Serbia and are also aligned with the goals and principles of the National Qualifications Framework for the appropriate level of education [8].

It can be considered that the practical application of the analyzed standards and procedures for ensuring the quality of study programs can represent an important factor in improving the quality of the work of the observed school of applied studies and thus for its tighter inclusion in the EU streams of higher education.

A further course of work could include a more detailed interpretation of the relationship between the quality of study programs, the outcomes of study programs, and the requirements set by the National Qualifications Framework for the observed level of higher education with application to study program accreditation, etc.

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Metrics for Dashboards in Education

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Abstract - The development of educational systems has become fundamentally oriented towards monitoring and improving learning and teaching through dashboards. This paper explores various metrics and factors used in educational dashboards to evaluate student progress and the effectiveness of educational practices. We examine different aspects such as student grades, attendance, tests, feedback from teachers and students, as well as resource accessibility. Additionally, methodologies for evaluating these metrics, case studies from practice, challenges that arise, and future research directions are considered.

I. INTRODUCTION

Swift progress in information technology and data science has paved the way for the development of comprehensive educational systems, where dashboards play a pivotal role in analyzing, monitoring, and enhancing the learning and teaching processes. Dashboards have emerged as indispensable tools for educational institutions, revolutionizing the way they operate.

These dynamic interfaces provide a real-time window into the educational landscape, enabling educators and administrators to gauge student progress with precision. By harnessing the power of data science, educational institutions can efficiently allocate resources and design curricula tailored to individual needs, thus optimizing the learning experience.

In this context, this paper delves into the very core of educational dashboards, exploring the fundamental factors and metrics that drive their functionality. Primary emphasis is on the practical application of information technology and data science, aligning them with the overarching goal of enhancing education. We aim to unveil the synergies between technology and pedagogy and showcase how the fusion of these elements reshapes the educational landscape for the better.

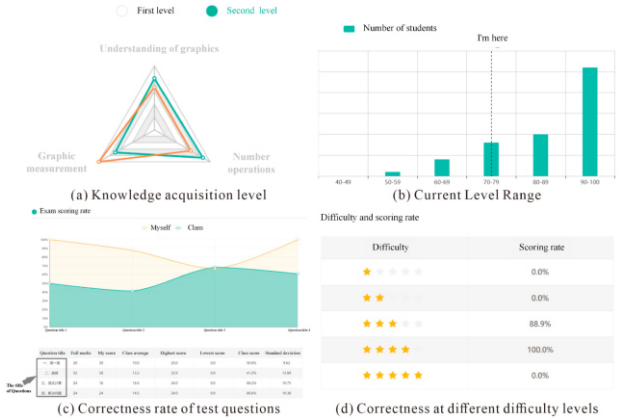

Figure 1. Descriptive dashboard. (from [1])

II. KEY FACTORS IN DASHBOARDS

Dashboards encompass a wide range of factors and metrics used to analyze student progress and teaching effectiveness. Some of the key factors include

- *A. Student grades as a fundamental indicator of student success [2].*
- *B. Monitoring attendance and student engagement [3].*
- *C. Test results and other assessment instruments[4].*
- *D. Feedback from teachers and students as a mechanism for continuous feedback [5].*
- *E. Accessibility to resources and support for diverse student needs [6].*
- *F. Teaching effectiveness and pedagogical improvement [7].*

In the following sections, we will delve into each of these factors and their practical applications. Methodologies for evaluating these metrics will be explored, along with case studies and application examples. Challenges will be identified, and future research directions will be discussed to gain a better understanding of the role of metrics in education and their future evolution.

III. METHODOLOGIES FOR METRIC EVALUATION

Evaluating metrics in dashboards requires a rigorous approach to ensure that the data is accurate, reliable, and relevant. Methodologies for metric evaluation include

A. *A Checklist to Guide the Planning, Designing, Implementation, and Evaluation of Learning Analytics Dashboards*

This methodology involves a systematic literature review of existing studies reporting on teacher-facing learning analytics dashboards [8]. The study proposes a four-dimensional checklist for planning, designing, implementing, and evaluating learning analytics dashboards.

