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The official language of the eLearning-2021 Conference is English. English will be used for all printed materials, presentations and discussion.

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VIRTUAL SCIENCE LABORATORIES:

WILL THEY REPLACE THE PHYSICAL LABORATORIES

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Abstract: *A virtual reality technology can be adapted to create a virtual laboratory that simulates the processes and actions in physical laboratories. The virtual laboratory makes it possible to conduct experiments with domain-dependent programs. Web enabled experiments can be designed for remote operation and viewing so as to enthuse the curiosity and innovation into students. This would help in learning basic and advanced concepts through remote experimentation. Today most equipment has a computer interface for control and data storage. It is possible to design good experiments around some of this equipment, which would enhance the learning of students. A concern is whether the students are skilful. A hope is that learning analytics can provide students with an opportunity to take control of their own learning, give them a better idea of their current performance in real-time.*

Keywords: *E-Learning, Virtual reality, online*

1. INTRODUCTION

Last years were seen as the dawn of a new wave of devices employing augmented and virtual reality (AR and VR), which define immersive technology, generating a three-dimensional image, which appears to surround the user. The VR can be adapted for educational needs to create for example a virtual laboratory (eLaboratory) that simulates the processes and actions in physical laboratories. The expectations are that VR will offer a completely new creative medium in addition to changing the educational paradigm as it was pointed thirty years ago in [1,2]. In [2], using empirical data from different sources it is argued that those components that improve performance by reducing effort may actually inhibit learning or long term retention. Many studies have been conducted for about twenty years on the use of virtual reality in education and training. A selected list of examples showing the reasons to use virtual reality is discussed in [3] together with advantages and disadvantages of using virtual reality. Conclusions are made on the basis of over 800 articles and reports published (1991-2009) on applications of VR in education. The technology can be regarded as development of computer-added teaching or computer-based training. Computers have been used as instructional aids since the early fifties of 20th century. Appearance of the personal computers changed substantially the educational system. Virtual reality, which is applicable on all types of computers, has contributed to modifying the forms of education. Despite the recognition of VR as a great tool, the debate on "whether its use can improve the intended performance and understanding" is ongoing [4,5]. While it is undisputable that VR grasp the student's attention immediately and holds it longer than

outdated educational tools, it is still not clear if the technology induces side effects – negative or positive - on the human health [6,7]. This makes important the discussion on when to use and when not to use virtual reality.

2. SIMULATIONS, GAMES AND VIRTUAL WORLDS

Let us take a closer look at the benefits, limitations and considerations for leveraging eLaboratory as a strategy for entering unknown world.

Simulations imitate a real-life process. They let testing hypothesis of the effects of input variables on the intended outcomes. “Social percolation” [8] was invented to model the emergence of a collective social/economic phenomenon, which in statistical physics and mathematics fits in percolation theory that describes the behaviour of a network when nodes or links are added. In [9] the hypothesis was that advertising in mass media (a new variable added in the model) would change the behaviour of the system in the vicinity of the percolation threshold. The social percolation is a dynamic process, which seems appropriate to describe the status of a group of learners before and after understanding a new concept. Major concepts and results achieved in the study of the structure and dynamics of complex networks, ranging from nonlinear science to biology, from statistical mechanics to medicine and engineering were published in [10].

Simulations allow the usage of virtual apparatus that could be cost prohibitive. For instance, frog dissection to teach anatomy in a physical laboratory can be replaced with a computer application as Vfrog [11] that provides virtual environment and allows learners to practice frog dissection numerous times that otherwise is not quite possible in the real life situation. However, concerns about the actual skills of the learners are rather valid. On one side, medical students can avoid the risk of applying certain procedures directly on the patient without having sufficient practice, which could be replaced by the VR laboratory. On other side, the real (physical) experience is badly needed for a surgeon before conducting operation in the surgical room. Hence, every field needs a detailed analysis when and how long to use VR before jumping to the real life.

A model that can be used to determine when to use virtual reality in an education or training course is presented in [3]. Before using the VR the instructor checks the following components: teaching or training using the real thing is dangerous, impossible, inconvenient, or difficult; a model of an environment will teach or train as well as the real thing; interacting with a model is as motivating as or more motivating than interacting with the real thing; the experience of creating a simulated environment or model is important to the learning objective; information visualization is needed, manipulating and rearranging information, using graphic symbols, so it can be more easily understood. VR is not recommended if no substitution is possible for teaching/training with the real thing; interaction with real humans, either teachers or students, is necessary; using a virtual environment could be physically or emotionally damaging; using a virtual environment can result in "literalization"; a simulation so convincing that some users could confuse model with reality; VR is too expensive to justify using, considering the expected learning out come. Based on the analysis described, a 10-step model to determine when to use virtual reality is proposed in [3]. The model can be considered as a part of the continuing search for ways to use VR in education.

Researchers have assigned games for learning as a special category of simulation. VR is still a testing ground of game design, and one area in which there are few standards when it comes to control schemes and design choices. VR provides new forms and methods of visualization, drawing on the strengths of visual representations. VR can more accurately illustrate some features and processes. The strongets demand of AR and VR technology comes from the communities involved in development of video games, live events, video entertainments.

Research suggests that in order to promote learning, games must be design to provide players with a sense of autonomy, identity, and interactivity [12]. In order to provide various experiences, game must include elements such as goals, achievement levels, and rewards systems. There are published software assets that cover a broad spectrum of functionalities – from player analytics including emotion detection to intelligent adaptation and social gamification [13].

The issue of usability and likeability of a virtual reality game that is meant to teach students a specific subject points at different categories of students in terms of their level of game-playing expertise.

We observe a high similarity to the real world expertise - personal performance skills are needed to appreciate knew knowledge. Hence, we ask: Could VR help in achieving performance skills?

3. DESIGN COGNITION

An approach for observing design activities, using VR design-build-test games with built-in physics simulation, is proposed in [14]. The paper reports on two exploratory design workshops where two groups of participants worked to solve a technical design problem using such a platform. Participants were asked to sketch ideas to solve the problem, and then to design, test and iterate some of their developed design concepts in a VR game. Continuous and multifaceted recordings of participants' behavior during the various design activities were obtained, namely on-screen design activities, verbal utterances, physical gestures, digital models of design outputs, and records of the test outcomes. The results of the study showed that VR game platforms not only offer a valuable addition to existing research options, but additionally offer a basis for developing training interventions in design education and practice.

4. TRENDS OF VR DEVELOPMENT

Let us comment on the trends of educational virtual reality games. Obviosly, these technologies cause a rapid transformation of the educational world. VR is computer-simulated, which gives users the illusion of being physically present in the world and uses not only sight but also sound and touch to fully engage a user in the virtual world [15]. A computer generates sensory impressions that are delivered to the human senses in a VR system. The level of immersion and the feeling of presence in VR are determined by the quality of the impressions - high-quality information should be presented to all of the user's senses. In addition it is expected that the environment itself should react realistically to the user's actions. However, in practice many applications stimulate only one or a few of the senses. The level of immersion characterise the modern VR systems. The simplest type of virtual reality applications is the Desktop Virtual Reality systems, which do not need special devices. A computer user views a virtual environment through one or more computer screens. A user can then interact with that environment, but is not immersed in it. Desktop Virtual Reality has begun to make its way and popularity in modern education because of its ability to provide real time visualization and interaction within a virtual world that closely resembles a real world.

Improvment of desctop VR was achieved via semi-immersive systems that support head tracking and therefore increase the feeling "of being there" thanks to the motion parallax effects. Immersive systems let the user totally immerse in computer generated world with the help of a head-mounted display (see Image 1) that supports a stereoscopic view of the scene accordingly to the user's position and orientation. These systems may be enhanced by audio, haptic and sensory interfaces. Head-referenced viewing provides a natural interface for the navigation in three-dimensional space. Realistic interactions with virtual objects via data glove and similar devices allow for manipulation, operation, and control of virtual worlds.

Image 1: 12 HMD vector images

https://depositphotos.com/vector-images/hmd.html

From a distance, virtual reality games might seem primitive - players' hands float in midair as they vault across virtual space, crudely teleporting from point to point. Perhaps a change in perspective is called for. What players may not know is that teleportation is not a lazy solution to moving about in virtual reality, but a direct response to motion sickness. Floating hands are a design choice, not a shortcut. The games are not bad. It is just that virtual reality often has to reinvent the wheel.

5. VR SICKNESS – UNDERSTAND REASONS

The most common problem is "VR Sickness," a term adopted by developers and players to describe the various afflictions caused by playing VR games. Nausea, dizziness, disorientation and a number of other motion-sickness related symptoms are common with many VR users and this is exacerbated by the nature of virtual reality: The player's eyes tell their brain they are walking, while their body tells them that they are immobile. Such a situation is happening when one reads a book in the back of a car - the vision is fixed on a stationary object while the peripheral vision and inner ear are detecting movement. But this is not a common situation for all humans, only for those that experience a motion sickness. As the VR usage in schools (at all levels) grows, motion sickness is potentially a major barrier to adoption for the technology. While it is not known yet the exact number of people who are likely to be affected by motion sickness, software engineers who develop VR or AR environments typically assume that 25% of users will experience it. The type of headset and tracking plays a big part in whether someone will experience motion sickness in VR. The first VR headsets featured 3-degrees of freedom tracking (3DoF), which means that one can look up, down, and to the sides in 360-degrees. 6-degrees of freedom tracking (6DoF) or spatial tracking, can help solve this problem. Headsets with 6DoF enable users greater freedom of movement within the virtual environment, and the environment around them will adjust accordingly.

Another factor that influences VR motion sickness is the type of controller. A few years ago, only high-end headsets had controllers - these are much more widespread now and help to lessen sensory conflict.

Latency in VR contributes a lot to motion sickness. Latency is the time it takes for movement to register in-app and can trigger those signals to your brain that something is not quite right. If the display gets the signal too late, the equilibrium becomes confused because the body movements do not match with what you are seeing or hearing. Research showed that most people were comfortable with the 13 milliseconds delay created by 90Hz display panels. This then became the industry standard for years. There are now headsets available that offer faster displays allowing users to adjust between 80Hz, 90Hz, 120Hz and 144Hz. As the industry develops, the latency will likely decrease, which will significantly help with the problem of motion sickness. Another element to consider is that motion sickness in VR could occur because of the unfamiliar eye motion that is required to keep the virtual scene stable on the

retina. The eyes must move differently from the normal to stablise the image in VR on the retina. This new movement causes motion sickness. Another interesting factor influencing motion sickness in VR is the postural instability. In circumstances where we have not yet learned to keep our balance, we tend to become sick. The feeling can intensify or decrease based on the duration of exposure time and the magnitude of exposure.

Knowing many factors that contribute to motion sickness in VR, makes it easier to think of ways how to minimise the chances of vulnerable students of experiencing it. These considerations, however, are outside the scope of the current paper. For education VR games the most important is that the students should be tested in advance in order to choose the proper HMD for each student. Another important requirement is to ensure enough relaxation time between the successive VR exercises.

6. REPLACEMENT OF PHYSICAL LABS?

«For example in [16] the article reports that Arizona State University (ASU) has launched its first fully online biology degree course that uses simulations instead of actual lab work. Labster has collaborated with Google Daydream to provide 30 three-dimensional (3D) lab simulations for the course, and says that more universities are likely to follow, including the University of Texas at San Antonio».

While the replacement is justified for laboratories where the students must work with toxic or radioactive substances, it is doubtful that a mechanical engineer will be skillful enough for assembing any mechanical component. The robots can do that, of course, but the lack of hand-skills limits the practical work. Trainees also need a chance to summarize and reflect on what they have learnt. Otherwise it is pretty common to encounter ineffective training. Studies have indicated that the students trained in virtual and physical laboratories achieve similar oucomes. The studies that show a detriment typically involve a completely unfamiliar physical task.

And this a very important finding to be remembered – physical laboratories are really needed for a new comer to establish a reasonable scaling of resistance, weight, speed, time. The metrics matters.

7. CONCLUSION

The VR technology gives enormous scope to explore the world of 3D and your own imagination. It has many applications from product development to entertainment.

We investigated at the master level whether the benefits of virtual reality instruction are maintained over time. On the basis of a five year study of master students performance - *Modeling of physical process*es and *High performance computing in statistical physics*, we can conclude that the benefits of simulations were greater when students were tested immediately after the instruction than when the assessment was delayed. However, the effects of virtual worlds were not affected by retention interval. A limited number of papers discusses the instructional effectiveness of virtual reality-based instruction in the context of retention and transfer of learning from virtual to the real environment. This needs attention.

We found evidence that if students spent more time playing educational games, the learning outcome gains starts to diminish. This result also coincides with the results from analyzing the forms of training, in which students performed better in practice mode than in stand-alone instruction.

Overall, virtual-reality based instruction was quite effective. However, there were several limitations, which in our view should be looked at in the future, in order to decide on when to use and when not to use virtual reality training.

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LEARNING ANALYTICS – MULTI-USER AND MULTI-LEVEL PERSPECTIVE

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Abstract: *This invited lecture covers a choice of research within the field of learning analytics, as well as the applications in educational systems which includes the strategic decision-making level (national) but also the analysis of the examples at study programme and course levels. Finally, I propose some research questions for future research.*

Keywords: *E-Learning, Online, Learning Analytics, Learning Design, Strategic Planning, Assessment*

1. INTRODUCTION

Learning Analytics (LA) is an interdisciplinary research field that has been developing in the last decade. Researchers in LA usually originate from educational sciences, informatics (ICT), mathematics and statistics but also from other research and professional areas. Therefore, it is still a problem to define the uniqueness of LA theoretical foundations, research methodology and central problems of interest. In my opinion, LA needs to contribute to student's learning and to the quality of teaching that are aligned with 21st century skills and values. Fast development of AI, availability of big data and learning information systems that collect, store, manipulate and visualize data enable researchers to see the usefulness of LA but also open many questions related to ethical and responsible use of LA.

Therefore, LA deals with the data that occur from students' interactions with information and communication technology (ICT): collecting data, analysing and reporting that can influence learning and teaching. Primarily, LA analyses data but not only the data produced exclusively by students' interactions with ICT, especially with Learning Management System (LMS) where huge quantity of data is stored [1].

Due to the COVID-19 pandemic, mainly since mid-March 2020, school and university closures were nearly universal [2], affecting almost all students from all educational levels across the globe. The majority of educational institutions switched from on-site to online teaching and learning. Therefore, a lot of digital traces have been available in LMSs and other tools and systems opening many opportunities for analysis, critical interpretation and evidence-based decision making about the future of teaching and learning.

In the following sections I will present a few examples of the use of LA coming from my research and practical experience including the national level, the level of study programme and the course level (peer-assessment and course level assessment programme):

- The first example is overarching strategic planning of LA System with special attention given to co-creation process with users.
- The second example is based on constructive alignment of Learning Outcomes (LOs) with student activities and the assessment.
- The third contribution is based on the assessment data that can measure the reliability of assessment programme, especially peer-assessment in higher education.

Finally, a short contribution of LA to the analysis of teaching and learning process during pandemic is given.

2. STRATEGIC PLANNING OF LA IN PRE-TERTIARY EDUCATION

There are far less research and predictions about the role and implementation possibilities of learning analytics in pre-tertiary education (schools) than in higher education. However, the research presented in paper [3] performed in primary and secondary schools in Croatia demonstrated how to strategical plan development od national Learning Analytics Systems for all schools.

The methodology was developed within the result "Learning analytics" in the scope of the pilot project „eSchools: Establishing a System for Developing Digitally

Mature Schools (pilot project)“ that lasted as a pilot project in the period 2015-2018 and then followed by the project eSchools second phase that include all schools in Croatia in the period 2019-2022. The coordinating body of the project is the Croatian Academic and Research Network – CARNET and the University of Zagreb, Faculty of Organization and Informatics (FOI) is one of the project partners. The purpose of the e-schools pilot project (2015-2018) was to establish a system for the development of digitally mature schools and the evaluation of the application of ICT in the educational and operational processes of 10% of schools in the Republic of Croatia [4].

Questions we researched are the following [3]:

- What are the specific needs of teachers and students (pupils) in pre-tertiary educational sector?
- What are the possibilities of applying LA in pre-tertiary educational sector?
- What are the similarities and differences between higher education and pre-tertiary education related to implementation and usefulness of LA?
- What are the specific challenges of ethics and privacy issues of LA in pre-tertiary education?
- What are the most useful data sources about learners in pre-tertiary education?
- How to integrate data from f2f classroom with data from LMS and other e-sources?

Within the pilot project „e-Schools“ the design for the development of national Learning Analytics System (LAS) for pre-tertiary education was prepared and reached its pilot phase.

The approach consisted of the following phases:

1) setting of overall objectives and vision

2) user needs analysis

3) data availability analysis

4) dashboards development, including setting aims for each dashboard and design of dashboard functionalities, followed by the

5) user evaluation of dashboard design and functionalities

Co-creation process with end users is crucial for the success of LAS. It is important to stress that the users have been consulted three times: once in phase 2) and twice in phase 5).

Primary objective of LAS is to improve students’ learning and motivation but also to support schools in accountability and the national authorities in setting, monitoring and evaluation of the strategic goals. There were identified six target groups (stakeholders): students (pupils), teachers, school management and support, regional and national authorities responsible for education, strategic bodies and researchers and finally project partners that work on system development.

The main requirements from six main groups of users were identified by means of questionnaires and focus groups [3]. Finally, we recognized the following main areas where users need the LAS support: to foster student success, to predict the students at risk based on the different factors (i.e. low grades, excessive absences, low course engagement), to allow friendly monitoring of students’ success, progress, needs and timely interventions to prevent students’ failures.

3. MULTI-CRITERIA DECISION-MAKING METHODS FOR LEARNING DESIGN

Consistent and sustainable Learning Design (LD) of study programme is one of the major challenges in higher education. Constructive alignment in terms of intended LOs, teaching methods and assessment [5] needs to be provided. The comprehensive planning process allows higher education institutions (HEIs) to analyse the related data and to provide teachers with the analysis and visualizations they can use for planning of teaching and learning activities and for ensuring the assessment validity taking into account the intended LOs as well as the students’ workload.

In [6], we present the problem of ensuring the course assessment validity from the pedagogical and decision-making perspectives. The first step was to identify the criteria by which the LOs will be evaluated. We used a focus group to identify the following four criteria: importance of the topic or context for the future profession; required level of the LO based on chosen taxonomy; contribution to the development of the 21st-century generic skills and student workload needed to reach the LOs. In the second phase, we used the Analytic Hierarchy Process (AHP) and the Analytic Network Process (ANP) to determine the weights of evaluation criteria and the consequent relative importance of LOs of a course we used as a case study. The problem is interesting from the decision-making point of view, since we consider the prioritization (not selection) of alternatives (here LOs), and the alternatives (LOs) being not independent of each other. Additionally, the problem can be broaden and analyzed from the LA and LD perspectives being a valuable source of data and analysis for decision-makers within HEI, teachers, students and employers. Other aspects of the assessment programme can be taken into consideration [7].

The research conceptual model is presented in Figure 1. and the details can be found in [6].

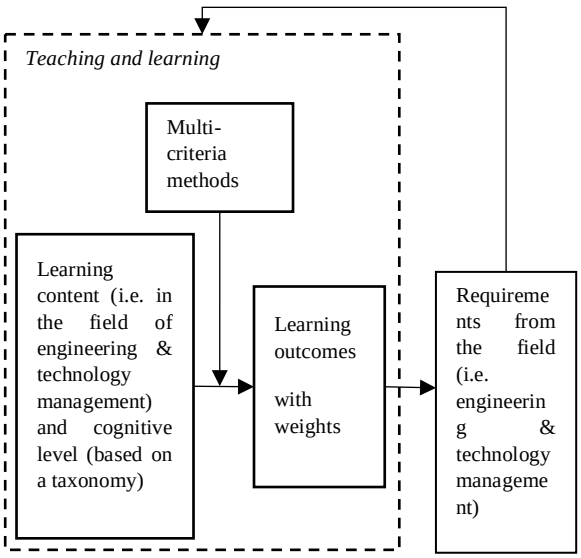

Fig. 1. Conceptual model of the presented research [6]

4. ASSESSMENT PROGAMME AT THE COURSE LEVEL

The most prominent role of the assessment is to support student's learning. Therefore, the assessment in HE has a dual role as the assessment of learning and the assessment for learning. According to [7] the utility depends on five factors: reliability, validity, educational impact, acceptability, and the costs of assessment. Due to lessons learned from COVID-19 pandemic period we should consider adding a new factor: feasibility of assessment encompasses the security measures.
The linkage between formative and summative assessment tasks is essential for timely feedback to students and for an adjustment of teaching and learning methods.

To confirm reliability of an assessment programme we analysed different approaches to construct reliability composite index for the assessment program on the level of the course. Based on that and the data from LMS we addressed the reliability of assessment tasks and the whole set on different courses.

LMS Moodle provides several statistics [8] we can use for the analysis of assessment on the level of item (i.e. Facility and Discrimination index) and on a test level (i.e. Crombach alpha, Asymmetry). One approach is to utilize Coefficient of Internal Consistency (CIC) which is based on Cronbach alpha (coefficient of reliability/consistency for assessment tasks). CIC and similar indices, available in Moodle, can also be analysed and interpreted for each of the assessment tasks. Moodle manual advice is that well-prepared assessment task should provide CIC that is above 70%.

The example of assessment tasks CIC index for the course Discrete Mathematics with Graph Theory (DMGT) [10] is provided in Table 1. Here we used weighted approach that takes into consideration the contribution (points) of the assessment task in final grade. The aggregated reliability index at DMGT course level based on arithmetic means is 72.73 % which is within the recommended boundaries. Geometric means for aggregation can also be considered but in our case it gives very similar results.

Table 1: DMGT composite reliability index data

Assessment tasks	Weights of tasks	CIC	Weighted arithmetic CIC
Test 1	0.3204	67.81	21.72
Test 2	0.2913	72.44	21.10
Quizzes	0.0971	87.85	8.53
Project (team)	0.2913	73.41	21.38

The reliability analysis has been especially important during pandemics when the majority of HEIs administrate the assessment online without having the appropriate transition period from on-site to online teaching and learning.

Furthermore, teachers can trace assessment statistics in LMS Moodle and try to interpret students' assessment results, find causes and effects of certain teaching and assessment activities, as well as to improve their own assessment construction skills or change their assessment approach.

Another example of reliability analysis by means of LA is the reliability of peer-assessment. The importance of the peer-assessment in HE is growing due to its extensive use within MOOCs (Massive Open Online Courses) and the development of 21st scentury skills. Naimly, peer-assessment engages students to become more active learners, take responsibility for their learning, to apply deeper learning strategies and to gain a better understanding of their own subjectivity and judgment [1]. Besides that, part of MOOCs or MOOC-inspired assessments are used in traditional courses [9] and that opens up possibilities for implementing LA approaches that where originally developed for MOOCs.

Many teachers do not involve students in peer-assessment because of relaibility concern. Academically, the reliability is studied through the analysis of variations that occur among raters and across different peer-assessment of the same individual rater. The former is commonly referred to as inter-rater reliability, while the latter is known as intra-rater reliability. In [11] the algoritham for measures for calculation of the final grade in peer-assessment and related inter-rater and intra-rater reliability measures based on the taxicab geometry and the use of the scoring rubrics. Further development is needed to utilize the results of analysis based on LA to students' and teachers' dashboards.

5. PANDEMICS AND LA

To make a better understanding of the decision-making in the context of the COVID-19 crisis in education there are different approaches that can be taken. First of all, the analysis of decisions made on national strategic levels as it was done in [12] where we investigated approaches taken by European Union Member States (MS) as the emergent responses to the COVID-19 crisis in pre-tertiary education. It includes a multi-case study of four MSs, examining their education systems' digital readiness and "fitness for change", as well as the decision-making practices.

Another perspective is from the bottom-up process of teaching and learning where LA is used to trace learning paths (digital footprints) of students in virtual environment and the findings considered as inputs for better online teaching and learning.

There are also other approaches including combination of the two mentioned above where interplay between strategic decision making and decision making on teaching and learning on the level of students and teachers might be researched.

6. CONCLUSION

The use of Learning Analytics (LA) is crucial for the future of learning and teaching at all educational levels, and therefore, it entrusts all stakeholders to co-create system for its responsible use. Also, the future research needs to encompass the strategic planning and decision-making about Learning Analytics Systems (LASs) at national level as well as at the level of institution (e.g. university). It should be done as the process of co-creation which involves the end-users, as well as other stakeholders from the very beginning and not just in the evaluation phase.

Sustainable and comprehensive Learning Design (LD) is a major concern of HEIs. One of the results of well-prepared LD is a valid assessment programme that is confirming the achievement of learning outcomes (Los) since ensuring the validity of the assessment is a necessary condition for acceptance of the assessment. To ensure validity, it is necessary to clearly align a course LO with the assessment methods and relate assessment tasks points to the relative importance of a LO. The problem is interesting from different perspectives since it is a valuable source of data and analysis for the decision-makers from HEIs, teachers, students and employers.

The assessment in HE has a dual role - as the assessment of learning in which especially employers are interested and as the assessment for learning that is focused on supporting students to be active and become independent learners.

Additionally, the analysis of assessment reliability is especially necessary during pandemics to maintain trustworthiness of education process. Namely because of the fast transition to online teaching and learning some technical and pedagogical aspects were used without double checking. On the other hand, the LMS provides assessment data that can be used for evaluation of the process.

In future, students' and employers' perspectives on quality criteria of assessment need to be investigated.

Finally, shift to mainly online teaching and learning opened many new research questions on strategic level, as well as on the level of quality of delivery and deep approach to learning. On both aspects, the LA can contribute to find answers.

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EDUCATIONAL DATA MINING AND LEARNING ANALYTICS TOOLS FOR ONLINE LEARNING

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Abstract: *Learning analytics and educational data mining can be used to accomplish student profiling, providing to teachers information about each student, while signaling teachers in real time about potential problems. The purpose of this paper is to provide a review of learning analytics (LA) and educational data mining (EDM) tools used in education. This study was conducted to examine currently existing EDM and LA tools, their benefits and challenges in the education setting. The review gives analysis from two perspectives: (i) EDM/LA methods that are used, and (ii) EDM/LA tools used for different stages in data mining including data transformation, algorithmic analysis and data visualization.*

Keywords: *educational data mining, learning analytics*

1. INTRODUCTION

Rapid technological development and the constant change of needs of new generations of learners has caused the need for teachers to adapt to new teaching modalities. This involves not only presenting the learning content, but also includes keeping student motivation, as well as monitoring and assessing the students in new learning environments. With the increase of usage of different web-based learning systems, as well as using different teaching modalities (distance learning, remote learning, blended learning, etc.), educational institutions have collected large amounts of different formatted data from different sources. Different formats and large amounts of data can be very useful in different educational formats and settings, but the challenge is how to transform this data into meaningful information that will provide a meaningful insight to teachers, students and educational institutions.

While educational data mining (EDM) and learning analytics (LA) communities deal with many similar questions, there is also a difference in terms of emphasis [1]:

EDM: EDM develops and adapts statistical, machine-learning and data-mining methods to study educational data generated basically by students and instructors [2].

LA: LA is defined as the "measurement, collection, analysis, and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs" [3].

LA is focused on educational challenges, decision making based on data, integrating the technical and the social/pedagogical dimensions of learning by applying known predictive models, while EDM is focused on the technological challenge, identification of new patterns in data, developing new algorithms and models [2].

This paper is organized as follows: Section 2 presents an overview of EDM/LA methods. Section 3 describes the tools used in EDM/LA for online learning. Finally, Section 4 concludes this paper.

2. EDUCATIONAL DATA MINING/LEARNING ANALYTICS (EDM/LA) METHODS

EDM and LA use different methods in their approaches, some of which fall in different categories of data mining, some of which are (but the list is now all inclusive) knowledge tracing, relationship mining, prediction, clustering, visual data mining, etc.:

Knowledge tracing – method for estimating student mastery of skills [4]. The goal is to monitor student knowledge over time [5].

Relationship mining – identifying patterns in large data sets [5]. Four main forms of relationship mining are correlation mining, association rule mining, sequential pattern mining, and causal data mining [1].

Prediction – Develops a model that uses both a predicted variable (particular component of the data) and predictor variables (consist of a combination of other data elements) [6]. Three main categories of prediction are classification, regression, and density estimation [7].

Clustering – the goal of clustering is to identify data that can form a group based on similar logic and observations. In online learning an example of clustering would be grouping students based on their learning patterns. Dividing data into clusters allows one to further make meaningful insights from the data.

Visual data mining – using visualization techniques allows to easily identify the relations and trends in the data [8]. Visual analysis of data can expose patterns and trends in datasets by using advanced computational methods and graphics.

Discovery with models – entails using previously defined models and applies it to conduct another analysis. This field provides analytic techniques to operationalize a range of learner behaviors, attributes, and states during the learning process [9].

Distillation of data for human judgment – this technique uses presentation of data using summaries, visualization, interactive interfaces, with the goal to visualize and analyze student ongoing activities [5].

Text mining – entails extracting information from data that are in text format. The application of this method is mainly used when extracting insight from chat, forums, web pages and different text documents.

Statistics - provides the tools, analytics techniques and science of learning from large amounts of data with a focus of analyzing, interpreting and drawing conclusions from educational data [10].

Causal mining – a method that enables finding causal relationships in data. For example, this method is suited for detecting certain student characteristics in student profile that may lead to lower student performance or drop out [5].

Association rule mining - this procedure has the intent to observe frequently occurring patterns and discover interesting correlations between variables in databases (identification of relationships in student behavior patterns) [11].

Outlier detection – primary step in various data-mining applications with the aim to detect the parameters that are affected by outlier tools from thousands of parameters (students with difficulties or invalid learning process) [12].

Correlation mining - identifying specific or unusual patterns of dependency between objects (sequences, signals, images, videos) [13].

Non-negative matrix factorization (NMF) –provides the separation of meaningful features from data that can be used for student skills assessment [5].

Process mining - method for gaining knowledge from the event logs in learning [14].

Recommendation - predicting grades, learner's specifics, or further learning material that need to be learned [15].

Social Network Analysis - sociological approach, that can analyze collaborative social networks (e.g., learner interaction in online learning environments, social media) [16].

3. EDM / LA TOOLS

There are a number of powerful free and commercial data mining tools, however, not all of these tools are designed to meet the requirements of educational data mining and learning analytics. The process of EDM/LA is complex and there are a lot of tools that support these steps such as: (i) transformation of raw and incomplete data into significant variables, (ii) algorithmic analysis, and (iii) informative visualizations [17] [18]. There are a lot of general-purpose tools and frameworks that can be used in described EDM/LA steps. In this section, general tools and software packages that allow EDM/LA processes to be conducted are described. It is important to note that these tools, while not primarily used for the domain of EDM/LA tasks, can be successfully used in resolving a wide range of problems in EDM/LA.

General-purpose tools require specific methods or algorithms and adaptation of parameters in order to obtain good results and models. These tools are not easy for educators to use because educators must possess a certain amount of expertise in order to find the right inputs and settings [5]. In order to overcome that challenge, educators usually use some of the specific EDM/LA available software tools. Keeping this in mind, the analysis of specific useful EDM/LA tools are presented.

3.1. General-purpose tools for transformation of raw and incomplete data

The first step in the process of EDM is the transformation of raw and incomplete data streams into significant variables that enable the preparation of the proper input dataset that is suited as compatible input with machine learning algorithm requirements. For instance, different Learning management systems (LMS) log user data in different formats, which are not directly applicable to algorithmic analysis. These raw collected data typically need "cleaning" before conducting analysis, which is done by creating new variables. This process is named feature engineering [19, 20]. *Microsoft Excel* is the most accessible and useful tool that falls in this category, for data analysis, documentation and prototyping of new data. In addition, using Microsoft Excel allows easy visibility and editing of data. *Google Sheets* is a similar web-based tool. These tools provide easy identification of structural or semantic problems (unusual, nonstructural, missing, or duplicate entries), but also by rapidly applying different calculations to the entire sheet enable an easy way to find how much students have a high success rate, an average time of learning, etc. The disadvantage of these tools is that they are not useful for the manipulation of extremely large data sets that have around one million rows and more.

The *Educational Data Mining Workbench* (EDM workbench) is a tool with the aim to address the limitations of spreadsheet tools, with the goal to help researchers with processing data from various sources in order to develop metacognitive and behavioral models [21]. EDM workbench supports learning scientists to perform a number of analytic tasks including: (i) defining and modifying behavior categories of interest (e.g., gaming, unresponsiveness, off-task conversation, help avoidance), (ii) labeling previously collected educational log data with the categories of interest, and (iii) providing support for running the labeled data through a machine-learning tool and export data to different formats for further usage in tools for algorithmic analysis (i.e. WEKA or RapidMiner).

Different online learning platforms and Massively Open Online Course (MOOC) usually produce data in formats such as JSON files where identification of missing data, duplicates, or unusual values is time-consuming. Several programming languages allow and provide libraries that support the manipulation of data and feature engineering where *Python* is considered the most suited and can support different formats of data and can work with larger datasets than previous tools [22]. Additionally, the *Jupyter Notebook* is an open-source web tool for creating and sharing of documents that contain live Python code, equations and visualizations [5]. However, Python still faces data size limitations and becomes slower when working with large amounts of data [5]. For the purposes of searching, manipulating and fast processing for basic tasks (i.e. selecting a specific subset of learners or obtaining data from a specific date range), SQL can also be used. SQL provides a powerful method for extracting exactly the desired data, sometimes integrating ("joining") across multiple database tables. However, SQL has limited functions in managing complex features in the feature engineering process. Working on a very specific problem set can be manually done. When researchers work on generic problems, it is time-consuming to engineer features from scratch. So, there are a lot of tools/libraries that automate feature engineering. Some of them are: *Featuretools, TSFresh, FeatureSelector, OneBM, Cognito.*

3.2. General-purpose tools for algorithmic analysis

After the features engineering and labeling outcome variables, structuring and cleaning data, the second step in the EDM process is to analyze and model datasets and validate the resulting models. The tools listed in this section describe algorithms and modeling frameworks for modeling and predicting processes and relationships in educational data.

RapidMiner is an open-source data mining tool that provides an integrated environment for data preparation, machine learning, deep learning, text mining, and predictive analytics. RapidMiner is developed in Java and provides easy integration with WEKA and R-tool. RapidMiner can be used in order to identify students who need special attention from the beginning of the course [23]. Similarly, the *Waikato Environment for Knowledge Analysis* [24] is a free and open-source collection of machine learning algorithms for data mining tasks (data preparation, classification, regression, clustering, association rules mining, and visualization, also supports deep learning). *Weka tool* is often used for EDM/LA and student profiling, where text mining and social network analysis techniques along with classification and clustering techniques, draw conclusions and unearth important patterns from raw data [25].

Orange provides tools for data visualization and analysis packages with a limited number of algorithms and tools, when compared to RapidMiner, Weka, or KNIME. However, Orange has an easier interface and is suitable for use by less experienced researchers [17].

KNIME is a data cleaning and analysis tool like RapidMiner, which incorporates all of WEKA's algorithms with additional specialized algorithms in areas such as sentiment analysis and social networks analysis [24]. Additionally, KNIME has a possibility to integrate data from multiple sources (i.e. a .csv of student data from educational management systems, a word document of homework responses, and a database of student demographics and learning logs) within the same analysis.

R is a programming language for statistical computing, data analytics and scientific research. Graphical, statistical,

time series analysis, classification and clustering by R Programming is used in EDM/LA to improve student performance and building analytics to guide students and support decision-making in learning [26][27].

3.3. General-purpose tools for informative visualizations

Data visualization represents the process of transforming data and information to different types of visual representation such as maps and graphs. Importance of using visualization in EDM/LA is that the human mind can easily interpret data from visual forms and detect insights like trends and patterns of students' behavior or performances [17].

JavaScript library *D3.js* enables building complex, interactive data visualizations for modern web applications. It enables a wide range of different charts and maps where interactive tools have the ability to be manipulated in real-time. Maps and diagrams can be used for different purposes in EDM/LA in order to obtain conclusions about trends in learning, success rate, etc. Tools that offer broadly similar functionality to D3.js but have been less frequently used by EDM and LA research are: *Chart.js*, *jpGraph*, *Raw*, *Google Visualization API*, etc.

Similarly, there are different interactive tools that provide data visualization and business intelligence tools: Tableau, Power BI, Sisense, etc. The goal of *Tableau* is to turn raw data into meaningful insight with a storyline with data visuals. The biggest benefit for Tableau is that it does not require any sort of coding for creating a model and is easily learnt. However, the problem with Tableau is high price and challenging integration with external tools. *Power BI* is easy to learn and most preferred for beginners, but not suitable for use with very large data. *Sisense* supports analyzing big data efficiently and generates particular models. In EDM/LA Sisense features like natural language processing (NLP) feature can be used to identify patterns in verbal information.

3.4. Specialized EDM and LA Applications

General-purpose tools for EDM/LA can be used in different scenarios in online learning, but sometimes accomplishing EDM/LA goals mean that researchers only work with specific data in order to solve specific educational problems. For example, *Datashop* provides an open repository to secure and store learning data and different analysis and reporting tools that can be applied to those data [28]. *Graphical Interactive Student Monitoring and Tracking Tool* (GISMO) is a monitoring tool in Moodle log data that produces graphical visualization used by educators in order to examine social, cognitive and students' behavior [29][30]. *Social Networks Adapting Pedagogical Practice* (SNAPP) uses a social network diagram to analyze the interactions of participants in forums. The aim of SNAPP is to help the instructors to rapidly identify patterns of user behavior [31]. *PDinamet* is a collaborative web-based adaptive learning system that uses clustering and student modelling to monitor interactions and makes suggestions about which learning activity is more suitable at the moment [32]. *Solutionpath StREAM* represents a system that works in real-time and supports decision-making and predictive models in order to determine aspects of student engagement and enable higher education institutions to identify risks and opportunities [33]. *Software asset management* (SAM) is a students' activities monitoring system for personalized learning environments. Based on monitored activities, SAM has the possibility to make a learning recommendation for students [34]. *Meerkat-ED* uses social network analysis techniques and provides a toolbox for analyzing interactions of students in asynchronous communications in forums of online courses [35].

There are also specialized tools used for the visualization of specific EDM/LA results. The *EDAIME* tool is optimized for processing educational data that enables visual analysis of different data with temporal characteristics. The tool is used in the analysis of student retention and drop-out [36]. *Outlier Detection and Explanation with EDAIME (ODEXEDAIME)* as an extension of EDAIME, provides automatically finding and visualizing anomalies [37].

CONCLUSION

Implementation and need requirements for EDM/LA methods and tools in educational settings are rapidly changing. This represents a challenge and introduces a wide range of research issues for educational data in online learning. The main objective of this paper was to provide a view of useful EDM/LA methods and tools for educational setting, and mainly in the setting for online learning systems. This work described general-purpose and more specific tools for EDM and LA that address different problems in online learning. Each described tool uses different approaches to different problems, with their own particular strengths and weaknesses. According to this paper, we can conclude that no one tool is ideally suited to conducting the entire process of analyzing most data sets from start to finish in online learning. However, the combination of these tools can be a useful discovery and the best way to perform complex analyses. Therefore, future work will analyze a larger number of papers with greater emphasis on practical usage to support the entire process in online learning.

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INTERNET OF THINGS (IOT) AS AN ACCELERATOR OF KNOWLEDGE AND COMPETENCE IN THE DOMAIN OF E-LEARNING

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Abstract: *New technologies, such as the Internet of Things, are rapidly being developed in today's digital environment, transforming the traditional education system into a flexible and efficient e-learning, which is characterized by quick adaptability to change and the dynamic application of the IOT model, facilitating an advanced collaboration between students and teachers. Thanks to the abundant amount of data gathered from IOT functions, it's possible to predict the educational needs of students in the teaching environment, which will significantly enhance the development of intelligent learning. Learning based on the IOT model integrates smart technology, presentative media in the digital context, computer science, and communication technologies with a high outcome and induced learning productivity, made possible through diligent standardization and meticulous observation, analysis and safety projections. The aim of this paper is to aid students in the development of skills, adaption and use of technologies in the context of learning. In addition, the interconnection, heterogeneity and speed of access to information which IOT provides, facilitates understanding for the needs of modern business, and provides students with a multidimensional acquisition of knowledge and future competenciesdocument presents a template for preparing the papers that will be included in the Proceedings for eLearning 2021 conference. We strongly recommend that your papers be in the form of this template. The maximum number of words allowed for this abstract is 150 words.*

Keywords: *E-Learning, Internet of things (IOT), higher education*

1. INTRODUCTION

The Internet of Things (IoT) is a new paradigm that, thanks to advances in technology, allows entities to efficiently connect to the Internet, providing access to vast amounts of data at any time, anywhere.

The number of devices connected to the network today is measured in billions and this trend of growth and increasing use continues.

In recent years, especially with the advent of the innovative 5G network, the use of IoT has increased rapidly. This is especially noticeable in projects such as smart homes, smart cities, also in the contribution to eEducation, eHealth, distributed intelligence, etc.[1]. The challenges that accompany IoT are finding adequate solutions in the field of privacy and security. Industry 4.0 sees the true value of IoT, which is reflected in the connection of devices, sensors, actuators, and their ability to communicate with each other and integrate with business systems [2].