B. *Learning Analytics Dashboard*

This methodology involves the use of descriptive analytics and machine learning to provide actionable insights to learners. The study proposes a state-of-the-art dashboard that not only leverages descriptive analytics components but also integrates machine learning in a way that enables both predictive and prescriptive analytics [9].

C. *Evaluating a Novel, Integrative Dashboard for Health Professionals*

Although this methodology is not specifically for education, it could be adapted for educational contexts. The study adopts the Plan, Do, Study, Act model and Standards for Quality Improvement Reporting Excellence framework to evaluate the dashboard [10].

These methods were explored to gain a better understanding of how metrics are collected, analyzed, and applied in practice.

IV. CASE STUDIES AND APPLICATION EXAMPLES

To demonstrate the use of metrics in education, specific case studies and application examples are presented. This includes examples of university systems using dashboards to enhance teaching and learning [12], as well as examples of online education and blended learning models that rely on metrics to evaluate the effectiveness of instruction [3].

A. *University Systems Enhancing Teaching and Learning with Dashboards [12]*

Learning Analytics Dashboard

The University of Michigan's School of Information and School of Education partnered with the Teaching & Learning team in Information and Technology Services to develop a learning analytics dashboard for students based on research-informed design. The dashboard, My Learning Analytics (MyLA), is designed to support adaptive motivation and self-regulated learning, which is critically related to academic performance.

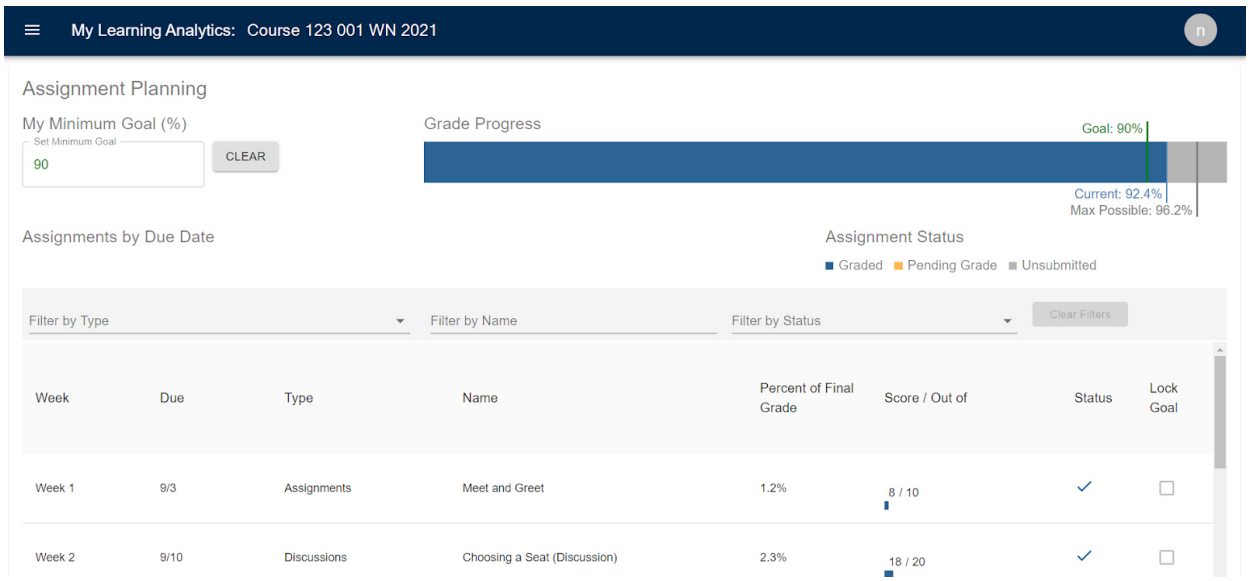

Figure 2. MyLA Dashboard Assignment Planning (from [11])

Actionable Insights

MyLA provides students with information about their engagement with course materials, assignments, and grades, and it supports learning by delivering actionable information. Specifically, the dashboard strengthens awareness, self-reflection, and sense-making by providing a tool for students to monitor their course performance and progress toward their learning goals.