The emergence of new technologies such as Big data, Dataware, IoT (Internet of Things), Cloud computing further affects the acquisition of benefits in the field of e-learning and education in general. Their application leads to major changes in both business and eLearning platforms.

Electronic learning or eLearning is the use of ICT in the learning process, to enable students to more easily access resources, learn from a remote place, and with flexible use of time. E Learning involves the use of electronic devices, such as smartphones, tablets, computers, that are available today for learning content. This makes the learning process more efficient for both students and teachers.

ELearning uses virtual classrooms, video lectures, online tutorials and study materials. The current education system is changing substantialy and constantly, and this trend will continue in the future.

Technology is rapidly being used as a tool to provide new and better ways to engage all actors in the educational cycle. Today, the future of smart education will be greatly influenced by mobile learning, digital books, student personalization, virtual reality, location-based services, and sensor technologies.

2. INTERNET OF THINGS

According to the authors [3], there is no single definition for IoT that is acceptable to the global user community. The term is defined by academics, researchers, innovators, programmers, business people, although its initial use is attributed to Kevin Ashton, a digital innovation expert. A comprehensive definition of IoT would be:
"An open and comprehensive network of intelligent facilities that have the capacity to automatically organize, share information, data and resources, react and act, and face situations and changes in the environment."

IoT Architecture

In the IoT architecture, three standard layers have been developed and each of them is defined by its functions and devices: [4]

Perception layer

The layer of perception represents the physical layer of architecture. Its purpose is to collect data and information from the environment with the help of sensors and actuators, and then transport them to the network layer.

Network layer

The IoT network layer serves the function of routing and transferring data with other smart objects, cloud computing platforms, servers, and network devices over the Internet.

Application layer

The application layer defines all applications in which IoT is deployed. It is the interface between the final IoT devices and the network. IoT applications include smart homes, smart health, smart cities, etc. The application layer is the layer in which the user interacts and where, in addition to creating a smart environment through guaranteed authenticity, integrity, and confidentiality of data, he gets the information he needs. Figure 1 shows the basic three-layer IoT architecture.

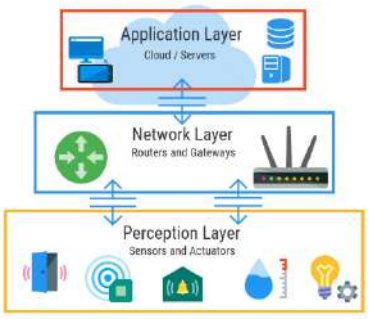

Image1 Basic architecture of IoT

Therefore, we can draw a parallel between the standard architecture and the main components of IoT, and these are:

- Devices or objects (things)
- Wired/wireless networks and the Internet
- Data and knowledge warehouses

Things are the basic units of the IoT ecosystem - they establish a connection between the physical world of the entity and the digital world of the Internet. In order for a thing to function as part of such an ecosystem, it must have the ability to track, detect, activate, calculate, and process. All of these abilities define it as an autonomous, proactive unit that can share knowledge and information with others for decision-making, making plans, achieving one's personal or shared goal. All these functions are classified and structured in the local Sensing layer used to acquire knowledge from the environment, the Data Integration layer used to share that knowledge in the ecosystem, the Analytics of Things layer which processes the acquired knowledge, and the Congress Actions layer which based on all collected knowledge can think about further actions, plans, goals. [5]

According to the authors [6], the three components on which IoT rests are:

- hardware - consists of sensors, actuators, and built-in communication hardware
- proxy software - for storage and computer tools for data analysis and
- presentation - new visualization and interpretation tools that are easy to understand and can be widely accessed on different platforms and that can be designed for different applications.

Some of the standard technologies available that enable the operation of these components are:

Radio Frequency Identification (RFID)

RFID technology enables wireless data communication. It is also used for automatic identification, identification and recording of data by radio waves, tag(s) and readers.

Wireless Sensor Networks (WSN)

A wireless sensor network is a network of sensor devices connected together. They consist of spatialy distributed autonomous devices equipped with sensors that can collect, process, analyze and disseminate valuable information collected in different environments. They can work with RFID systems to better monitor the status of objects such as their location, temperature, and movement.

Data storage and analytic

One of the most important outcomes of IoT functioning is in creating a large amount of data. Storage and data ownership alone are becoming critical issues. Data must be stored and used intelligently for smart tracking and activation. It is important to develop artificial intelligence algorithms that could be centralized or distributed as

needed. Machine learning methods based on evolutionary algorithms, genetic algorithms, neural networks and other artificial intelligence techniques are necessary to achieve automated decision making. They also have a modular architecture, both in terms of hardware system design and software development, and are usually very suitable for IoT applications.

3. E LEARNING IN FOCUS OF IOT

E-learning can be defined as a social and specific information approach that integrates heterogeneous technologies and pedagogical methods that do not limit distance education. [7]. E-learning, using ICT and the Internet, makes the learning process more efficient for both students and teachers. The interactivity enabled by e-learning makes the effect of acquiring knowledge more pronounced, allowing students flexibility in the educational process.

Introducing IoT into E-learning can really help transform education. IoT provides a large number of research opportunities for lecturers, students, and researchers around the world. Based on student assessment, IoT can encourage them to become more freely involved in the learning process by linking real objects to their responsibilities, homework, and research. [8]

The basic IoT model consists of 4 layers and is shown in Image2. The first layer contains physical devices, sensors, actuators, things, and controllers that can control multiple devices. The next layer is communication and connection. The most important function is reliable and timely transfer of information. This includes transmission between devices and networks, over networks, and between networks.

In the data layer, data is collected and disposed of. Finally, in the layer that represents educational applications, the data can be used in real time. Applications access data as needed; converts event-based data to query-based processing. Learning data abstraction requires multiple storage systems to accommodate IoT device data.

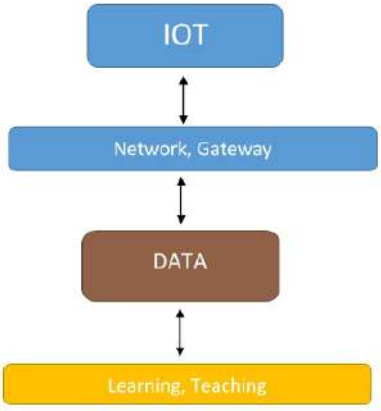

Image 2: IoT model for smart education

4. IOT ARCHITECTURE TO E LEARNING

An overview of the IoT architecture related to smart education and e-learning is given in Image 3. The authors explained in detail the application methodology, which also follows a layered approach. [9].

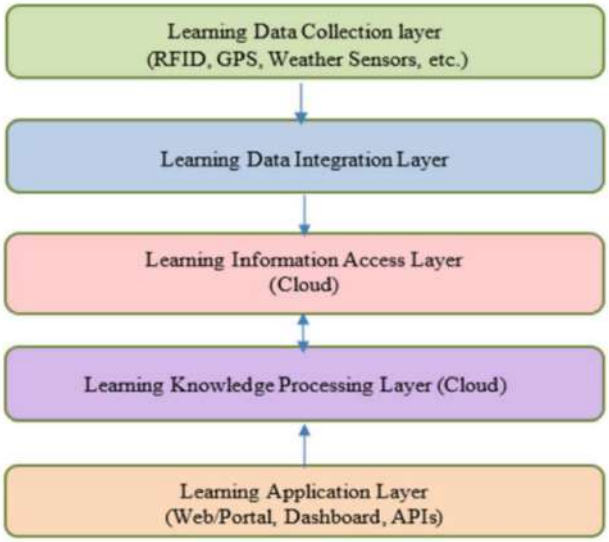

Image3: IoT Architecture to Smart Education

The Data Acquisition Layer uses a large number of different devices and communication technologies, such as sensors and actuators, to detect and control relevant aspects of the physical world. These sensors can be connected to sensor platforms that work on more powerful devices e.g., mobile phones, gateways, or dedicated servers.

The Data Integration Layer for Learning also integrates access to data and services that may still be in an unstructured form. The data is delivered by the previous layer, and also allows the management of devices in the data collection layer for learning and configuration and control of connection and communication.

The Learning Information Access Layer provides access to information at a higher, common level of abstraction which may be requested by Applications and components of the learning knowledge processing layer. This layer integrates information from different sources into the learning data integration layer.

The Learning Knowledge Processing Layer processes information and data, primarily information provided by the Learning Information Access Layer, in order to arrive at a higher level of knowledge, implicitly contained in the information. Smart applications can be supported by recommendations based on information while considering the objectives of the application.

The Learning Application Layer is the place for end-user applications. Applications primarily access the Learning Knowledge Processing Layer and the components of the Learning Information Access Layer to have a good basis for optimal support to users in their respective tasks. Applications interact directly with users to learn about their goals, which are then the basis for interacting with the Learning Information Access Layer and the Learning Knowledge Processing Layer to retrieve the necessary information and knowledge.

5. IOT TECHNOLOGY BENEFITS ON E LEARNING

The benefits of applying new technologies in the educational process are obvious. IoT, Cloud computing, Blockchain, Data Science, Big Data, Data Warehouse, AI, and machine learning [10] can in many ways empower the leaders of educational institutions as well as lecturers and students to apply with adequate flexible solutions what is already in function in other branches such as medical technology, retail, logistics and supply chain management, transport, insurance, energy, information security, home automation, environment monitoring, manufacturing, agriculture, education, telecommunications [11] and everything with the prefix e- (e-governments, e-health, e-community, etc.).

IoT provides services with less hardware needs and connects resources at minimal cost. Thus, educational institutions can focus on their basic role, which is teaching, instead of concentrating on seeking and purchasing a cost-effective module for the e-learning system. [12]. Some of the benefits for students with the use of IoT technologies:

- IoT provides students with better conditions to connect with their university and teacher 24/7, even if they travel from one place to another.
- The student can take exams online via any internet connection via Wi-Fi, via 2G, 3G, 4G and 5G based on GSM.
- IoT offers connectivity to anyone, anytime, anywhere, while the development and accessibility of e-learning applications requires adequate web development.
- Students can work from anywhere, from the library, home, office, campus, workplace.
- A student using IoT has access to their files and data on a laptop, mobile and desktop computer.
- The use of IoT and data recovery techniques in cloud storage is almost unnecessary.

According to the authors [13], the relationships between some educational components and IoT can be observed, and the values provided can also be discussed.

Remote access to LAB

The structure of the IoT allows the user to remotely connect instruments and equipment where he can do experiments, collect, and receive data for further analysis or homework. Students or teachers can also conduct designed experiments with virtual access to virtual laboratories remotely

Real time access to global library

An online global connection with libraries around the world can provide global research for students, researchers, or teachers. Using smart technology such as IoT makes it possible to make a huge number of links and connections between book collections and public libraries around the world.

Online Self Learning

A student can gain access to a large number of educational resources anywhere, anytime, doing homework, collecting materials, sending, and receiving homework to teachers. IoT allows you to connect anything to anything, anywhere and anytime.

Smart Collaboration

The online environment provided by IoT, as well as the efficient connection and communication between facilities, enables the creation of an interactive platform at different levels of educational ecosystems. Effective communication is necessary in the context of a collaborative environment for educational infrastructures. In a smart collaborative environment, developed via the Internet, online users are more intelligent, collaborative, and present in the learning process. They can devise a better schedule of their activities in a smart collaborative environment. Smart collaboration systems can also encourage more efficient teamwork planning.

IoT can have exceptional application in university campuses and in educational infrastructure and institutions in general. Connected devices can help schools simplify day-to-day operations, such as class attendance, fee alerts, and student reports, which can be easily automated. Energy costs can also be reduced. From the aspect of safety of schools and faculties, in addition to IoT, care can be taken to activate the system that initiates emergency calls to appropriate services, hospitals in order to speed up the response in emergencies. Surveillance will become extremely easy with IoT.

Special needs students can also benefit from IoT. Specialized software can help students with certain problems. For example, it can recognize students with impaired vision or hearing impairment and make changes accordingly, such as increasing font size or multiple visual cues. [14].

5. CONCLUSION

In the very near future, IoT can be a very important segment of the application of technologies that would improve the smart learning system and significantly influence the development of new platforms of the educational cycle itself. A learning system that, despite the current challenges that IOT brings with it, primarily related to ensuring a stable privacy and security policy, can influence the creation of alternative effective methodologies in e-education.

It can be noticed that many models have been presented in the literature, but there is still work to be done on the IoT architecture in e-learning systems, which adequately includes people, processes, services, data, and infrastructure.

Technologies are becoming more common in the recent education sector. Modern technologies use today's education with improved teaching and learning using smart devices. This technology is changing the educational platform to offer advanced real-time search, sharing, collaboration, communication, and enhanced classroom experiences. The solution to smart education includes smart teaching, smart learning, a smart educator, smart analytics, smart monitoring, smart reporting, and a smart learning environment.

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ANALYSIS OF THE CURRENT SITUATION AND PROPOSAL FOR THE RESEARCH CONCEPT ON THE TOPIC OF INTELLIGENT TUTORING SYSTEMS

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Abstract: *Advances in the development of intelligent tutoring systems enable the application of new technologies, learning concepts and functionalities available to the student and the author of the teaching material. Within this paper, an analysis of papers on the topic of intelligent tutoring systems in the last five years was performed with a focus on the technologies used for system development, software architecture components and new functionalities available to system users. It is necessary to determine what the basic components of the software architecture of such a system are and what their role is, as well as whether it is possible to develop new components and improve existing functionalities. In addition to the mentioned analysis, a special chapter of the paper includes the analysis of the applied research concept in the mentioned works, the obtained results (based on the applied research concept) and the proposed research concept for future works on intelligent tutoring systems.*

Keywords: *intelligent tutoring systems, adaptive learning, e-learning, research concepts*

1. INTRODUCTION

The intelligent tutoring system (ITS) consists of two parts: a reasoning mechanism and a knowledge base. The reasoning mechanism works analogously to human reasoning using the facts presented to it in order to derive logical results. In order to display the results, it is necessary to use defined rules (which consist of different conditions and actions). Conditions are used to initiate a particular action within a system. These systems are computerized learning environments that use computational models, learning methods, artificial intelligence and different student states (motivation, year of study, etc.) to provide the student with an adaptive learning process. The system must also monitor the psychological state of the student (skills shown, learning strategy, level of motivation, emotions) in order to know at any times in what state the student is. Enabled interaction between the student and the system is constrained by the student characteristics, curriculum and learning materials used by the student.

The research questions that need to be answered through this paper are:

1. What are the specifics of intelligent tutoring systems in the last five years (components of software architecture, used technologies and methodologies)?
2. What are the most commonly used research concepts in papers on the topic of intelligent tutoring systems?
3. What are the proposed research concepts for future research in the field of intelligent tutoring systems?

The second chapter in this paper presents an overview of the literature on intelligent tutoring systems in the last 5 years with a focus on the components of the software architecture, the improvement of existing functionalities and the used methodology. The third chapter includes an analysis of the used research concept within the selected papers based on the theoretical basis of the research concept in the field of software engineering. The obtained results represent the basis for future research on the topic of intelligent tutoring systems. The fourth chapter includes a conclusion, limitations and a proposal for future research on this topic.

2. ANALYSIS OF RESEARCH OF INTELLIGENT TUTORING SYSTEMS

Within this chapter, an analysis of papers on the topic of intelligent tutoring systems in the last five years is presented. The analysis includes the technologies used for system development, the components of the software

architecture, the way of collecting information about the student and the way of obtaining feedback from the student, as well as the used system specifics and functionalities that can improve student success.

Components of the intelligent tutoring system software architecture

The software architecture of intelligent tutoring systems is specific and it is very rare to find two systems with the same components. As such, intelligent tutoring systems are made to solve a specific problem and respond to the needs of a certain type of system user, i.e. student [1].

The components that are most often used within an ITS system are:

The domain module: defines chapters, lessons for students and contains information on the level and difficulty of a particular chapter. The system offers twenty-one lessons divided into segments that represent basic and advanced knowledge of CSS (Cascading Style Sheets).

The student module: contains student accounts with their profiles and information on: date of the last session, student ID number, name, current and total result, level of difficulty and number of problems while working with the system. Current result for each student is obtained by taking into account the weight of lesson chapters that the student is studying, and the obtained total score (the score for all levels of a lesson).

The tutor module: contains the functionality of the complete system. It regulates the difficulty levels for a specific student, records the transfer of students from one level to another and returns the student to the same level if he does not have a sufficient level of knowledge.

User interface module: there are two parts of the user interface for the student and for the teacher. When the teacher logs in to the system (s)he can add, delete, change lessons, add chapters, exercises, font size, color to better present certain important parts of the lesson to the student. When a student accesses the system, (s)he has the opportunity to review the questions, examples and messages defined by the teacher. The student receives a demonstrative example that is related to the theory with each sentence of the theory. The student can choose the exercise within which (s)he solves the task, and if the task is too difficult for his/her level of knowledge, he can choose to re-list the task within which (s)he will receive a different task to solve. By clicking on the button, the student can check the obtained solution of the task and if (s)he is satisfied to continue further learning [1]. Teaching materials, for the needs of ITS, need to be created in the form of a learning concept. Such approach to the creation of the teaching material allows the teacher to supplement or modify the existing concept at any time with additional materials that can help a particular student to understand and possibly apply what (s)he has learned.

The system should single out the concept of student learning and generate a feature vector for each concept that the student has made [2]. Data on student progress within the system can be obtained by monitoring student interaction with the basic functionalities of the system. By mining data on student activity in the system, it is possible to single out rules (which are presented as constraints) [3].

The domain module can configure the course (on areas, sections, topics and interdependencies). The student module serves the process of setting up an adaptive learning mode for a specific student while the tutor module is the control part as it controls the entire system and uses inputs from other modules. The user interface module uses the student and the teacher to perform the basic functionalities available to them in the system [4].

The content of teaching materials (within the learning process) can be organized so that the basic teaching material from which students learn is primary and additional questions, materials, external links are sent to the student. If (s)he wants, the student can open additional content and watch, and if (s)he does not need to, he can only read basic information [5]. Additional help and advice during the assignment help the student if they have an intermediate level of knowledge. Hints (small additions that serve as help) can also be of great help to the student, they can be classified into those that come in the process of designing the task and those that come with the solution of the task [6].

The tutor module (presented in some works as a pedagogical model) obtains data from the student model, connects them with the student's results in a certain part of the learning process, defines the student's level of knowledge and records the current result [7]. The student can have the following results [7]:

1. A student has less than 50% of the expected points

- ITS displays a message to the student: "You have not done the exercises well enough; I suggest you go back and re-study the teaching material and then try again."
- ITS, through the tutor module will close the task solving screen and return the student to the home screen of the learning process.

2. The student has more than 50% and less than 70% of the expected points

- The tutor module displays the message: "Your result is not good enough".
- The tutor module collects questions related to the same teaching material that the student has gone through and puts them back into the learning process so that the student can solve them again.

3. Student has more than 70%

- The tutor module displays the message: "Your result in this learning process is good and you

have passed to the next step." Next to the message, the achieved result is also displayed.
- The tutor module guides the student to the next level of difficulty and the next learning process that needs to be solved.

If he does not do the tasks the second time, the student can choose to go through the lower-level of teaching materials [8]. During the interaction with the system and the creation of the task, the student receives different types of help from the system, which leads him to work in different ways [9]. The domain model enables the division of the learning process into chapters (short lessons from one to twenty-five). The goal of this domain model in this particular system is for the student to understand and apply the knowledge acquired on a particular topic [10]. The use of intelligent tutoring systems has raised student performance well above the levels achieved by students who have traditional classroom lectures or use another form of computer-based learning [11].

Based on the analysis, *the most common components of tutoring systems* are: domain model, student model, tutor model and interface model [12]. The results of the analyzed literature in paper [12] show in how many analyzed systems a certain components is used (in percentage). The following components are used in:

Tutor model (81.82%) - The authors of the teaching material generally do not use programming tools or commands to create the learning process.

Domain model (75.75%) - This model allows the authors of the teaching material to define the necessary elements of the learning process and show what students need during learning.

Student model (18.18%) - Most intelligent tutoring systems rely on the use of artificial intelligence that automatically represents student models using different mechanisms (Bayesian networks, etc.).

Interface model (15.15%) - Mostly fixed interfaces are used for authors of teaching materials, while in some systems the author may have a personalized interface (possibility to adjust certain palettes and commands) that helps him when creating teaching materials.

The *types of intelligent tutoring systems* that are most commonly used are:

- Model Tracing/Cognitive Tutor 21.21%
- Example-Tracing 18.18%
- Content and problem-based 12.12%
- Dialog-based 9.09%
- Constraint-based and Machine and human-based 6.06%

Model Tracing / Cognitive Tutor - is an ITS that uses a cognitive domain model to check student responses. The model uses elements of cognitive psychology of problem solving and learning methods, and the tutor verifies the answers given by the student at any time.

Example-Tracing - means the type of ITS in which the assessment of student behavior in relation to generalized examples of behavior during problem solving. By applying generalized examples, the technical costs of tutor development are reduced, students are generalized through several defined examples of behavior and, accordingly, they receive teaching material.

Content and problem-based - students within this type of ITS interact with the content of teaching materials and answer questions, tests obtained by an intelligent tutor**.**

Dialog-based - use natural language processing mechanisms in order to obtain a natural teaching process.

Constraint-based - They use an evaluation model that relies on pedagogical models and solutions and allows the author of the teaching material less effort to develop a generic domain model.

Machine and human-based - allows the inclusion of the machine in combination with human intelligence during the learning process. The pedagogical components within ITS are mainly used.

The most used *functionalities* provided in the process of creating teaching material within an ITS are:

- Define/Give feedback 27.27%
- Define problem solutions 18.18% - allows authors of teaching material to create possible solutions to problems that will be presented to the student
- Authoring by demonstration feature 15.15% - the ability of the system for the author of the teaching material (using ITS) to show the steps of the solution and to define the basic principles of problem solving through appropriate generalized examples
- Automatic domain model generation and View learners 'statistics 12.12% - uses algorithms to automatically generate the constraints of a possible solution expected from the student.
- Make assignments and Define hints 9.09% - the authors of the teaching material, using this functionality, create and define hints to students about the content of the teaching topic they study within the learning process.

Intelligent tutoring systems have been developed using the following *technologies* [12]:

- Artificial intelligence and authoring tools (to solve different types of problems) 39.39%
- Design template, specific components and add-ons to expand existing systems 33.33%
- Distributed systems in order to reduce interoperability problems 9.09%

Intelligent tutoring system based on knowledge units

An intelligent tutoring system based on knowledge units does not have a clearly defined order of them during one learning process.

Problems generation module [13], enables solving a potential series of problems during the programming of the learning process. Dynamic problem generation can be done using specific templates that are precisely planned and meet the pedagogical goals set by the teacher.

The system using a tutor module, defines the domain structure and the complete learning process for a specific student [14]. The learning process requires the student to select the first unit of knowledge. When a student has selected the first unit of knowledge, the system creates a learning structure that contains the selected unit of knowledge and all units of knowledge of one level below the selected one.

Figure 1 shows possible combinations within the tutor model.

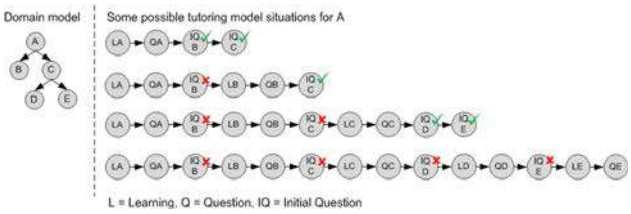

Figure 1: Possible situations within the tutor model [14]

On the left side of Figure 1, some of the possibilities of the domain model are shown, and on the right side of the picture, the possibilities and paths that the student can have. The student can go through the knowledge model by choosing the units of knowledge he wants to open. The right side of image 1 shows four randomly selected paths (of a large number of combinations) that a student can create or select during the learning process.

In the first example, the student chooses a unit of learning (LA) and then receives a question from the system (QA) which checks the level of knowledge about the unit of knowledge through which he passed. The next step (regardless of whether the student answered the QA correctly or not) implies that the system asks another initial question from the unit of knowledge of the level below the one in which the student is currently in the system (IQB or IQC level). In case the student answers both questions correctly, the learning process is completed and the student goes to the home page.

In case the student has previously reached the previously defined level of knowledge for the B and C level units then the situation ends after the LA-QA sequence. In that case, the system does not add to the student a unit of knowledge that he has already passed and has a level of knowledge higher than the stated level.

The fourth situation is shown in Figure 1 and represents the most complex learning process if the student answers all the initial questions incorrectly (B, C, D, E). The system must adjust the learning process to the level of student knowledge by omitting the final units and thus the learning processes will be the same for all students who answered incorrectly to the stated initial questions [14].

The reasons why students go through a particular learning process more often than through to others can be both positive and negative. Positive aspects are:

- Discovering common learning processes through the structure of domains;
- Discovering optimal pathways through the domain structure;
- Monitoring the structure of the domain based on the proposal of the tutor

Negative reasons are:

- error in structuring the learning process
- unanswered questions
- difficult questions
- system / algorithm / database errors

Learning processes that guide students in a circle with repetition of units of knowledge should be eliminated and the author of the teaching material should be informed that while learning processes that open new structures in the learning process go into depth, a certain topic should be positively assessed and possibly recommended to increase knowledge [14].

Initial questions after the first units of knowledge have little impact because they are used as a starting point in guiding the student through a particular topic. Grading is as follows, correct answers bring 0.2 points and incorrect answers subtract 0.1 from the current value of the student's results in the knowledge matrix. The results of the student in a certain learning process start from the evaluation of the learning process he went through (duration and length of the journey), the time spent in the learning process, etc. Student scores are stored every hour and are used from an ever-growing set of student interaction data with the system. The goal is to optimize the learning experience and shorten the time needed to learn a certain topic, and at the same time improve the results of students' tests or the overall grade on the course. The part of the system that deals with assessment works in real time from the selection of the unit of knowledge. If the student chooses the unit of knowledge of A level, the structure of the learning process can be B, E, C. Also, the algorithm first checks whether the student has already been assigned a unit of knowledge of a certain level, if not the student has been given access. If the student already has a grade in the specified topic of a certain level, the algorithm checks the grade and filters the units of knowledge that the student has already gone through. When this step is completed, the student gains

access to the learning process with clearly defined units of knowledge.

Classification of students in ITS

In addition to the classification, it is necessary to set rules that determine the movement through the learning process for those students who are satisfied with the presentation of the learning process for a high level of knowledge and for students who are satisfied with the presentation of the learning process for a low level of knowledge. It is important to identify "harmful behaviors" of students in the learning process so that they do not recur with the approach of other students. Rules can have a weight that depends on the importance it represents to a particular student in the system [15].

The intelligent tutoring system provides adaptive interventions through the user interface during the learning process and thus informs the student about a particular action. First, a text message is sent and then a hint with an arrow or a graphical display (adaptive interface) of what needs to be done within the learning process [16].

Evaluation can be performed on the student, system or way of learning and usability using the attributes: performance, efficiency, satisfaction, accuracy, reliability, adaptability [17].

The goal of student classification techniques is for the system to change what the student sees so that the content is adapted to the goals, abilities, needs, interests of the subject [19].

Unlike an intelligent tutoring system that is based on the performance of one student, a system in which the student works as a team to solve problems requires sending more information to different addresses. Students can receive information about the work of other team members at any time and be classified into different groups [20].

3. ANALYSIS OF THE RESEARCH CONCEPT OF INTELLIGENT TUTORING SYSTEMS

This chapter presents an analysis of the literature on the topic of intelligent tutoring systems. The problems covered in the paper, the research concept as well as the input parameters and research results are presented. The aim of this analysis of the available literature is:

1. Identifying the research concept for a specific problem to be solved

2. Defining the research concept for future work on the topic of intelligent tutoring systems.

3. Based on the analysis of papers Table 1 shows analyzed research papers and results of their analysis.

In table 1 it is possible to notice that researchers use literature review as a research concept when it is necessary to define the theoretical basis for the development of intelligent tutoring system (learning concept, learning styles, presentation of additional functionalities) or to improve existing functionalities by analyzing other works. The case study, as a research concept, is used when it is necessary to get feedback on the satisfaction of using the system from a student through a prototype or demonstration example (improving the learning process, improving the user interface, applying new concepts based on current impressions). Within one of the analyzed works, a research survey was applied with a prototype of the system used for learning within the team. The goal of applying a research survey is to gather information about student behavior within the system.

Table 1: Results of the conducted research

Applied research concept	Number of papers	The type of problem to be solved
Literature review	10	1. Adaptive teaching material for each student 2. Defining the components of the software architecture 3. Defining the concept of adaptive learning 4. Identify ways to reduce the time required to go through the learning process 5. Modifying student assistance options within ITS 1. 6. Defining learning styles in ITS
Case study	9	1. Improving feedback from the system to the student during the learning process 2. Analysis of basic functionalities through ITS prototype 3. Improving the user interface 4. Application of different learning concepts 5. Evaluation of the acquired knowledge of the student in the system 6. Collection and processing of a large amount of data for the student model 7. Integration of specific components with existing ITS components 8. Application of different templates for adaptive learning 9. Analysis of how the system is used by students
Research survey	1	1. Analysis of student behavior within ITS

Table 1 shows that ten papers on the topic of intelligent tutoring systems in the last five years use the literature review as the main research concept. nine papers use a case study supplemented by a case study or prototype of a system through which it is possible to identify the basic functionalities of the system and mainly a certain part of the user interface (student or author of teaching material). one paper uses a research survey as a basic research concept with a prototype system based on which students should give their opinion on the usability of functionality and user interface.
Based on the obtained results of the analysis of recommendations for research concepts that need to be applied in future research in the field of intelligent tutoring system is:

1. Literature review in the last five years
2. Case study

The recommendation for review of the literature in the last five years refers to the application of new technologies for the development of intelligent tutoring systems, software components used in these systems as well as the application of new methodologies. It often happens that technology and methodology progress at a high speed in relation to the possibility of implementation in such systems. By reviewing the literature, it is possible to gain insight into the standard components of such a system, the possibilities for improvement and the shortcomings that such a system has.

A case study, as a special research concept, can provide a case study or prototype of a system on the basis of which it is possible to obtain real feedback from users. Future research as a starting point should have the shortcomings of the systems observed in the research of works in the last five years.

4. CONCLUSION

The paper presents the basic components of software architecture and opportunities for improvement (additional components and functionalities). Also, the methodology applied for creating the learning process and improving the quality of teaching material is described. Possible observed limitations relate to the application of certain components of the software architecture (in the analyzed works) and a small number of deviations from them. The proposal for future research regarding the software architecture of the intelligent tutoring system refers to the development and improvement of software architecture components that will enable a simple user interface and processing of a large number of data obtained from different system components.

The results of the analysis of research concepts applied in selected papers showed that, within the research in the field of intelligent tutoring systems, the most commonly used method is literature review and case studies. The beginning of research in the field of software research requires an analysis of the available literature in the last five years in order to get acquainted with the currently used technology and methodology. The analysis also showed that it is necessary to develop a demonstration example or prototype of the future system that will have the basic functionalities of an intelligent tutoring system (and defined components of the software architecture) as well as the applied methodology and customizable user interface.

The observed limitations of the research may be the specificity of the topic being covered (intelligent tutoring system) and the impossibility of applying a research concept other than those listed. The proposal for future research refers to combining additional research concepts in the field of software engineering with the concepts found in the analyzed papers.

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META-FEATURES OF LEARNING MANAGEMENT SYSTEM DATA

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Abstract: *Educational institutions tend to use learning management systems (LMS) to enhance teaching and learning process. An LMS collects data about students' activities in log files. This data is used in prediction of student success. Machine learning algorithms are increasingly used to support development of accurate and reliable descriptive and predictive models from educational data. However, selection of machine learning algorithm is complex task and depends on characteristics of dataset used in the analysis. Characteristics of dataset (meta-features) can explain why one machine learning algorithm performs better on certain dataset than other algoriths. Meta-learning field deals with this issue. Identification of meta-feature in educational domain is still insufficiently researched area. In this paper, we are trying to fill that gap by providing meta-features identification in educational domain. Our focus are general meta-features and learning management system data. Research results indicated patterns in LMS datasets meta-features.*

Keywords: *meta-features; LMS data; machine learning; meta-learning.*

1. INTRODUCTION

Application of data mining in educational domain is an emerging interdisciplinary research field focused on development of algorithms for analysis of specific datasets from educational environment [1], including learning management system data (LMS). A wide range of algorithms have been developed and applied in educational settings. The challenge is how to select appropriate algorithm to be used in a specific situation, at a particular dataset. Due to No Free Lunch (NFL) theorem [2] there is no best algorithm for all situations [3]. Selection of the best algorithm for a specific dataset is of huge importance. Meta-learning has been used successfully to address this problem [4]. Meta-learning process consists of three phases, presented in Figure 1.

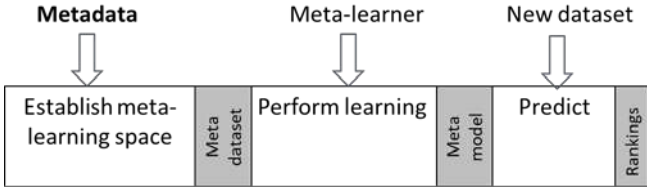

Image 1: Meta-learning process ([5])

The first phase of the meta-learning is to create a meta-learning space based on meta-data consisting of dataset characteristics called meta-features and a performance measure for data algorithms [5]. Meta dataset is created as a result of first phase. Meta-data consists of characterizations of dataset on one hand, and algorithms performance on previous datasets, on the other hand. Those characterizations are called meta-features which describe characteristics of the dataset. Description and definition of meta-features in not unique, and they vary across different domains. In this research paper, focus is on the first phase of the meta-learning in educational domain. To be more specific, this paper deals with learning management system data characteristics and identifies meta-features of learning management system data.

This paper is organized as follows. Section 2 gives brief overview of related work. Section 3 provides description of methodology and datasets used in the research. Section 4 gives research results along with discussion. In the conclusion, research limitations are provided along with directions for future research.

2. LITERATURE REVIEW

There have been various research papers focusing on studying and improvement of the meta-features. Different groups of meta-features have been used so far to characterize data sets. Vanschoren [6] examined 40 meta-features grouped into six categories: general, statistical, information-theoretic, complexity, model-based, and landmarkers. General measures are commonly known and easily extracted from data [7], [8], [9]. Those measures are: Number of instances, Number of attributes: (number of categorical attributes, number of binary attributes, number of numerical attribute), Number of classes, ratio of

categorical to numerical attributes, ratio of instances to attributes [10], [6]. General meta-features are in focus of this paper and their identification on educational LMS datasets.

3. DATA AND METHODOLOGY

Meta-learning process begins with the initial data collection and continues with activities aimed at getting to know the data, detecting the quality of the data, and gaining first insight into dataset distributions. At this phase, data from learning management systems are collected in educational domain. Five datasets of LMS Moodle extracted from various courses at the University of Zagreb, Faculty of Organization and Informatics were part of the analysis. Description of this datasets is provided in the table 1 by listing their main attributes.

Table 1: Description of datasets

Dataset acronym	Main attributes
Dataset 1	*Pass* *additional_grades* *blitz_1* *blitz_2* *blitz_3* *blitz_4* *exam_1_excel* *exam_2_accessdb* *retry_full_exam* *attend_lab* *attend_lectures* *self_check_1* *self_check_2* *self_check_3* *self_check_4* *self_check_5* *self_check_6* *self_check_7* *self_check_8* *self_check_9* *self_check_10* *self_check_11* *self_check_12* *access_map* *access_file* *access_forum* *access_student_report* *access_lesson* *pick_group* *upload_file* *access_links* *access_review_report* *access_page* *access_system* *access_exam* *access_homework*
Dataset 2	*File Forum Report Folder Choice Choice of group Submission Overview Page System Test Assignment Overall points*
Dataset 3	*File Forum Report File Choice Submission Overview Page System Test Assignment Overall points*
Dataset 4	*File Forum Report Choice File upload Link System Assignment Overal points Grade*
Dataset 5	*type of video material,* *the complexity of the content in the video,* *the number of spikes,* *the number of dips,* *the week of semester,*

	the type of study, *absolute duration of the videos,* *the week of COVID isolation,* *subject,* *the number of students on the course,* *total views,* *the number of views in different time segments,* *total watch time,* *average percentage viewed in different time segments,* *the number of students that didn't watch the videos,* *the number of downloads of files associated with videos in different time segments and others.*

Following meta-features were computed for those datasets. Selection of general meta-features was based on the paper from Jos and Marques [10]. General meta-features are relatively quick to compute, usually taking no more than a single iteration over a dataset to measure. The general meta-features give a general context of a dataset. Table 2 provides description of those meta-features.

Table 2: Description of general meta-features [10]

Meta-feature	Description
cat_to_num	Ratio between the number of categorical and numeric features.
freq_class	Relative frequency of each distinct class.
inst_to_attr	Ratio between the number of instances and attributes.
nr_attr	Number of attributes.
nr_bin	Number of binary attributes.
nr_cat	Number of categorical attributes.
nr_class	Number of distinct classes.
nr_inst	Number of instances (rows) in the dataset.
nr_num	Number of numeric features.

Whereas datasets 1-4 are classic LMS data with attributes regarding students' activities such as: accessing files, forums, their reports, lessons, links, choice of group or uploading file, dataset 5 represents interesting integration of LMS data and youtube analytics of videos embedded at LMS.

General meta-features are extracted for those five datasets. Meta-features from section2 are further divided into three sub-categories:

(i) Independent (number of attributes, number of categorical attributes, number of binary attributes, number of numerical attributes, number of classes),
(ii) Dependent (number of instances, class frequency),
(iii) ratios (ratio of categorical to numerical attributes, ratio of instances to attributes).

4. RESEARCH RESULTS

In this part we present research results. Our focus is on understanding of general meta-features for educational LMS data sets and providing explanation of those meta-features. Tables 3 to 7 give information about meta-features for five selected datasets from educational domain.

Table 3: General meta-features of dataset 1

Meta-feature	Values
cat_to_num	2/35
inst_to_attr	309/36
nr_attr	36
nr_bin	1
nr_cat	1
nr_class	2

nr_inst	309
nr_num	35

Table 4: General meta-features of dataset 2

Meta-feature	Values
cat_to_num	0/13
inst_to_attr	58/13
nr_attr	13
nr_bin	0
nr_cat	0
nr_class	0
nr_inst	58
nr_num	13

Table 5: General meta-features of dataset 3

Meta-feature	Values
cat_to_num	0/12
inst_to_attr	27/12
nr_attr	12
nr_bin	0
nr_cat	0
nr_class	0
nr_inst	27
nr_num	12

Table 6: General meta-features of dataset 4

Meta-feature	Values
cat_to_num	0/9
inst_to_attr	74/9
nr_attr	9
nr_bin	0
nr_cat	0
nr_class	0
nr_inst	74
nr_num	9

Table 7: General meta-features of dataset 5

Meta-feature	Values
cat_to_num	7/28
inst_to_attr	25/35
nr_attr	35
nr_bin	0
nr_cat	7
nr_class	2
nr_inst	25
nr_num	28

LMS data consists mostly of numerical attributes since students' activities are measured through their logs. Number of categorical attributes increases when LMS data are integrated with youtube data analytics and students grades at the courses. Number of instances vary depending on the different number of students at different courses. There is low number of binary attributes. It is to be noted that we can find some patterns in educational datasets general meta-features, while some meta-features values vary across different datasets. A larger number of data sets needs to be included in the analysis to provide in-depth conclusions and to be able generalize for LMS domain general meta-features.

5. CONCLUSION

Selection of appropriate algorithm in the meta-learning application is dependent on the quality of the meta-data. Meta-features need to be identified to explain meta-data focused on characterization of a specific domain. In this paper, we investigated educational domain and five experiments were demonstrated in order to understand characteristics of datasets in educational domain with the emphasize on learning management system data. This research used one group of meta-features, general meta-features to explain properties of learning management system data.

This research provided following scientific contributions: (i) identification of relevant general meta-features in previous research, (iii) identification of meta-features for educational datasets. Research has several limitations. First, only small number of meta-features was taken into account. Secondly, number of dataset included in empirical research is limited. Our future research will include broader number of educational datasets and broader number of meta-features, including statistical meta-features, information based meta-features, landmarkers and model based meta-features. Additionally, this meta-will serve as an input into meta-learning to develop meta-models and provide basis for recommendation of machine learning algorithms application in educational domain.