Data Visualizations

The MyLA dashboard consists of data visualizations designed to reveal behavioral patterns associated with good learning skills; to guide decisions about actions students can take that may improve their academic outcomes, and to provide a transparent view of a student's course standing.

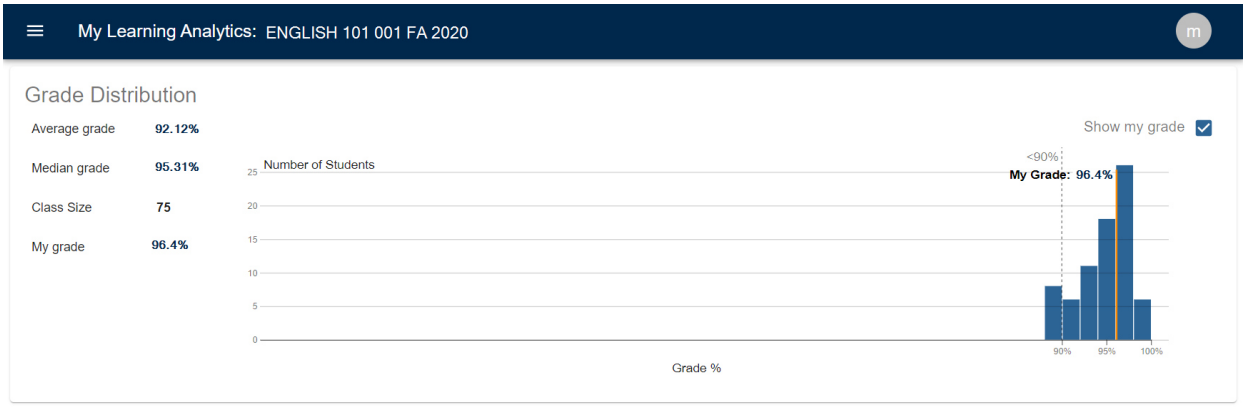

Figure 3. MyLA Grade Distribution Visualization from [11]

B. *Online Education and Metrics-Based Evaluation of Effectiveness [3]*

Blended Learning Models

Clayton Christensen's research on blended learning schools and programs found that the majority of blended programs fall into one of four models: rotation, Flex, A La Carte, and/or Enriched Virtual.

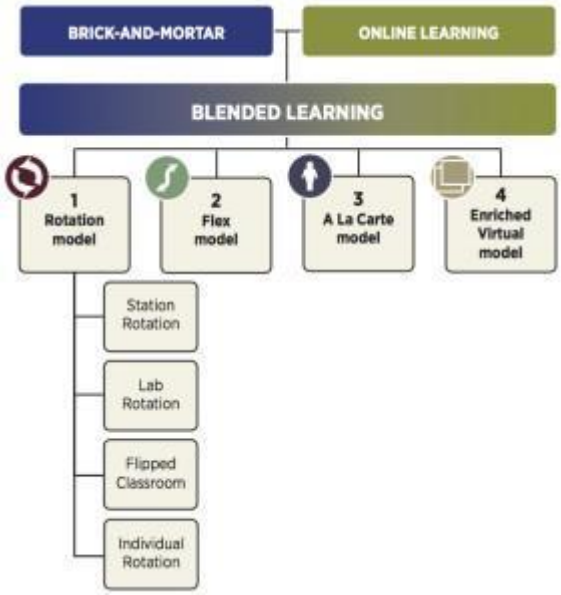

Figure 4. Blended Learning Models. Adapted from [13]

Effectiveness of Online and Blended Learning

A study titled "The effectiveness of online and blended learning: A meta-analysis of the empirical literature" concluded that these technologies do not differ significantly from regular classroom instruction in terms of learning outcomes.

Institutional Implementation

An article titled "The Institutionalization of Online and Blended Learning Initiatives in Politics and International Relations at European Universities" analyzes four cases of institutionalized blended learning implementation at European universities.