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E-LEARNING ORGANIZATION: A HYPOTHESIS FOR TEACHER TRAINING

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Abstract: *In the last two years, pandemic containment measures have demanded a strong transformation from education systems: the shift from the physical classroom to the virtual classroom. However, there has been no reflection on the discontinuity represented by this transformation: the research conducted in Italy on teachers' teaching practices in schools and universities (Fondazione Agnelli, 2021; Ricci, 2021) reveals how most have transferred the methods used in presence to a distance. This contribution aims to start a reflection on the perspectives opened by the concept of learning organisation applied to teacher training (Baldassarre, 2009). In learning organisations, people increase their ability to achieve results (Senge, 2004) and to adapt to change. An e-learning platform can facilitate shared organisational learning (through the use of chat, forum, evaluative feedback, individual and group products) and represent a lever to attack those mental models that have resisted even in emergency school.*

Keywords: *E-Learning, Teacher training, Learning organization*

1. INTRODUCTION[1]

In the last two years, the measures to contain the pandemic have required a major transformation in education systems: a shift from the physical classroom to the virtual classroom. The Internet has become the model for the school system: the school has extended into the network just like a body [1] and the educational relationship has continued to take place at a distance. The school has had real experience of 'liquid modernity', a dimension in which society is interpreted more and more as a network and less and less as a structure [2]. In analogy with society, learning environments are also becoming fluid, and the liquid learning environment can be seen as a metaphor for a future that is already present [3]. The crisis generated by the pandemic has tested the resilience of the educational relationship within virtual learning environments and the experience of the educational relationship at a distance has been experienced as negative: in fact, there is no evidence that being in the same physical space with teachers is positive for learners' learning. If the relationship between teachers and learners has not developed, one can suffer a lot of distance even in presence [4]. In a connected and interconnected world there is a need to reinvent education [5] by setting up new hybrid environments that can foster contextualised learning processes and merge formal, non-formal and informal dimensions [6]. The discontinuity represented by the crisis has not been the object of reflection: research conducted in Italy on the teaching practices of teachers in schools and universities reveals

[1] Despite the authors have shared the whole construction of the paper, Michele Baldassarre ha written the paragraphs 1. Introduction & 4. Conclusions; Valeria Tamborra has written the paragraphs 2. From learning organization to e-learning organization; Paola Lisimberti has written the paragraph 3. Teacher training in an e-learning organization.

how most have transferred the methods used in presence to a distance [7]. The transformation of education systems was the subject of research well before the pandemic: the emerging model of Industry 4.0 offers new opportunities for distance learning, which are, however, not exploited in developing countries and recent research developed in this direction shows that e-learning tools are more attractive to students [8]. Since March 2020, both educational institutions and universities have been called upon to reshape their educational offerings in the direction of ERT (*Emergency Remote Teaching*), considering the crisis generated by the pandemic as a temporary event [9], experimenting with *online learning* for synchronous or asynchronous training through Internet access devices [10]. Training courses delivered in this way require a circular continuity between teaching activities [11]: teaching in online learning environments requires careful design that encourages participatory processes to promote meaningful learning [12].

More than in other phases of recent history, it has become clear how resistant teachers are if they must adapt to change. However, it is necessary to grasp all the lessons of the emergency and imagine a school and university in which technology represents a normal dimension of teaching practice, a scenario that Rivoltella calls *onlife technology teaching* [13].

2. FROM LEARNING ORGANIZATION TO E-LEARNING ORGANIZATION

This contribution aims to initiate a reflection on the perspectives offered by the concept of *learning organization* applied to teacher education [14], since a substantial analogy can be detected between learning organizations and school organization. A learning organization is an organization that enables all its members to learn and that is continuously transformed [15]. Organizations can only learn through individuals learning [16] even though the learning of individuals does not guarantee that the organisation learns, but without the learning of individuals the organisation cannot learn, therefore it cannot develop, it cannot grow. That is why in addressing education in the post-Covid digital age, teacher training is central. If we apply this concept to school organisation, we cannot but consider teacher training as the only way to develop adaptability and respond to educational challenges which, due to the pandemic, are even more urgent.

A learning organization is a place where people discover how to create their reality and how to change it, and is characterised by the way individuals perceive themselves and the world. If human behaviour were an innovation, the components would therefore not be technologies but disciplines (in the sense that the term has in the Latin language, i.e. 'learning'). One of these, systemic thinking, can be considered the fifth discipline, without which we would not be able to grasp the interrelationships between disciplines [17].

Applying the concept of learning organization to teacher training and declining it in a contemporary key means putting at the base the dimension of enquiry, that is, of self-reflective research aimed at removing those blocks that prevent one from seeing and subsequently evaluating the level of discontinuity with respect to a problematic situation [18]. Recognising discontinuity is at the heart of the learning process developed during the crisis: this is what teachers should have done in the lockdown phase. Acknowledging the discontinuity would have started the self-reflective practice and set in motion a learning process on which methodologies - not on which technologies - the teaching practice should be based. On the contrary, as research shows, teachers reproduced the model of the transmissive lesson even at a distance. If schools were to move as an onlife learning organisation, i.e. as an e-learning organization, education could reap many benefits.

Before the pandemic, new innovative teaching models had emerged with respect to school organization: models that were (and are) transforming [19] education into a collaborative experience, in which empathy must win out [20]. An e-learning platform can facilitate shared organizational learning (through the use of chats, forums, evaluative feedback, individual and group products) and represent a lever to attack those mental models (e.g. the lesson-individual study-evaluation cycle) that have resisted even in the emergency school: the transition from a transmissive to a constructivist approach could be favoured by a problematizing approach typical of learning organizations [21]. There have been several significant experiences of online learning using e-learning platforms in schools - also in primary schools [22] - and in academics [23]. For academic e-learning the focus is shifted to the quality of the learning experience, which goes beyond the concept of performance and outcomes to focus on the process of constructing the experience [24]. Significant criticalities have been recorded regarding the skills of teachers, who are required to have a solid preparation in didactic design, as well as good experience in the use of methodologies, knowledge of learning models and processes, mastery of digital tools, use of models for lesson management [25].

3. TEACHER TRAINING IN AN E-LEARNING ORGANIZATION

What are the competences required of the 21st century post-pandemic teacher? How to overcome the critical issues that have emerged?

The opportunity must be taken to overcome the logic of a return to the past, of a school that is school if in presence, and this is possible through the implementation of modern training models, centred on teachers' online learning. It is the right time to practice a turnaround, to ask ourselves

what kind of normality we want to return to [26], but, whatever the direction, we need to equip teachers with secure digital skills [27]. Online learning has accustomed teachers and learners to a ubiquitous approach to learning resources; to using different devices; to exchanging digital resources, which can be stored and edited; to interacting in real-time chats; to experiencing assessment as continuous feedback of a process and not exclusively as judgement of a finished product. In online teaching/learning there is no single pedagogical model but a plurality of models that the teacher can examine in the design phase.

Among the dimensions of e-learning (didactic-pedagogical, informal, technological, content-related, socio-cultural, professional, organisational-managerial, economic), priority should be given to the pedagogical-didactic dimension, the only one that can guarantee the sustainability of teaching practices and that can guide teacher training [28].

Teachers will be able to teach learning with technologies if they make - before the learners - a learning experience, for example through participation in the web forum, one of the most long-lived features of e-learning activities: in this dimension, teachers will be able to understand the sense of an independent time dimension, the sense of mutual commitment, common goals and shared repertoires, which are the essential aspects of this artefact [29]. By experiencing and practising participation in the web forum, the teacher understands in which training contexts to design the use of this artefact, since the added value of the web forum depends mainly on the concrete teaching practices within which the tool is used [30]. The design of a virtual dialogue space is the central element for the creation of learning communities in e-learning courses [31].

The potential of online education, according to the founder of the Khan Academy, revolves around personalised learning using computers, an inclusive tool that would eliminate inequalities in the world. In fact, not only can this model revolutionise schooling in industrialised countries, but it can also be instrumental in improving education in developing countries. One of the central nodes of the potential of online education can be explained by the concept of 'pedagogy of mastery'. Its meaning, applied to learning, is clear: a student does not move on to a more advanced concept if he or she has not understood the previous one. Technologies allow the pedagogy of mastery to take shape: in a virtual learning environment, released from school space-time, standardised, and rigidly organised, the learner can really learn in his own time and methods [32].

The use of an online learning platform such as Moodle, for example, fosters this 'educational revolution': not only are and will be pedagogical approaches and learning resources important in the future, but interaction with technologies is important to achieve a meaningful teaching-learning cycle [33].

4. CONCLUSIONS

Interpreting the school organization as a learning organization can facilitate the identification of training practices that can enable teachers to acquire the pedagogical and methodological skills needed to face the challenges of the 21st century. Rethinking training and experimenting with e-learning in teacher training courses means supporting the reflective practice that should accompany teachers in their profession. Planning, designing, incorporating the use of technology in appropriate contexts: these are the critical issues that have emerged during the crisis, but they are also the levers from which we can start to relaunch education in all countries.

In Italy, teacher training is entrusted to the 'Formare al futuro' programme, aimed at all school staff in service, on integrated digital teaching and the digital transformation of school organisation. The aim is to continue the innovation outlined by Law 107 (2015) and the National Digital School Plan through territorial training poles (Future Labs) that constitute a territorial network dedicated to training. The programme was launched in July 2020 and will continue until 2022: fifty thousand teachers have already been trained and in the period July-September 2020 all the training courses were delivered online, a method that continues to be practised. In this way, teachers will be able to live and learn within an e-learning organization, in order to bring about the cultural change necessary for the organization to achieve growth and development, going beyond individual know-how in favour of shared knowledge [34].

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TEACHER TRAINING AND NEW E-LEARNING PEDAGOGIES

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Abstract: *The digital transformation had already affected education systems before the crisis generated by the pandemic, but recent experience has accelerated the process of change in education systems: platforms, virtual classrooms and digital archives call for a methodological transformation, not just a technological one. International surveys (OECD, 2018) show how only 39 % of educators in the EU felt prepared to use digital technologies in the profession and as a result of the recent crisis, digital competence has become a priority. This contribution intends to analyse what the training needs of teachers are by comparing the Framework for the Digital Competence of Educators (DigCompEdu, 2017) with the priorities expressed in the Digital Education Action Plan 2021-2027. The analysis will be followed by the formulation of hypotheses for e-learning training paths aimed at enhancing digital professional collaboration; the selection, creation and modification of online resources and the experimentation of new e-learning pedagogies.*

Keywords: *E-learning, Teacher training, DigCompEdu, Digital Competence*

1. INTRODUCTION[1]

In this paper the aim is to reflect on the training needs of teachers starting from the urgency of developing digital competence. The spread of digital technologies in every sphere of life, also referred to as the fourth industrial revolution [1], calls for the digitization of the educational process as a political and social priority at national and European level.

Although in Italy the interest in the introduction of technologies at school has been present since 1980s with numerous computer literacy and teacher training programmes and projects, there has been a patchy diffusion of technologies in school curricula and a disconnect between the use of technologies at school and in formal and non-formal contexts [2]. In this sense, the history of technologies has always led to thinking about new models of learning, new visions of teaching practises. Indeed, the use of technologies provides innovative and challenging learning environments, facilitating personalized learning and increasing students' motivation [3, 4].

However, "it is not so much the inundation of technology that produces didactic innovation but rather a profound restructuring of school times, spaces and practices" [5], so a mutual reciprocity is necessary between technological functionalities and pedagogical approaches. Reciprocity witnessed by the introduction of terms such as "e-

[1] Despite the authors have shared the whole construction of the paper, Michele Baldassarre ha written the paragraphs 1. Introduction & 5. Conclusions; Martina Dicorato has written the paragraphs 2. Teachers' training: a historical perspective & 3. Teachers' training needs: the digital competence; Ilaria Fiore has written the paragraph 4. From distance education to digital school.

pedagogy" [6] and "pedagogy 2.0" [7] that refer to a new way of doing school, to a "teaching 2.0" [5].

Hence, the need to work primarily in the field of teacher training. Specifically, it is about implementing a complex training process that goes in the direction of both the development of digital competence and the concretization of digital skills in teaching practices [8].

2. TEACHERS' TRAINING: A HISTORICAL PERSPECTIVE

The role of technology in the Italian school has evolved over time. Since 1980's there have been many programs and projects aimed at promoting an enrichment of teaching practices in the direction of digital and teacher training. Specifically, at the beginning of the new millennium, ForTic (2002-2003), the "National plan for teacher training on information and communication technologies" was launched [9]. About 180000 teachers were involved in a path to acquire technical and pedagogical knowledge with respect to an effective use of technologies at school [10]. Subsequently, in 2007, the National Digital School Plan (PNSD) was introduced ant it was based on three main initiatives [11]:

- The interactive whiteboard action (IWB), through funding for the purchase of multimedia interactive whiteboards and associated teacher training;
- The "Cl@ssi 2.0" action, which involves setting up classrooms where digital tools will be used on a constant and widespread basis;
- The School Digital Publishing action, which promotes the transfer of teaching resources from paper to digital format.

Finally, with the latest PNSD [12] 35 actions are established in the direction of innovation and digitalization of Italian schools, paying more attention to the active role of teachers in training. This plan stems from the need to develop and improve the digital skills of teachers and students. In particular, the National Digital School Plan intervenes in three areas:

- tools: Internet access, digital learning environments and BYOD guidelines, electronic register and administrative digitalization;
- skills and content: computational thinking, promoting open educational resources (OER), careers in STEAM;
- training and support: initial and in-service training for didactic and organisational innovation, introduction of the figure of the digital animator in each school and creation of an Observatory for the Digital School.

These actions are part of the larger European scenario and in line with the Recommendation of the European Parliament and of the Council of 18 December 2006 on key competences for lifelong learning (2006/962/EC) aim at the development of digital competence by teachers and students, also defined as "knowing how to use digital technologies in a creative way to create new knowledge, innovate processes and products" [13].

3. TEACHERS' TRAINING NEEDS: THE DIGITAL COMPETENCE

In the school of the 21st century, the development of digital competence is a priority in order to be able to exercise an active and aware citizenship [14]. The concept of digital competence is a multidimensional construct that refers to "the conscious, critical and responsible use of digital technologies for learning, work and participation in society, as well as interaction with them" [15]. Furthermore, it consists of several aspects, including information and data literacy, communication and collaboration, media literacy, digital content creation (including programming), security (which includes digital well-being and cybersecurity skills), intellectual property issues, problem solving and critical thinking [16].

In this sense, the Joint Research Centre (JRC) of the European Commission has developed three different frameworks to support schools in the digitization process:

- DigComp 2.1: framework for citizens' digital competencies [17].
- DigCompOrg: framework for digitally competent educational organizations [18].
- DigCompEdu: a framework for the digital competencies of teachers and trainers [19].

Specifically, the Digital Competence Framework for Educators brings together the skills and competences needed in current school contexts. It consists of 22 competencies divided into six areas: professional engagement and enhancement, digital resources, teaching and learning practices, assessment of learning, enhancing students' potential, and promoting students' digital competence [19]. Teachers are required to know how to design and use digital technologies in the different phases of the teaching-learning process, identifying the resources that best suit the educational objectives and characteristics of the students. More generally, teacher's training in the field of digital literacy includes the three components technological, cognitive, and ethical. The first concerns the ability to select the most appropriate digital resource for the task. The second "includes programming skills (e.g., in 3D printing), the development of computational thinking, the design of applications within the Internet of Things, robotics and the analysis of large volumes of data" [20]. The third includes knowledge of and compliance with data security and protection regulations.

At the European level, two plans for digital education have been developed: 2018-2020 and 2021-2027 [21, 22]. The strategic priorities of the new action plan are twofold and

concern the promotion of an efficient digital education ecosystem and the development of competences and abilities essential for the digital transformation [22]. The ultimate goal is to adapt education and training systems to the current era in which the disproportionate use of technology due to the health emergency can represent a momentum towards the conscious and responsible digitalization of teaching-learning processes.

4. FROM DISTANCE EDUCATION TO DIGITAL SCHOOL

The health emergency due to Covid-19 has led to the suspension of teaching activities in all Italian schools with the Prime Ministerial Decree of March 4, 2020 and therefore, the consequent activation of the so-called distance learning [23]. This expression refers to a mode of training based on the use of digital environments, tools and resources and on the physical distance between teachers and students. It is a type of teaching and learning that takes its cue from the world of e-learning and that, due to its execution time, has led to a technological synchronization by the entire teaching staff [24]. The closure of schools has highlighted, in this sense, the role that technologies play in the construction and maintenance of interconnections between students and teachers. Not only that, but the inability to participate regularly in classroom lessons has become a strong extrinsic motivation that has led teachers of all levels to change their way of teaching. A situation of discomfort, therefore, acted as "a sort of Trojan horse for a broader reflection on the introduction of ICT in teaching" [5]. In the first phase, in fact, schools had to review their teaching practices without adequate pedagogical, digital and technological preparation. For these reasons, the Ministry with the decree-law 17 March 2020, n.18 has allocated 5 million euros for the professional updating of teachers, supported by INDIRE. In addition, there are webinars and training courses promoted by the teachers most experienced in the use of teaching technologies. From the exchange and comparison of knowledge and experiences among teachers were born, then, communities of practice, such as "self-managed learning communities, where that is, the professional growth is not based so much on a training path "traced" (a course in presence or at a distance), but rather on the sharing of experiences, the identification of best practices and mutual aid in addressing the daily problems of their profession" [25]. Some authors [26] tried to reconstruct the chronological steps of the evolution of online communities created in the first period of emergency, identifying three phases:

- 1st phase of communication and collaboration: in the first instance the problem of maintaining contact with colleagues and students was posed, so the different communication platforms (e.g. Google Suite, Edmodo, Office365, WeSchool, etc.), sharing repositories of materials were analyzed and chosen based on the specific needs of the class and the teacher.
- 2nd phase of information and data literacy: in a second phase the interventions in the various communities and the concerns of the teachers concerned the choice of content to be taught through the selected platforms, the design of the lessons and there was no lack of sharing of presentations, videos, material already created and reusable.
- 3rd phase of communication and creation of digital content in safety: the debate in this phase concerned the methodology and management of the lessons, the customization of content and materials and privacy concerns.

"In a few months, all five aspects of digital competence were developed; the path of ½ years of training was learned, experienced and put into practice" [26], identified in DigComp. 2.1. While it is true that the most advanced technologies open up new paths in the world of teaching, distance learning has required a complete reorganization of teaching methods and content. It is not enough to transpose traditional teaching methods into the virtual classroom, but the educational message has to be adapted to the multimedia medium which conveys it and makes it possible. New technologies are not only a means for the rapid, flexible and interactive transfer of learning content, but are themselves a learning content. It is therefore a situation that potentially offers stimuli both to teachers, struggling with digital tools and languages, and to students, "more protagonists and empowered [...] by the digital environment in which they feel more free to take charge of their own learning process" [27].

Technological learning environments have different characteristics than those of a physical environment [28]. Hence the need to prepare specific arrangements capable of promoting collaboration among users aimed at learning [29, 30, 31, 32, 33, 34]. The closure of schools has, therefore, revealed "the importance of being a digital school in order to also be a resilient school" [35]. In this regard, numerous researches have been conducted on the impact of the Covid-19 emergency on schools, teachers and students at the national level and international [36, 37, 38, 39], which have highlighted the willingness of teachers to strengthen and in some cases acquire the digital skills necessary to deal with the new teaching mode. In this sense, "teacher training should be oriented towards a greater understanding of the affordances of digital for a technological-didactic design aware of the strengths of electronic environments to support cooperation" [40].

5. CONCLUSIONS

The inclusion of digital technology at school is not only an opportunity to keep up with the needs of the 21st century, but also an opportunity to reflect and innovate the educational processes in a conscious and critical way [41].

In this sense, technologies, thanks to their flexible and collaborative nature, become efficient vectors for providing teacher training. Hence the proposal of training courses in online or blended mode that through active participation follow paths of digital education. The latter includes two different but complementary perspectives, on the one hand the development of digital competences of students and teachers, on the other the pedagogical use of digital technologies to support and improve educational processes [15]. However, three aspects need to be considered for an effective use of technologies at school: the presence of a solid IT infrastructure, continuous teacher training, and student-centered instructional design [42]. Moreover, the integration of ICT in the classroom involves several stages involving experimentation through personal use of the tools, a gradual acquisition of technical and pedagogical mastery and culminating in a redefinition of the conception of the teaching process and the role of the teacher [43]. In this regard, the SAMR model proposes a classification of the forms of integration of technologies in teaching and learning [44]. In fact, technologies operate for the improvement and transformation of teaching practices through 4 phases: Replacement, Augmentation, Modification and Redefinition.

These are the foundations of the attempt to modify the structure of the educational process through the use of technologies that give both the student and the teacher a more active role [45, 46, 47, 48], accompanying them towards a joint construction of knowledge and the development of the skills necessary for the exercise of an active and aware citizenship.

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OPTIMAL VIRTUAL INTERNSHIP MODEL FOR VOCATIONAL STUDIES

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Abstract: *Key performance analysis in higher vocational studies in the last few years revealed significant difficulties for the conducting of traditional, on-site internships in the field of information technologies. The main on-site internship obstacles are geographical, social, financial or physical disabilities, or lack of experience of many world-of-work educators. In many cases, such internships are not able to fulfill their main goal, to make a painless student's transition from education to employment. The current COVID19 pandemic crisis made this fact more obvious. Therefore, there is a need to reevaluate the traditional internship performance in a time of globalization of the professional world. This paper analyses information gathered from a large data collection, past and present internship experiences, in order to design a virtual internship model for higher vocational studies of information technology.*

Keywords: *Virtual internship, vocational education and training, online.*

1. INTRODUCTION

The National Association of Colleges and Employers (NACE) gave one of the most complete description of in-person or traditional internship, defining it as "a form of experiential learning that integrates knowledge and theory learned in the classroom with practical application and skills development in a professional setting. Internships give students the opportunity to gain valuable applied experience and make connections in professional fields they are considering for career paths; and give employers the opportunity to guide and evaluate talent." With the standards of the present professional world, the fulfillment of the internship criteria that arises from this definition and is well-known is reasonably under suspicion in developing regions. Increasing levels of education and globalization of present professional world impose a working environment that can rarely be found in companies from such regions. The reasons are various: financial, social, rapid changes in business environment, shorter knowledge lifetime, constant advances in Information and Communication Technologies (ICT) or lack of experience of many world-of-work educators. If we take into consideration geographical obstacles and inadequate transportation infrastructure the fact is that the majority of students from such regions do not have a chance to gain experience and be well prepared for employment. Additionally, multi-national and multi-cultural working environment, which is of great importance [1] for students' adjustment to a globalized job market are not often in mentioned areas. Obviously, reevaluation of traditional internship is needed.

This paper presents statistical data from internship experience of vocational studies that proves previous assertions and will make suggestions about how to develop internship opportunities with due recognition of competing demands and expectations. Filed of information technologies is in focus.

2. CHALLENGES OF TRADIOTIONAL INTERNSHIP IN HIGHER VOCATIONAL STUDIES IN THE FIELD OF INFORMATION TECHNOLOGIES

This chapter discusses the various challenges that have been identified through the realization of internship programs of higher vocational studies of information technology for the past four years. The study program of information technology at Western Serbia Academy of Applied Studies, Department of Uzice was analyzed.

After collecting data from 160 students, the following information was found significant:

- Was the company where internship program took place appropriate to students' vocation?
- Are there enough companies for students to choose from?
- Did the students perform work assignments in accordance with their knowledge?
- Did the internships turn out to be passive - an observation and analysis of the current workflow at the company?

The study program gathers mostly students from West Serbia, East Bosnia, and North of Montenegro. These are unbalanced geographical areas due to economic development. Companies where the internship programs took place are located mostly in these regions. There are only a few strictly information technology companies among them. The number of students with internship program in information technology companies is limited because they are mostly small companies. The companies which are not in information technology field have information technology department. It can be concluded that the companies bid is not good enough and company profiles in terms of information technologies are poor.

Further analyze of student's data gives the following facts, only three students of 160 have completed some form of on-line internship. The analysis revealed difficulties in ad hoc organization of the internships as well as limited insights of teachers into internship planning and implementation. The requirement to commute to the other city for the internship also appeared an obstacle for the students. Only few students commuted up to 30km from their residence, while the majority were not motivated to conduct the internship in another town. As all of the implemented internships were of the non-paid type, the commuting is considered as a financial burden for the students.

Numerical results of this analyses are: 59.375% of all students had internship appropriate to their vocation, among those students only 64.21% had their work assignments through internship program and the other 35.79% learned by observation, which means that only 38.125% of all students completed the internship in accordance with the plan and achieved previously set goals. According to presented numerical results it can be concluded that small percentage of students have appropriate internships.

Taking in account all the presented facts and numerical results it can be concluded that this is an unacceptable result for any study program. The necessity for improvement is obvious.

3. VIRTUAL INTERSHIP MODEL FOR INFROMATION TECHNOLOGY STUDENTS

Virtual internships (VI) can be a solution to the problem in question since they can serve as a bridge between academic and business world [2]. VI is defined as "a set of ICT supported activities that realize or facilitate international, collaborative experiences in a context of teaching and/or learning" [3]. Without a doubt, this is especially convenient for the field of information technologies due to the range of available resources and services, and additionally, ICT students have necessary skills for VI. With the specially designed VI model and on-line platform the optimal learning environment for internships can be created.

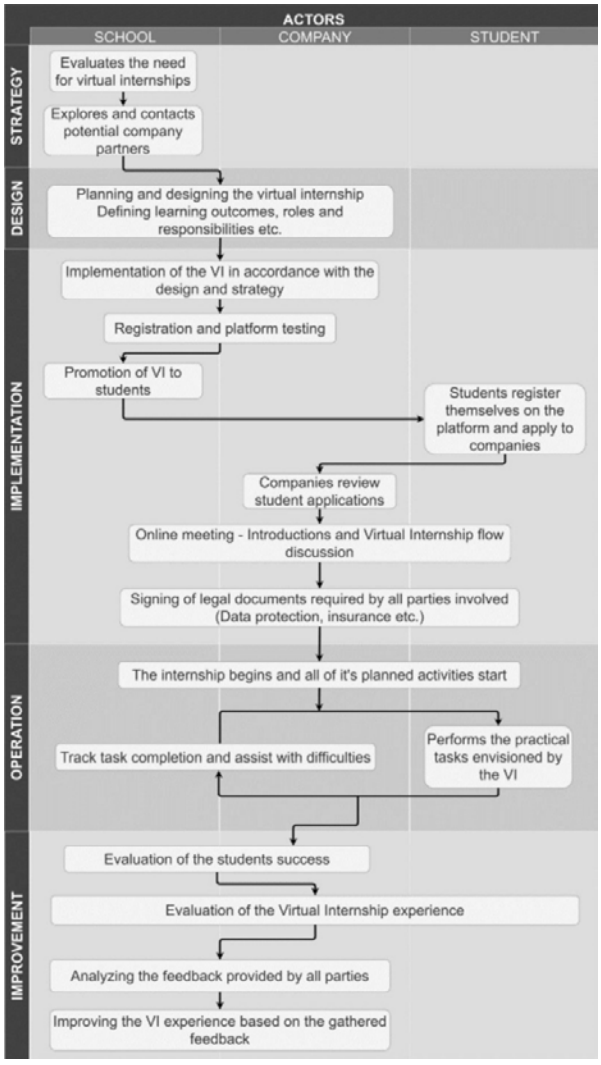

Fig. 1 Virtual internship activity workflow [4]

In [4], complete guide for designing specialized adaptive lifecycle and workflow model for virtual internships in general is given. Creation process is going through five phases: strategy, design, implementation, operation, and improvement. It involves all parties of interest in terms of internship: students, colleges or faculties (teachers) and companies (mentors). Fig. 1 shows the main activities and workflows across different lifecycle phases and roles (parties).

Depending on the field of work this general model must be adjusted to a specialized model. In this particular case, VI model for information technologies is analyzed.

Companies in VI model become partners with schools. School management and teachers together with company officials create learning outcomes that match specific needs of the company for certain competencies of employees. Company's employees become mentors and educators who together with the teachers determine the project plan, which contains duration, activities, goals, deadlines and required knowledge.

The teachers have an important role to motivate students to choose a company and a corresponding project in accordance with their interests. They then identify students that fit the requirements of the specific project plan. The teacher thus becomes an intermediary between students and companies and contributes to the success of all parties involved.

Mentors through effective communication and collaboration with students and teachers, monitor the implementation of internship step by step from its start to final evaluation. They assist the student when facing issues and difficulties while carrying out the tasks assigned to them. In that way, mentors get the opportunity to guide students, shaping their future competences.

At the end of the internship, the students deliver personal reports about success of the implemented practice and gained experience. This is crucial for the future VI experiences and further improvements on existing ones.

Technical prerequisites for the realization of VI model are the existence of flexible, scalable, and functional web platform together with the staff trained for setting and maintaining the platform. [4] completely describes the requirements that the web platform should meet in terms of specific VI processes and workflows. Moreover, it proposes an open-source software solution.

Implementation of the VI model for the information technology study program at Western Serbia Academy of Applied Studies, Department of Uzice started with school year 2020/21. First group of students successfully finished their internships at software companies Heliant and Infolab from Belgrade. Internships at Bulgarian company Tornado Studious are in progress.

Fig 2.: Course information on VI platform

3. CONCLUSION

The primary benefit of virtual internship is it can provide students with a safe, real-world learning experience based on authentic projects for companies located anywhere in the world.

Company catalog will depend on school management and teachers' skills, but it might contain a significant number of leading information technology companies in wider region of southeastern Europe [6], [7] or even all over the world. That will give opportunity to students to carry out their internships with foreign companies and to collaborate on projects with students from abroad. Student's biography will have representative reference. Students will build relations and network with future potential employers.

Communication and interactions between the teachers, students, and mentors, can be intensive through virtual platform which makes teachers' and mentors' roles more active and proactive and thus ensuring the success of the project.
Virtual internship model includes no travel and housing costs and removes barriers such as time and relocation.

Thus, bearing in mind that nowadays students widely accepted the online communication in everyday life, the virtual internship may easily prevail over traditional in-person internships.

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INNOVATIVE APPROACH TO PERSONALIZED TEACHING AND LEARNING IN THE VUCA WORLD

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Abstract *The environment is rapidly changing that cause need for constant learning and innovation. That is why those who are willing to prepare for all disruptions and challenges in the VUCA world through education have an advantage. As the new generation is prone to active and collaborative learning, it is necessary for the training and education system to adapt to that. Lifelong learning, as a sustainable process, is a must for anyone who wants to become and remain a serious player in the market, both educators and learners. Artificial intelligence, robotics, blockchain, biotechnology have been predicted to completely reform future employment. Educators need to use different skills and prepare students for jobs that are not exists yet. Effective education leadership, that builds skills by employing coaching and training techniques, makes a difference in improving learning. The goal of personalized learning is to engage students in the process of co-creation, building the curricula on mutual interests, developing a person's abilities and strengths, thus igniting intrinsic motivation for success and contribution.*

Keywords: *innovative teaching style, personalized learning, new generation, e-coaching, creative classroom*

1. INTRODUCTION

The term VUCA [1] world refers to the beginning of the fourth industrial revolution that began with the use of computers, new technologies and the Internet in business [1]. We have been living and doing business in the VUCA world for a long time, but the intensity of the changes has been significantly increased by the appearance of the COVID-19 pandemic, which did not bring with it the changes, but only accelerated the existing trends. Entering the third decade of the 21st century, members of the new generation - Generation Y (1980-1995) and Generation Z (1996-2010) participate in the world of creating additional values, new forms of buying and spending, decision-making, leadership and creating their legacy for new generations [2].

Digital technologies have become a starting point for learning, improving business skills and solving private problems. Today's education opportunities may occur with YouTube sessions, lunch-and-learn training, case study review, gamification, problem-based activities, podcasts, Coursera, Khan, Ted Talks, MOOC's, open courseware, and other web-based learning tools. The incentives and digital tools implemented vary depending on the learner's needs, agility to learn and demographic. In situations where advanced technology is used in communication, trainings aimed at e-learners should include challenges, control, collaboration, personalization, engagement, relevance, and feedback. In order to truly engage e-learners, their curiosity and feedback must be encouraged and maintained throughout the process. Interestingly, in both spheres of life, private and business, the same strategies have proven successful, such as video content, gamification, mobile applications' learning and e-coaching [3].

2. LITERATURE BACKGROUND

The importance of lifelong learning in the VUCA world for the new generation is undeniably greater than was the case with previous generations. Whether they are students, employees or leaders within organizations, members of the new generation must constantly adapt to new demands of the market and eco-system. That is why those who are willing to prepare for all new situations and challenges through education have an advantage. Digital world encourage teachers and students to reorient themselves to new ways of thinking about teaching and learning: a) from linear to hypermedia learning, b) from teaching to construction and discovery, c) from teacher-cantered education to pupil-cantered and student-cantered education, e) from absorbing materials to learning to navigate, e) from school to lifelong learning, f) from adapted to everyone to personalized learning, d) from learning as torture to learning as entertainment and h) from teacher as transmitter to teacher as facilitator [4] [20].

[1] volatility, uncertainty, complexity, ambiguity

For the new generation members, the time of information processing is much shorter, and that is a consequence of the speed with which the Internet has been used since their early childhood [5]. They easily select and process virtual data and this fact helps them in their work, while for employers it is a great advantage. From the point of view of educators participating in the education of younger generations, it is very important to be familiar with their behaviour and habits, to develop and implement techniques, skills and tools that will prepare students and newly employed ones for the challenges that await them in the work environment. On one issue, GenZ continues in the footsteps of GenY: it uses inventive solutions such as "gig economy", circular economy, "shared economy" or sharing economy, e-learning, m-learning, nano-learning, e-coaching [3] [5]. Because they primarily communicate via Instagram and Snapchat, most GenZ's communicate and express themselves visually, and not verbally, expressing themselves through emoticons, images, and video clips [6].

All these factors lead to the need to introduce more practical work in teaching and education. This would guarantee better student performance in employment. In addition, a curriculum that includes internships is one more reason for students to opt for a particular educational institution. We increasingly hear terms like innovation, agile leadership and many others that rely on the new skills needed to manage a team and company in the first half of the 21st century. The need for social emotional skills, leadership, and willingness to take initiative accompanied with greater cognitive, creativity, and problem-solving abilities is predicted to significantly increase emphasizing the need for all to become lifelong learners [8].

Personalized learning is designed to address the disengagement of today's students and to be proactive in closing the growing achievement gaps occurring in far too many schools. The goal of personalized learning is to engage students in the process, building on their interests, aptitudes, and strengths, thus creating intrinsic motivation for achievement and success. Students feel empowered when involved in goal-setting and decision-making processes. One primary key to effective individualized personalized learning is sparking the innate curiosity of students through active engagement with their environment. Activities included in this learning paradigm are intended to be meaningful and relevant, and promote individual development [9].

The focus on learner strengths is integral to engagement and empowerment in this learning process. The use of videos for educational tutorials on most any topic is an excellent example of the change in paradigm and availability in learning opportunities. Detlor, Booker, Serenko, and Julien [10] reported on the array of educational settings and tools that learners in the 21st century may choose to expand knowledge, skills, and competencies. For high-quality education, the role of a teacher, a human resource with superior competency compared to an excellent educational program or physical environment, is essential, and one of the key factors that influence the reinforcement of the teacher's job competency is the principal's leadership. Those challenges require the school leader to re-think and re-design the existing management processes to satisfy and retain staff. The principal's leadership has a significant impact on student performance through indirect effects on teachers, the educational process, and the educational environment [11]. So, the principal's leadership in education often stands in the spotlight [12].

3. THE ROLE AND SIGNIFICANCE OF COACHING AND TRAINING IN PERSONALIZED LEARNING

An additional value of an university can be the coaching offer. Educators who apply coaching principles encourage students to think critically about what they have learned and fit that material into their map of knowledge and values. Educators who support the lifelong learning process encourage creative exchange of opinions, help students set goals and respond to the challenges of studying. Consequently, they contribute to a better sense of self-confidence in students. In addition to formal education, the new generation is also showing interest in non-formal forms of learning that they recognize as legitimate models of lifelong learning [7]. Given the characteristic of the organization, coaching leadership is an effective leadership style for school principals and educators. Coaching is directly related to leadership in terms of the skills needed by leaders. Coaching is one of the most frequently discussed leadership skills and an active topic in management [13][14]. Furthermore, coaching was emphasized as an essential competence for organizational managers [15]. Leaders should spend more time coaching and developing their capacity as internal coaches within their organizations [16].

In order for leaders to inspire, motivate and engage their teams so that they can operate in a world of change such as COVID-19, they should develop their own leadership practices. The development of a e-coaching approach in leadership and employee development provides a more active approach to change management [17]. The benefits of this style of leadership are increased productivity and quality of work of individuals and teams, strengthening enthusiasm for teamwork, building trust and increasing employee satisfaction and loyalty. Milovanović et el. [18] pointed out in one study that recommendations included a more innovative training system for existing and future traders (employees) through constant education. The coaching style of managers and leaders has a positive impact on the motivation and self-confidence of employees, their creative and inventive dimension, which makes the company more competitive in the turbulent market [7] [33]. By asking carefully tailored questions, the coach provokes thinking and reflection of experience and thus develops potentials and creativity [33]. The most effective form of work that enables the use of the experiential learning method is coaching (e-coaching). This form of work implies the responsibility of the person who is developing and his active participation in strengthening his abilities and skills. By using different methods of work, individuals not only improve themselves, but they also implement the developed skills and contribute to the development of the organization [7]. Employers

should avoid making decisions based only on assumptions. If the reason for a certain employee's or student's behaviour is unclear, asking questions is a possible solution.

Good communication, in addition to enabling understanding and adherence to work rules and procedures, also ensures responsibility because everyone knows who is responsible for what. Good communication in the company opens space for creative thinking, which is the basis for the contribution of employees in an innovative way of thinking, which makes the company more competitive in the market [19]. The training style of the educator refers not only to the subject being taught, but also to the purpose and the bigger picture. What is important for the student and the trainee? What are his or her values? Coaches and educators can help students learn how to set goals, define measurable action steps, and evaluate themselves. Their role is to stimulate thinking, ignite creativity and integrate different strategies and tools into the learning process. Thus, students are supported during challenging study times [20].

According to the Horizon report, launched by the New Media Consortium [21], the “flip” classroom is one of the important development technologies in 2014. Flip classroom characteristics are collaborative learning, interactive discussion and communication, that establish strong social interaction among students and solve problems in the team, with a minor guidance from teachers. It is the opposite of a traditional classroom because students attend lectures outside the classroom, through video material, and develop an interactive group discussion in the classroom [22] [23] [24]. The way we learn is very important nowadays. In order to learn in such an active and collaborative way, students and staff should be involved in activities such as problem solving, role play, reading, writing, or participating in discussions and debates [25]. According to Trilling and Fadel [26], the challenge of the 21st century is for everyone to build and maintain their own identity based on given traditions, and at the same time it is necessary to learn to be tolerant of different identities and values of others. The 21st century skills are developed in the context of: learning for life, student-centeredness, content quality, practical skills in the workplace, collaboration, interactive exchange and others [26]. Training and development of employees can help the company's competitiveness because they can directly increase the value of the company by adding value to intangible assets [19]. Just as the company and its management influence the interests, behaviour and advancement of employees, so employees directly influence the development of the company and its goals [27].

Leadership training can prepare students for a more serious and secure future career [7]. It is at the beginning of your career that it is important to cultivate self-confidence. The new generation members are constantly learning at the job they have chosen. But, that is exactly why it is important to prepare them for that during their schooling and to develop their curiosity and desire for improvement. The reorganization of educational content and delivery structures have been labeled as “urgent” with a call for immediate action [28].

4. CREATIVE CLASSROOMS AS INNOVATIVE ENVIRONMENTS IN PERSONALIZED LEARNING

Creative classrooms are designed as innovative learning environments that fully incorporate the potential of information and communication technologies (ICT) to innovate and modernize learning and teaching practices. The term "creative" refers to innovative practices, such as collaboration, personalization, active learning and entrepreneurship, fostering creative learning, while the term "classroom" is used in its broadest sense, including all types of learning environments, formal and informal. The aim is a systems approach needed for the sustainable implementation and promotion of innovative and open learning environments through the use of ICT across Europe (European Commission, 2012) [29].

The types of learning that are characteristic of creative classrooms are:

- Collaborative learning is a method by which a group of students work together to achieve common goals [30]. Active and collaborative learning practices have a more significant impact on learning outcomes than other practices. Students are most successful when they are taught how to learn and what to learn. Innovative behavior during e-learning has been refreshed with the development of technology. Some successful learning strategies that have proven effective among members of the new generation are gamification, scenarios based analysis, story-based learning, interactive videos, and other methods. E-learning materials should be easy to navigate and prepared for implementation through exercises, case studies, knowledge tests, scenarios, simulations and interactive games. The e-student prefers interactivity by selecting different documents, videos, web pages as additional web resources. E-learning games put e-learners in a situation to learn faster and easier, engage them and introduce questions that provoke thinking. To keep the new generation of students focused, the educator can add humor. E-learning materials meant for e-learners include challenges, control, collaboration, personalization, engagement, relevance, and feedback. In order to truly engage students, their curiosity must be stimulated and maintained throughout the course [3].

- Experiential learning has proven to be the most effective learning today. The experiential learning model is Kolb’s model. David Kolb's learning model [31] shows that experiential learning goes through four phases:

1. Concrete experience (based on feelings and experiences).

2. Thoughtful observation (based on observation and answer to the question "What?").

3. Abstract conceptualization/generalization (data analysis, discovery of meaning and theoretical framework; formulation of abstract concepts).

4. Active experimentation (testing implications in new situations “What will happen?”).

The learning process can start at any stage and it is continuous, i.e. there is no limit in terms of the number of

learning cycles. This theory advocates the view that dysfunctional behavior is repeated without reflection (thoughtful consideration and observation). Learning is the process by which, through the transformation of experience, knowledge is created, and knowledge arises from combinations of experiences that we gain and that change us. Reflection is a process that is also applied in business in order to draw from existing learning, through contemplation, conclusions for future action steps.

- Constant learning and improvement through trainings, courses or monitoring of e-learning materials, even if a tangible document is not obtained for that knowledge, are parts of lifelong learning. Today, many recognized faculties have digital courses available, and in order to obtain a certificate, it is necessary to join the course. All materials are still available to anyone who wants to learn more about the chosen topic. According to that principle, a large number of Internet pages and sites function today.