V. Challenges and Future Directions

While dashboards are a powerful tool for improving education, challenges exist regarding their usage. Challenges encompass issues related to data privacy, accurate result interpretation, and accessibility for all students. We will also explore future research directions, including the application of artificial intelligence and advanced analytics in education to gain a better understanding of student progress and teaching effectiveness.

VI. Conclusion

Dashboards play a pivotal role in modernizing education and enable the improvement of learning and teaching through metric and factor analysis affecting student success. In this paper, we have explored various metrics and factors in dashboards, methodologies for their evaluation, practical case studies, challenges, and future research directions. Understanding these aspects will help us harness the potential of dashboards in education to enhance pedagogy and support student development.

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Comparison of Traditional and E-learning During the Covid-19 Virus Pandemic

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Abstract – The Covid-19 virus pandemic forced us to switch from traditional learning methods to electronic ones. The aim of this research is to give an insight into the perception of e-learning during the Covid-19 period from both sides, student and teacher, as well as its comparison with traditional learning. The empirical data were collected by anonymous questionnaires, intended for professors (as well as assistants) and students from the Technical Faculty "Mihajlo Pupin" in Zrenjanin, Republic of Serbia. The research results provided answers to the research questions, pointing out the advantages and challenges of both learning approaches, electronic and traditional.

I. INTRODUCTION

If we ever wondered whether the traditional way of learning/education will die out soon, Covid-19 was an inevitable opportunity for us to form attitudes and draw conclusions about it.

This paper addresses the learning topic from two different perspectives: students' point of view and professors' point of view, analyzing the differences in their perception of traditional and e-learning.

If we define e-learning as: "E-learning is a wide set of applications and processes, such as Web-based learning, computer-based learning, virtual classrooms, and digital collaboration. It includes the delivery of content via internet, intranet/extranet (LAN/WAN), audio and video tapes, satellite broadcast, interactive TV, and CD-ROM" [1] we are setting up the basis for the further analysis.

The Covid-19 pandemic significantly transformed the field of education, forcing us to move to online learning. [2] Considering the situation in the Republic of Serbia, it can be stressed out that regardless on unpreparedness for this state, professors adapted teaching materials for an on-line education in a very short time, while students were facing the challenge of attending the classes from their homes. [3]

These changes in the way of education require careful analysis and evaluation, because thay had grate impact on the quality of the learning outcomes.

II. RELATED RESEARCH

E-learning has a lot of definitions and it is commonly referred to the intentional use of networked information and communication technology in teaching and learning. [4] E-learning incorporate all educational activities that are carried out by individuals or groups working online or offline, and synchronously or asynchronously via Networked or standalone computers and other electronic devices. [4, 5] The American Society for Training and Development (ASTD) defines e-learning as a broad set of applications and processes which include web-based learning, computer based learning, virtual classrooms, and digital. [5] E-learning is used to offer instructional programs to distant learners [6].

In this paper authors addresses e-learning as learning in virtual classrooms, supported by platforms that enable its creation, inviting students, attaching learning materials, communication, and interactivity. This learning environment was practically the only way of the institutional education in the time of the Covid-19 virus pandemic in our country. This certainly left its mark on the effects of institutional education, which was traditional, face-to-face education. There are research dealing with this topic.

The research [7] from 2021 pointed out negativ students' perception of e-learning. A survey of a research sample of 27 students indicated that:

"There is only 1 student who strongly agrees with the current e-learning process, there are 10 students who said the process less effective, 1 student say they are moderate (4%), 12 students disagree (not effective) and 3 students strongly disagree or said the E-learning is not very effective. This findings show that students still prefer to study on campus directly than learning through online (E-learning) like today." [7]

The factors that influenced on the students' perception in the most cases are:

- Network connection difficutlies;
- The price of internet boxes and the need for transfer of a large amount of data;
- Poor adaptability of teaching material to e-learning;
- Lack of learning motivation;
- Lack of time;
- Poor interaction between professors and students;