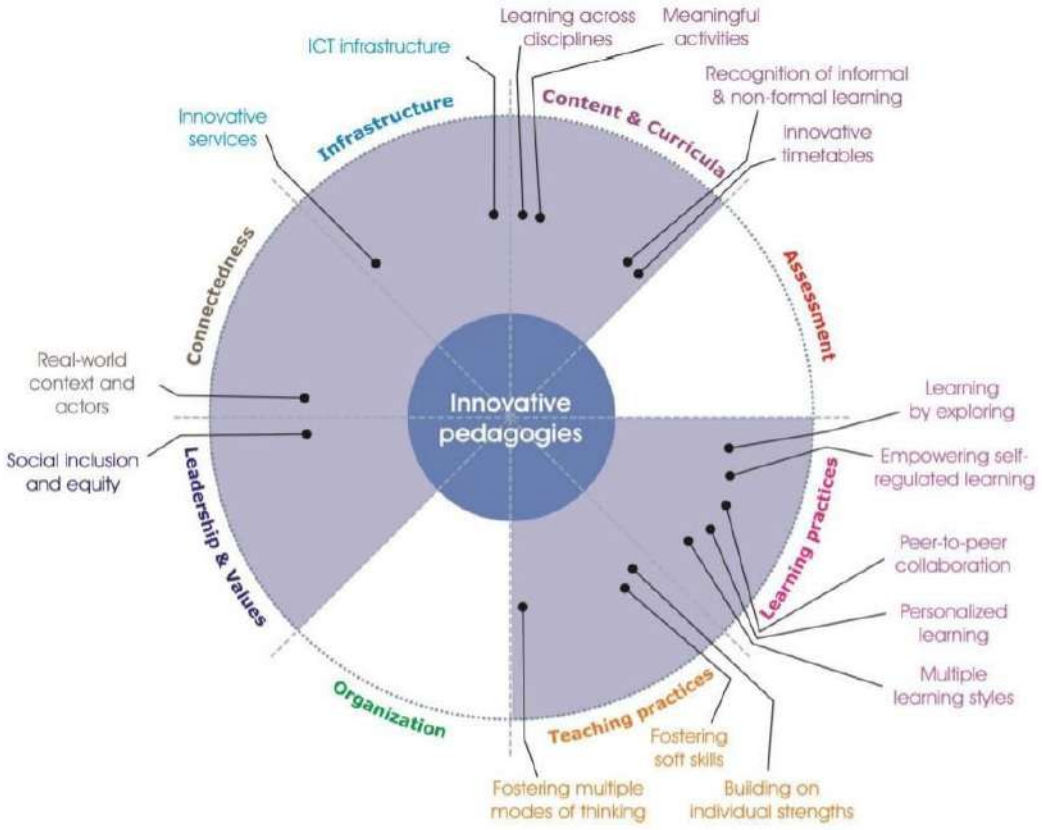

Figure 1. Innovating Learning: Key Elements for Developing Creative Classrooms in Europe

Source: Bocconi, S., Kampylis, P.G., Punie, Y. and Farrer, P., 2012

The term "creative" refers to innovative practices, such as collaboration, personalization, active learning and entrepreneurship, fostering creative learning, while the term "classroom" is used in its broadest sense, including all types of learning environments, formal and informal. The aim is a systems approach needed for the sustainable implementation and promotion of innovative and open learning environments through the use of ICT across Europe (European Commission, 2012) [29].

Creative classrooms are designed as innovative learning environments that fully incorporate the potential of information and communication technologies (ICT) to innovate and modernize learning and teaching practices.

6. CONCLUSION

In the 21st century teachers and educators should apply an innovative style in classrooms, supporting teams of students and employees in terms of research and the acquisition of new skills that will prepare them for future life. There should be coordination in adapting curricula, evaluations and other key performance indicators. Some of the findings show that in the VUCA world, the new generation is more willing to respond and act more agile. These are the needs for learning new technology over and over again, lifelong learning, flexibility, the ability to create disruptive and incremental innovations, attitudes towards environmental values in the long run, attitudes towards virtual, nomadic way of working, greater collaboration, joint creation. Technology provides a framework for access to international educational experiences designed to enhance learners' worldview and global perspectives. The competencies imposed by new technologies will reshape the labor market as we now know it. The education sector is faced with the task of preparing new generations to be ready for the challenges of the 4th industrial revolution that

develops sectors such as SMART Enterprise, SMART City, SMART banking, SMART medicine, SMART transport and communication, SMART education and others. As the digital generation in the age of smartphones, they are accustomed to instant access to information - the ability to learn anytime, anywhere. The new generation in the VUCA world is a generation that not only can learn in a million different ways, but it also must do so. If they want to keep up with the times, they will accept the fact that the online world is a new classroom. Digital technologies have become a starting point for improving business skills and solving private problems. Interestingly, in both spheres of life, private and business, the same strategies have proven successful, such as video content, gamification, mobile applications and e-coaching. Critical thinking, communication, creative thinking and collaboration are vital in the workplace, at home and in every interaction, as four skills that act as essential wheels in the exciting journey of the 21st century.

Uultimate goals are to develop enhanced employability competencies, improved communication skills, stimulate critical thinking, and grow deeper appreciation for others' perspectives resulting in greater tolerance for differences.

In order to keep up with the times, with rapid changes, with novelties that appear almost every day, the leaders of the new generation have learned to constantly follow the novelties, learn about them and how to use them. It is possible that this is the answer to the question why flexibility and personalized learning are important to them, and constant work on oneself is a lifelong obligation. As such, they can embrace all the changes they are witnessing, as well as actively participate in the creation of new values, solutions and their implementation in the VUCA world.

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EDUCATIONAL TECHNOLOGIES FOR THE NEW MILLENNIUM. HOW TO RETHINK TEACHING IN THE POST-PANDEMIC ERA: THE RESULTS OF AN ITALIAN RESEARCH PROJECT.[1]

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Abstract: *During the months of the lockdown, teachers had to deal with different means and ways of teaching from their usual practices. How did it go? Did distance learning effectively replace face-to-face teaching? Has the response been similar in all levels and grades of school and in the different territories of the country? In the paper, after some reflections on how to rethink education in the post-pandemic period and an examination of the actions implemented by the Italian Ministry of Education for a school transition towards innovative teaching, we present the results of a national research promoted by the Italian Society of Research and Didactics in collaboration with some associations of teachers who have tried to answer the questions mentioned above.*

Keywords: *E-Learning, Distance Learning, Education, Research, Didactics*

1. RETHINKING EDUCATION IN THE POST-PANDEMIC ERA

The year 2020 will go down in history as the year in which the whole world had to deal with the spread of the COVID-19 SARS virus, which spread so rapidly that the World Health Organisation (WHO) immediately spoke of a pandemic and a global health emergency, marking an immensely important historical crossroads on which to reflect. Because of this emergency, measures were imposed to suspend all activities not considered necessary for survival. In particular, in-person teaching activities were replaced with alternative and innovative ways of doing school (Ramella and Rostan, 2020). The Italian government, in order to contain and limit the pandemic, immediately took action by giving all schools of all levels and all Italian universities the possibility, through the legislative decree of 9 March, to carry out distance learning (Bates, 2008) activities. In fact, after a short time, almost the majority of teachers had already set up their own virtual classrooms and were holding their lessons on the appropriate technological platforms, thus launching distance learning (DAD). Teachers, however, who in most cases were not adequately trained in media education (Buckingham, 2006) and distance education (, and who often transferred the classic methods of a frontal lesson into

[1] Paragraph 1 was written by Alberto Fornasari, paragraph 2 was written by Matteo Conte, paragraph 3 was written by Alessia Scarinci.

virtual classrooms without reference to the pedagogical constructs necessary to design an online lesson (Limone, 2008) . The rapid transformations of societies, which are now glocal, have caused the clear dividing line between formal and informal education to collapse. Today we learn beyond the walls of a classroom in a sort of nomadic learning that requires those who design and deliver content to use participatory methods in life (Salmon, 2002) in which the complementarity of presence and distance now play a fundamental role (Rivoltella, Rossi, 2012). Today, learning environments must be ubiquitous, multimodal and interoperable, and teachers must be designers of learning paths (Laurillard, 2014). Reviewing a traditional didactics still based on the *"lectio*" and the "*disputato*", rethinking the syllabi requires different pedagogies that increase the educational effectiveness (Bloom, 1956) based on processes of co-construction of knowledge in which significative relationships can be created beyond the body and the presence in a physical place where it is important to know how to work on the depth of the relationship in the physical distance (Fornasari, 2020).

Life should be conceived as an 'extended classroom' where personalised pathways are delivered on the basis of adaptive learning methodologies (Rivoltella, 2014) and hybrid lessons. I believe that we should stop being anchored to the 'classroom liturgy', the same classroom and the same school model that in Italy, for example, encourage early school leaving with increasingly worrying rates of early abandonment of compulsory education (Fornasari, 2020) The National Institute of Statistics (ISTAT), in fact, estimates that 543,000 young people will drop out of school in Italy in 2020 (13.1%), involving more young men (15.6%) than women (10.4%), making it one of the countries with the highest percentage of young people dropping out of school. We have a generation that uses digital technology (Jenkins, 2010) but not digital rationality. The twentieth century was characterised by the cult of the specialist, while the new millennium requires the intelligence of the gamer, induced by the digital revolution (Finnis, 2008) , where it is not so important to be the most knowledgeable as to be able to make different skills work. As the Italian writer and essayist Alessandro Baricco (2020) put it, in the world of education we often see 'chess masters playing Fortnite'. Hence the central theme of teacher training to rethink teaching in the light of the above-mentioned changes that the Covid 19 pandemic has only brought into sharp focus. Even before the difficult pandemic situation, a good number of teachers in Italian schools were already involved in the use of new technological devices, ICT (information and communication technologies) and digital languages that have marked the transformation of teaching (Bonaiuti, Dipace).

For the first time, in 2007, there was talk in Italy of a National Digital School Plan, which was based mainly on three levels: training, infrastructure and content. The PNSD was a project that aimed to include new technologies in schools, spread the idea of lifelong learning and extended a concept of school that includes not only the physical place but also virtual learning spaces. More than ten years have passed since the modification of learning environments was first mentioned (Nunziata, 2017). In 2008, thanks to the LIM Action, the distribution of the Interactive Multimedia Whiteboard (LIM) was started in many classrooms, which allowed a gradual digital awareness without disrupting traditional teaching. Starting in 2009 and for the following three years, the Classes 2.0 Action project was approved and tested: the in-presence work was suitably integrated with the inclusion of technology, while the online work included the use of paper-based material at a distance.

Class 2.0 had as its slogan 'no longer the classroom in the lab, but the lab in the classroom' with the aim of making learning and teaching environments innovative. On 18 September 2012, the MIUR (Ministry of Education, University and Research) - Regions agreements were signed to ensure total collaboration between the central level and that of each individual region, in order to guarantee technological innovation throughout the country. These agreements have led to the allocation of about 2,000 interactive whiteboards, the formation of 900 classrooms and 23 2.0 schools. With Decree-Law No. 179, approved on 18 October 2012, Digital School Centres (DSC) were set up to meet the needs and particular problems in certain geographically disadvantaged areas. Forty-five initiatives were created to support all those schools located on small islands or in remote areas by providing them with the possibility of a connection with schools located in urban centres.

Today we are faced with the need for a school that is capable of focusing learning not only on the sterile and impersonal reproduction of concepts but on understanding that leads learners to examine, evaluate and take positions through personal and divergent reasoning. What is peculiar is that while technological progress enters the school, modifying and improving it, on the contrary, the school fails to enter the outside world, as if it remains imprisoned in its physical building without making an effort to be an integral part of the coeval society (Ostinelli, 2019). With Article 11 of the Decree-Law No. 104 signed in 2013, wireless connectivity was promoted in most schools, thus allowing, thanks to the Action “Poli Formativi”, the creation of 38 interprovincial poles for teachers, going to develop digital skills.

Subsequently, in 2014, training courses were introduced at regional level. Thus, teachers were required to implement innovative methodologies (e.g. flipped learning, cooperative learning, problem solving, inquiry-based learning, role-playing, brain storming, outdoor training, etc.). Numerous resources, made available by Europe, have contributed to the process of technological development. The main objective of the National Operational Programme (NOP Education) 2007-2013 was to increase

information in schools on new communication technologies and, thanks to the activities proposed by the multifunctional service centres, to achieve total technological knowledge of school staff. It is important to stimulate students to critical and subjective reflection by stimulating group discussion and putting students in a position to use the knowledge they have learnt and transfer it into practice in the school context, to solve problems in the social and, eventually, the work context (Nunziata, 2017).

When we talk about cultural action we are referring to an innovative idea of school, in that it is not only seen as a physical place and as a place for developing pupils' skills and knowledge, but also as an open place where students have the opportunity to express themselves. This innovative idea of school does not want to go and change the traditional objectives with which the school was created such as the formation of individuals, citizens and professionals of the society of the future, but these objectives will be updated in the way they are carried out and achieved as they must respond to the challenges of a rapidly changing world, which demands transversal skills and knowledge in order to enable young people to play active roles in society (Turkle, 2016). Law 107 of 2015 approved the National Digital School Plan, "La Buona Scuola". This is projected towards the innovation of the school system and digital education.

This plan is not intended to eliminate the classic teacher-learner relationship, which is fundamental to the education of students. Digital education has as its primary purpose a cultural action in that it must train students to deal with learning throughout their lives (life-long) and in all situations, formal and non-formal (life-wide) (Fornasari, 2019). The plan therefore calls for a collective commitment not only of those who have always been specifically familiar with technology, but also of those who have only just become acquainted with the new technological methodologies. Teachers play the role of facilitators, accompanying students in the strengthening of their skills by sharing the teaching strategies learned. The first step is the action of the Digital Animators who replace those teachers who, in the past, were dedicated to technology. Their role was very underestimated, they lacked funding and projects from the European Union and because of this, innovation in teaching was slow. Since the approval of the "Buona Scuola" reform, the figure of the Digital Animator has become so important that he or she works alongside the Headteacher and the Director of Administrative Services in the design and implementation of digital innovation projects. He or she is a teacher in the school and never an external technician, as he or she must know the strengths, limits and weaknesses of his or her school.

The debate on the role of digital technologies in schools has always been dominated by sterile contrasts between the advocates of 'digital at all costs', those whom Umberto Eco would have defined as 'integrated', and the supporters of 'digital at all costs', or the 'apocalyptics', to quote the great Italian semiologist (Ranieri, 2011). Between the end of 2020 and the beginning of 2021, the Ministry of Education has approved a new training programme: 'Training for the future'. This is aimed at all school staff and focuses precisely on integrated digital education and the transformation it has brought about in the transformation of schools. The aim is to continue the project of innovation of the Italian educational institution especially after the opportunities experienced during the Italian health emergency which helped to accelerate this process. This was made possible by an update of the National Digital School Plan (PNSD). The programme activities started in July 2020 and will continue until 2022.

Enrolment for these training courses is open to all and interested parties can go online to all digital platforms dedicated to training activities. In these areas it is possible to find out about all the paths that are still being developed, the paths that have already been realised and the materials that have been produced. All participating staff, including teachers, will acquire all the digital competences that are part of the European reference framework DigCompEdu[2] so that they can have a complete preparation in all the areas necessary for teacher training. The evolution of didactics can only go towards hybrid forms of didactics where the paper book, which remains important for the knowledge of a specific content, coexists alongside the digital contents, which are easily updated and upgradable, flexible and manipulable (Horton, 2006). The above summarises very succinctly the long journey that Italian schools have made towards digitalisation and innovative teaching that takes account of the major changes that have taken place in recent decades.

2. WHAT DO ITALIAN TEACHERS THINK ABOUT DISTANCE LEARNING? SIRD RESEARCH FINDINGS

Since March 2020, the entire world has had to deal with the spread of the SARS COVID-19 virus, which has led various scientific societies to consider how to deal with teaching activities in conditions of isolation. Among these, the Società Italiana di Ricerca Didattica - italian society of educational research - (SIRD)[3], promoted a national survey

[2] DigCompEdu refers to the European framework for teachers' technological competences which is based on the work completed in 2017 by the Joint Research Centre (JRC) by the European Commission on behalf of the Directorate-General for Education, Youth, Sport.

[3] The SIRD (Italian Society of Educational Research) is a scientific society that associates university teachers and

to start reflecting on distance learning (ODL) adopted during the COVID-19 emergency[4]. Since the very first days of the pandemic, it wondered what contribution a scientific society could provide to the country and chose to work on an in-depth knowledge of the problems that were arising during the didactics in the emergency phase. The introduction of distance learning (ODL) proved to be a valuable tool for ensuring the continuity of the transmission of culture as well as a way of not abandoning students at one of the most difficult times in their growth. It has also changed the relationship between teachers, students and parents by bringing part of the activities carried out in the classroom to the home, involving the families and making their active participation in the student's school life (Piras, 2020). Despite the fact that most Italian schools were lagging behind in terms of digital skills and tools, the situation of difficulty and protest on the part of many parents, who saw their children drifting further and further away from culture, gave a decisive impetus to the development of the technological knowledge that today is increasingly proving to be fundamental in the world of work and education (Ibidem.).

Has distance learning effectively replaced face-to-face teaching? Has the response been similar in all levels and grades of school and in the different territories of the country? These are some of the questions to which the first national research promoted by SIRD in collaboration with some teachers' associations wanted to offer answers. The aim of the research was to start a comparison with teachers with the intention of being able to assess the situation and better understand the dynamics that were being activated; the intention was not to evaluate teachers, schools or the indications of central and regional authorities, but simply to try together to highlight the characteristics of the experience carried out and make an estimate of what was possible. In order to carry out the research, an online questionnaire consisting of 122 items with 6 open-ended questions was drawn up and administered to 16,000 teachers of all levels throughout the country. The questionnaire is developed around ten main axes:

- The impact on the reshaping of the teaching schedule;

- The technological tools used;

- The ways in which synchronous and asynchronous teaching is carried out;

- The teaching strategies used;

- Teachers' preparation for distance learning;

- The critical points encountered in distance learning;

- The quality of the activated forms of collaboration;

- The problems encountered in assessing students;

- The interventions carried out for students with Specific Learning Disorders and Special Educational Needs;

- The overall evaluation of the experience;

The open-ended questions, on the other hand, were designed to complement the questionnaire by allowing the teachers' voices to be heard, their reflections to be heard and how they experienced the experience. A space dedicated to comments and reflections also made it possible to capture the views of the teachers surveyed in greater detail. There were six broad response spaces aimed at free expression on:

Students' difficulty in following distance learning;

- The strengths of the distance learning experience (2 response spaces);

- Weaknesses of distance learning (2 response spaces);

- Reflections and comments.

The first results of the survey, related to the analysis of the closed questions, together with the description of the general objectives of the research and the structure of the questionnaire, were presented by Lucisano (2020) and highlight the need to deepen the aspects related to the perception of the more than 16,000 teachers who participated in the survey, through the qualitative analysis of the answers to the open questions of the questionnaire that report their voice and reflections. In any case, the answers indicate the perception of teachers who only partially represent the whole of their colleagues, so caution is needed in their interpretation in a national dimension. Consistent with the objectives set, some aspects of the ten axes into which the questionnaire is structured have been selected: impact on the remodelling of the didactic programming; methods of carrying out the teaching and use of technological tools; evaluation methods; evaluation of the experience and criticalities.

The teachers who participated in the research represent about 2% of the Italian teachers, with a wide representation of the national territory, in fact, the answers come from 1834 municipalities equal to about 23% of the Italian municipalities. The unit of analysis reached is composed of 1,910 kindergarten educators, 6,831 primary school teachers, 4,003 secondary school teachers, 3,272,

researchers who deal with didactics and educational research methodology.

[4] The research group is made up of members of the SIRD Board (Loredana Perla, Antonio Marzano, Giovanni Moretti, Ira Vannini, Roberto Trinchero, Ettore Felisatti, Maria Luisa Iavarone, Alessandra La Marca, Loretta Fabbri) and of Giordana Szpunar, Patrizia Sposetti, Andrea Marco De Luca, Gianluca Consoli, Federico Batini. The research was coordinated by Pietro Lucisano (SIRD President). On 22 July, SIRD held an online press conference where the first results of the research were presented. The summary is available at: www.sird.it.

secondary school teachers and 117 teachers working in C.P.I.A., vocational training and adult education. The Covid emergency required teachers to rethink their didactics and training offer both in terms of contents and methodologies/teaching activities in the transition from face-to-face, or blended in the best of cases, to entirely distance teaching (Capperucci, 2020). This remodelling, detected from the answers to the questionnaire using a 5-step Likert scale, indicates that there are differences between contexts. Preschool and primary teachers had to intervene more on objectives and teaching strategies and had a greater collegial commitment. The remodelling of the objectives took place in a very short time, at the same time as the functionality of the tools was checked. From the data that emerged, we can say that there are significant differences between the different school orders, in particular for the preschool and primary school teachers had to significantly question the same learning objectives and for the primary school only they needed a greater increase in the actual number of hours (Lucisano, 2020). This resulted, especially in primary schools, in an increase in the actual number of hours (4.1).