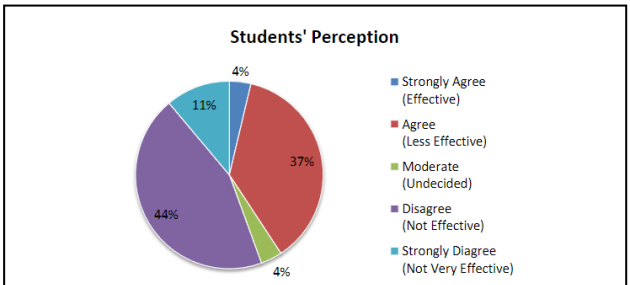

Figure 1. E-Learning in COVID-19 Situation: Students' Perception [4]

The research [8] conducted at the Faculty of Science "Ben M'Sick" provides an insight into the attitudes of professors about e-learning during the Covid-19 virus pandemic. This study indicated that 73.1% of professors were trained to use the tools provided by the faculty and half of them were satisfied with the quality of these resources.

The answers to the question about the evaluation of the institution's technical support in e-learning are as follows: 55.8% of professors are quite satisfied with the support, 23.1% of the professors are satisfied, while 9.6% are dissatisfied, and even 11.5% of the professors are very dissatisfied with this support.

More than a half of professors were against the continuation of e-learning as a part of the faculty practice after the Covid-19 virus pandemic. The reasons for this are many problems, which arose despite the faculty's efforts to achieve the best possible conditions for remote work. Prominent problems are the availability and commitment of students.

III. METHODOLOGY

The main goal of the research described in this paper was to determine the effects of the e-learning during the Covid-19 virus pandemic, both from the point of view of professors and from the point of view of students. In order to achieve that goal, questionnaires were created, based on [7], which were different for professors and students. In addition, the questionnaires contained questions, which, according to the authors, should enable a comparison of the effects of e-learning and traditional learning.

As previously stated, the research conducted at the Technical Faculty "Mihajlo Pupin" in Zrenjanin, Republic of Serbia contained from two different survey based on an on-line questionnaire. The first survey was intended for students, while the second one was intended for professors and assistants from the Technical Faculty "Mihajlo Pupin" in Zrenjanin. Both surveys are based on the assessment of traditional and e-learning, as well as their comparison. The survey research sample for students is 32 students, while the research sample for professors is 25 professors. The collected data were analyzed in a quantitative and a qualitative manner. [9]

IV. RESEARCH RESULTS AND DISCUSSION

A. Students' Questionnaire

According to the research sample of 32 students, 71.9% are male, while 28.1% are female. The respondents were born between 1991 and 2003.

The majority of students' opinions about the adaptation of subjects to e-learning were positive (25% excellent, 31.3% very good, 34.4% good, 6.3% bad and 3.1% very bad). Also, the communication with professors was mostly evaluated as good (34.4% excellent, 37.5% very good, 15.6% good, 12.5% bad, and not a single student answered that communication with professors was very bad). The experience of 21.9% of students is that the technical support, i.e. platform reliability, connection quality, etc. were excellent, 21.9% evaluated it as very good, 34.4% as good, 18.8% as bad and 3.1% as very bad. Over the 80% of students said that the presented educational materials were sufficient for the passing the exam. The opinion of 25% of students is that the "face-to-face" contact with professor is extremely important for acquiring the knowledge, 12.5% evaluated it as very important, 18.8% as important, 9.4% as slightly important and 34.4% as unimportant.

The average time (number of going to the same exam) for passing the exam does not differ significantly between traditional and e-learning. The most common grade that students had during the traditional classes was 8, which matches with the most common grade that students had during e-learning. Answers to the question of when students' concentration and focus on educational materials was greater, were almost evenly distributed between traditional learning, e-learning and the answer that there is no significant difference between these two.

Figure 2. Students' concentration and focus on educational materials

Although a third of the students did not have any problems during e-learning, the most common problems related to the e-learning are: lack of concentration, poor communication, poor organization, poor organization of lectures and problems with power outages and internet connection. The most common problems related to the traditional learning are: poor teaching schedule (long breaks between lectures), uninteresting lectures, poorly equipped classrooms and lack of proper teaching equipment, as well as traveling from the place of residence to the faculty.

When asked which type of teaching they would opt for, 75% of students answered that they would opt for a combination of electronic and traditional learning, 18.8% for e-learning and only 6.3% for traditional learning.

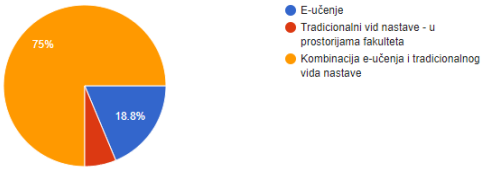

Figure 3. Students' choice of learning type

B. Professors' Questionnaire

According to the research sample, out of 25 professors and assistants, 68% are female, while 32% are male. The respondents were born between 1960 and 1995.

The results of the questionnaire showed that 8% of professors and assistants said that it was very easy for them to adapt the educational materials to e-learning, 28% said that it was easy for them, 44% that it was neither easy nor difficult, 20% that it was difficult for them and no one stated that it was very difficult for her/him to adapt educational materials to e-learning. The opinion of 4% of professors and assistants is that students adapted very poorly to e-learning, 20% that students adapted poorly to e-learning, 48% that they adapted well to e-learning, 28% that they adapted very well and none of the professors or assistants think that the students have adapted well to e-learning.

Furthermore, 44% of professors and assistants say that the response or the attendance of students to lectures is higher during traditional classes, 16% that it is higher during e-learning and 40% that there is no significant difference. On the other hand, even 72% of professors and assistants said that students are more engaged during traditional classes, while 28% said that there is no significant difference in student engagement between traditional classes and e-learning. Not a single professor or assistant said that students were more engaged during e-learning. Also, 84% of professors and assistants had good communication with students during e-learning, while 16% did not. The opinion of 48% of professors and assistants is that "face-to-face" contact with students is extremely important for qualitative teaching, 28% very important, 20% important, 4% slightly important and 0% unimportant.

The most common problems related to e-learning are: problems with the Internet, students' lack of interest in lectures, lack of interaction and problems with e-learning tools. The most common problems related to the traditional type of learning are: poorly equipped classrooms, students' irregular attendance at classes and students' lack of interest.

When asked which type of teaching they would opt for, even 60% of professors and assistants answered that they would opt for the traditional type of teaching, 40% for a combination of electronic and traditional learning, and no professor or assistant would opt for electronic learning.

It can be concluded that the aforementioned is in agreement with the results of the research shown in [7, 8] in the assessment of the effects of e-learning and traditional learning, both from the point of view of professors and from the point of view of students.

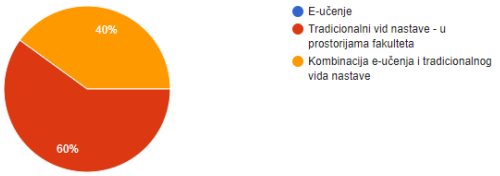

Figure 4. Proffesors' and assistants' choice of learning type

V. CONCLUSION

The surveys results showed different perceptions of electronic and traditional learning from students' and professors' point of view. Each type of learning has its advantages and disadvantages. Looking at the results of both surveys, the most common problem (for students, professors and assistants) concerning traditional learning is insufficiently equipped classrooms. While the most common problems (for students, professors and assistants) concerning e-learning are definitely lack of communication and interaction and problems with internet connection.

As we were forced to adapt to e-learning suddenly and inevitably, it is clear that it was not an easy job to do. Traditional learning has been around far longer than e-learning. It is very important to look at the direction in which e-learning is developing and to solve new problems of this, different type of learning, which has never taken place before. By solving these problems, we will be able to take advantage of the numerous advantages of e-learning.

It is interesting that everyone: professors, assistants and students, are pointing out the advantages and disadvantages of both types of learning. To the question of choosing the type of learning, even 75% of students and 40% of professors and assistants answered that they would choose a combined type of learning. Although the views of the respondents mostly differ, this gives us a topic for further research regarding the implementation of the combined view of teaching.

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