There are significant differences between the different school levels, in fact, the average scale values referred to the remodulation of programming are higher in the nursery and primary schools than in the secondary schools and show a greater commitment to the redefinition of learning objectives, teaching strategies, assessment methods and time dedicated to collective work (Fornasari 2015). As for the section dedicated to the use of technological tools in the questionnaire, this included 15 items. In order to be used, distance learning requires technological support, learning management skills and IT familiarisation processes that allow for an intentional and functional use of the chosen devices (assets, devices, platforms, software, etc.) (D'Alonzo, 2017). If we consider the responses of the entire unit of analysis, it emerges that the most used tool overall was Digital Platforms, followed by instant messaging tools, while among the little used tools it is worth considering social networks and the school website. Again, there are significant differences in teachers' choice of tools according to school cycles. In the nursery school the first choice is Chat (4,3), followed by the telephone (3,6), which gives an idea of the effort required by teachers to make contact with families who necessarily had to intervene as mediators of the distance relationship between teachers and children. In primary school, after chats (4.0), we still find e-mail (3.8) and the electronic register (3.8); on the other hand, in secondary school we find digital platforms in first place (4.5), together with virtual classes and the electronic register (Ibidem).

Regarding the preparation for distance learning in the SIRD questionnaire there were four questions, the first question "In your school was already in use the electronic register?", appears to be a tool adopted in the majority of schools but shows a significant decrease in kindergarten (50.6%) while in the other grades the percentages exceed 90%. Then, when asked if they had practiced forms of distance learning in the past, percentages below 30% emerged in all grades. On the other hand, if we look at the issue of training, we see that in secondary school 66.7% of teachers have carried out training courses on new technologies in their school; high percentages are also recorded in other schools, 64.6% in secondary school, 66% in primary school and 52.4% in kindergarten. Finally, we also asked the question "Had you already practiced forms of distance teaching?" in this case we see both how the positive answers range from 9.9% in kindergarten to 23.4% in secondary school, and how the differences are accentuated in relation to having had direct experience of forms of distance teaching. This means that in the school cycle where teachers declare more experience 7 out of 10 teachers had no practice of this kind of didactics and only two out of 10 had received specific training. An encouraging finding emerges with regard to the willingness of teachers to integrate face-to-face teaching with forms of distance teaching even after the emergency, making use of the skills related to the use of ICT acquired during the pandemic.

The teachers' answers also brought out clearly the critical issues encountered during the delivery of distance learning. In short, they concerned the increase in working time and student assessment, but not to be underestimated are all the technical problems and the different ways in which distance teaching has implemented the new learning environments. The relationship with parents is problematic in some cases, while it seems that within the school the emergency climate has stimulated solidarity with colleagues and the management. The differences between the teachers of the different cycles respond in part to fairly predictable considerations, for example the reduced autonomy of the students was a very strong criticism in kindergarten and primary schools (average 4) and less so in lower secondary schools (3.5) and lower secondary schools (3.3); similarly, the reorganisation of programming had the same trend: 3.7 in kindergarten, 3.4 in primary, 3.2 in lower secondary, 3.1 in lower secondary.

As far as evaluation is concerned, which even in face-to-face teaching is often one of the weak points of Italian schools (Vertecchi, 2003; Domenici, 1993), also in distance teaching it has been one of the most difficult aspects for teachers. The questions of the questionnaire aimed at investigating above all the ways of assessing profit and the types of instruments used for this purpose. Most of the teachers declare that they followed the instructions of the teaching board (87%) and of the Ministry (74%) and that they had to change the criteria compared to their previous experience (73%). The prevailing methods remained written assignments and oral questions, while fewer teachers declared having activated self-assessment and group work methods. Observing the answers of the entire teaching staff interviewed, we see that the traditional modes prevailed, in fact, we find in first place written assignments (71.5%) and oral questions

(64.3%), followed by research and other practical work (63.7%), tests (61.0%), concluding the list with rubrics (53.0%), self-assessment modes (44.1%) and group work (24.3%). An analysis of the answers according to the school order shows that also in primary schools, where there are normally forms of active teaching, it was problematic to carry out group work activities, while the use of forms of self-evaluation shared with the pupils seems to be more widespread. In this case, the use of questions is lower, whereas it is very high in the secondary school (Lucisano, 2020). The use of written assignments, tests and the use of research and practical work for assessment is more present in lower secondary schools.

Finally, the research included items that asked teachers to evaluate the overall experience, on this topic teachers were also asked to express themselves in the open questions that will integrate this first analysis of the data collected. The question asked to evaluate some aspects in relation to the quality of the experience that the teachers were having. In this item the teachers evaluated very positively the activation of the teaching staff in the emergency phase and considered that a considerable workload had been faced, while the feedback about the evaluation and the effectiveness for learning was less satisfactory (Ibidem.). Finally, the responses also suggest that the emergency encouraged greater collaboration among teachers and that schools did their part in terms of organisational and technological support.

3. MATTER OPEN TO DEBATE

If it is true that the use of technology alone does not guarantee the improvement of learning, the problem must be posed differently and the moment of decision becomes crucial: which technologies to use, when and how (De Angelis, Santonicola, Montefusco, 2020, p. 75). According to Capperucci (2020, p. 20), the data collected by the SIRD research are absolutely precious for the wealth of information they provide. Although they need further analysis, statistical analysis and integration - also through qualitative tools such as open-ended questions and focus-groups, foreseen in the second phase of the research - they provide useful information for policy-makers, schools and teachers who will continue to be involved in distance learning activities. The pandemic, in fact, has brought out the historical fragilities of our school system, well highlighted by this research such as the inadequate initial and in-service training of the teaching staff with respect to the use of ICT and distance learning (Dipace, Scarinci, 2021), the need to implement the skills of teachers with respect to the processes of student assessment even more if referred to distance learning (Gui, 2019). Many critical points emerged from the SIRD research: the time dedicated to learning gave way to the time for the management of the virtual classroom; most of the time was dedicated to the reorganisation of teaching, to the assessment methods but also to the daily management of the learning environments such as technical difficulties in connections or interference from parents; not all students were reached and the digital dividend was penalised above all by students in the South with lower levels of use of digital technologies than their peers in other areas of the country (Save the children, 2020). Some of the elements that emerged lead us to think that the emergency found a school system that was already dragging along a number of unresolved problems, from staffing levels to an inadequate building situation and the narrowness of resources, from initial training and the way teachers are recruited to the regulations governing the processes of assessing student performance. (Lucisano, 2020, p. 25). The data in this first part confirm that the pandemic situation has given an acceleration to the use of new technologies, which can complement and certainly not replace face-to-face training, which is essential for the educational role assigned to schools by our Constitution.

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ONLINE EDUCATION DURING AND AFTER COVID-19 PANDEMIC; CHALLENGES, OPPORTUNITIES AND POST-PANDEMIC CHANGES

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Abstract: *COVID-19 pandemic has caused plenty of changes to humanity and organizations at their core. Educational sectors decided to carry on their studies to spread the knowledge through online education, commonly known as 'pandemic pedagogy'. This paper underlines features of online teaching during and after COVID-19 pandemic, including its delineations and major elements, comprised on effective outcomes, shadowed by major challenges, opportunities and post-pandemic changes for online education within educational institutions. The paper emphasizes on literature review from research studies towards the areas of online education. An accurate blend of different strategies regarding hybrid (combination of face-to-face and online) mode of education and changes and focus on particular areas after COVID-19 pandemic are required for successful implementation and constructive outcomes through the application of online education.*

Key Words: *Challenges, COVID-19 pandemic, Hybrid education, Online education, Opportunities, Post-pandemic changes*

1. Introduction

Education is a method to transfer knowledge and skills to the learner that creates new philosophies and concepts. There are millions of humanoid viruses in this world and few thousands of them are defined with detailed facts; consequently, these viruses have created thousands of complications to humankind and environment [1]. Our history is witness that knowledge is a tool that finds the solutions of these viruses, diseases and other problems; hence, knowledge cures diseases and ignorance grows sickness; is a common knowledge. We all know about COVID-19, a contagious pandemic, currently causing lots of destruction to the humanity; subsequently, all the world is suffering. People stay and work from their homes, for the reason of social distancing and protective measures. Educational institutions, business organizations, planes, transport systems and many others have changed their working schedules. Educational sectors have decided to carry on their studies to spread the knowledge through online teaching that is generally known as 'pandemic pedagogy'.

The overall approach of teaching and learning around the world has changed during COVID-19 and post pandemic way of education will not be the same, as earlier. Academicians and field experts are required to search techniques and methods to embrace the current changes and find solutions to face existing challenges; keeping in view the future. Schools and tertiary education around the world are in quest of novel e-learning practices to carry on the offering of sound teaching and learning. Educational policy makers, researchers, instructors, students, managerial head of educational institutions, and parents are the key stakeholders of an educational system [2].

Parents can play a vital role to make the house as an appropriate place of learning through learning familiar environment; parenting styles are counted as catalysts and moderating variables. Teachers and students are going through difficult stages, at present. Teachers are facing problems in using new technologies and students are fronting difficulties in learning new technologies. Moreover, teachers are working hard towards the adoption of strategies for increased motivation and engagement of students and implementation of soft skills. It is commonly know that curriculum is another key area, facing challenges, at present, and will be in a dire need of revision towards the way of instruction, after the pandemic. Therefore, the change of transfer from formal face-to-face education to online learning is challenging and demanding.

It is witnessed by UNESCO that there is a closure of teaching and learning around the world during COVID-19, which has affected sixty percent of learners, globally, and impacted two hundred countries with a total count of 1.5 billion affected learners [3]. Some of the pedagogical organizations had tried to manage COVID-19 situation and moved towards emergency online education and others could not find proper ways of crisis management [3]. Next sections of the paper explain the terms of online education, prominent elements of effective online education, challenges, opportunities, changes and areas to focus after COVID-19, conclusions and references.

2. What is Online Education?

Online education is a practice where learning material is provided to learners through electronic gadgets using internet [4] that helps the learners to study remotely, from anyplace [5]. Online education is a paperless pedagogical process of online instruction through electronic devices

that is also called Electronic learning, E-learning, and online teaching and learning [6].

3. Elements of Effective Online Education

There are many elements for effective online education. Some of them are as following:

3.1. Selection of mode for online learning and preparation of Course Material

Type of mode for online learning is significant. There are different types of e-learning modes, like computer assisted instruction, synchronous online learning mode, asynchronous mode, adaptive online learning, linear online learning and collaborative online learning, and the preparation of course material according to the selected modes is the key of effective online education [7].

3.2. Selection of Instructional Tool for online conferencing and Training

There are famous tools available in the market for online conferencing, such as Google Meet, Zoom and Skype. The selection of conferencing tool is an important step towards online education. This tool needs to be easily accessible and installable; learners should be trained and well aware about the usage of web conferencing tool for online sessions.

3.3. Students Attitudes

Attitude is an opinion, view and feeling of a person about something [8]. The success of learning depends on the learners if they are ready to go through online education in a worthy manner [9]. As cited by [10] attitude of learners is counted as a substantial element for successful online education.

3.4. Students Motivation and Engagement

Motivation is a purpose to act and a will to do something with a specific approach [11]. Engagement is an energetic agreement to perform something [12]. The idea of motivation is thoroughly connected with engagement; therefore, learners' engagement is directly based on motivation [13]. Motivation and engagement are the most important elements in online education [14].

3.5. Formative and Summative Assessments

Formative assessment is a practice that is used to receive the learners' feedback on studied material, continuously, to enrich the instructional process [15]. Online formative assessment is significant for the success of online educational process [16].

Summative assessment is the most important part of an educational process [17]. During COVID-19 formal method of summative assessment has transferred to online assessment [18]. Currently, the assessments are done through remote online invigilation [19]. Unobserved cheating in online assessments harmfully affects the assessment and learning outcomes [20].

3.6. Scenario based learning – active learning

Scenario based learning is based on scenarios linked to real world situations that connects the learners towards its implementation, as they will come across in their approaching future and is significant for active learning [21]. Scenario based learning in online education is very effective for students motivation and engagement towards active learning and these scenarios can be created from text-based data to collaborative and immersive simulations [22].

3.7. Online Implementation of Soft Skills

Collaboration, critical thinking, decision making, problem solving, time management and teamwork are necessary soft skills for the effective pedagogical instruction [23]; therefore, these soft skills are also necessary during the process of online instruction.

3.8. Readiness of stakeholders towards Online Learning

Major stakeholders of the pedagogical process are policy makers, researchers, teachers, learners, administrative heads of educational establishments, peers and parents [2]; all of them need to be ready for the process of online instruction.

3.9. Parenting Styles

According to the declaration of [24, 25] there are four parenting styles, including: authoritarian or disciplinarian, permissive or indulgent, uninvolved and authoritative. Style of parenting has a direct impact on the process of online learning and linked environment.

4. Challenges, Opportunities and Post-Pandemic Changes of Online Education (during and after COVID-19)

A research was conducted by [26] through receiving the survey questionnaire feedbacks of 184 students, and detailed that online learning is still not as much effective that can be considered a perfect alternate of face-to-face instruction. Researcher aimed to explore the challenges of online education during COVID-19, faced by the learners of the English language course. Students faced problems in accessing the learning management system (Blackboard). Key issues were based on technical problems, such as internet connection, joining of online meetings and downloading of electronic resources. Less than fifty percent of students were pleased with the practice of online learning, fourteen percent were dissatisfied with online pedagogy and forty three percent of students were not in the favor of online education as an ongoing practice after COVID-19.

A study piloted by [27] underlines the challenges and elements prompting the use of online education during COVID-19 as a pedagogical process for Zagazing University, Egypt. Total number of participants was 346. Outcomes of the study discovered that all the participants

had accepted online learning as a medium of self-paced learning (36% strongly agreed and 64% agreed – rounded data). Subjects had strongly agreed about the helpfulness and comfortability of online education. Major challenges were based on technical issues, like internet connectivity and non-availability of computers and laptops.

Online learning has gained a fame at international level during COVID-19; several universities have implemented learning management systems like Moodle, but it is obvious that these online learning systems are not entirely satisfying the requirements of learners [28]. A survey was conducted by [29] on undergraduate learners at an African university; total number of subjects was 137, and requested to furnish their opinions on the use of online learning technologies during COVID-19. Outcomes of the study specified that portable electronic devices were used for the study and to access the resources. Learners had faced problems with network issues and encountered challenges during online study, connected with the different atmospheres at homes. Study recommends towards the mobile learning as a feasible solution for Africa.

Instructors' and learners' deficiency of expertise towards online education, problems in motivation, engagement and interaction between instructors and learners, issues in transformation of offline instructional resources (contents of curriculum) into online (curriculum revision), issues in conducting formative and summative assessments and internet connectivity problems were some of the challenges faced by the field of education during COVID-19 pandemic [30].

The major opportunities during COVID-19 pandemic are the changes of pedagogical systems towards online education that indicate towards re-structuring of pedagogical practices in the direction of purpose and importance, change in policies and procedures of institutions, testing of different styles of online instruction, escalation in teachers and learners expertise and competencies, increased research towards online pedagogy and new instructional practices with blended learning approaches, and this transformation during COVID-19 towards online education provides a significant opportunity to recognize deficiencies and limitations in present educational structures that will help to move in the direction of online educational technologies to meet the future requirements [30].

COVID-19 has suddenly moved our formal face-to-face instruction to online pedagogical education [27]; and has provided the opportunity to identify the limitations to re-structure the existing educational system towards future requirements [30]; therefore, proper selection of online learning mode is very important for the process of successful online instruction [7]. It is claimed by [31] that parenting styles have direct impacts on the academic achievements of youngsters. Therefore, it is important to adapt a suitable style of parenting that caters the need of a learner's online learning environment. As detailed by [23] soft skills are substantial during the process of education, like time management, problem solving, teamwork are crux of teaching and learning; therefore, implementation of soft skills through online instruction is very important. If a learner feels that an electronic communication tool is friendly and comfortable while using, and counts it as an important part of online instruction then overall this attitude helps the learner in better learning outcomes [32, 33, 34, 35, 36, 37, 39, 40]. Scenario based learning needs to be included in online education because it promotes active learning and learners get motivated and engaged through the use of scenarios [22].

Post-pandemic (COVID-19) changes for educational systems require a greater implementation of online communication and teamwork, diverse digital methods of online learning and formative and summative assessments, different settings of hybrid learning environments that could replace traditional methods of pedagogy, self-directed and decentralized educational atmosphere, concentration on personalized and learner-centered approaches, artificial intelligence based tutoring and solutions, augmented reality and virtual reality based solutions, robust trainings to develop and polish the expertise of instructors and learners, increased budget for online educational tools and research based activates, and increased faith in online instruction [30]. Post-pandemic (COVID-19) changes for the educational institutions involve in concentrating on four significant elements, including: 1). Formation of polices towards online education. 2). Easy approach to online materials and means of learning. 3). Training opportunities. 4). Continual assessment and observation [38].

Following figures 1, 2 and 3 show the key points of literature review, given in above sections of this paper, concerning 'Challenges towards online education during COVID-19 pandemic', 'Opportunities towards online education during COVID-19 pandemic', 'Changes and areas to focus towards online education after COVID-19 pandemic', respectively.

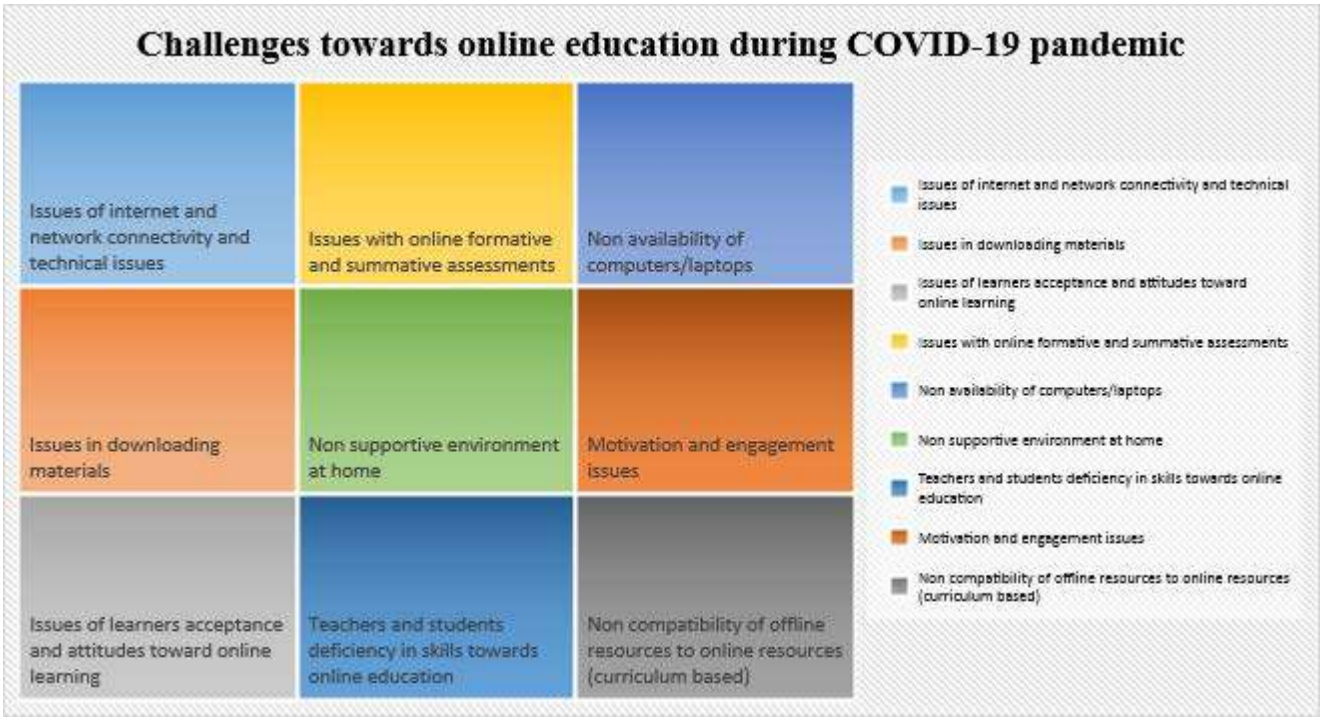

Figure 1: Challenges towards online education during COVID-19 pandemic – key points (based on literature review, given above).

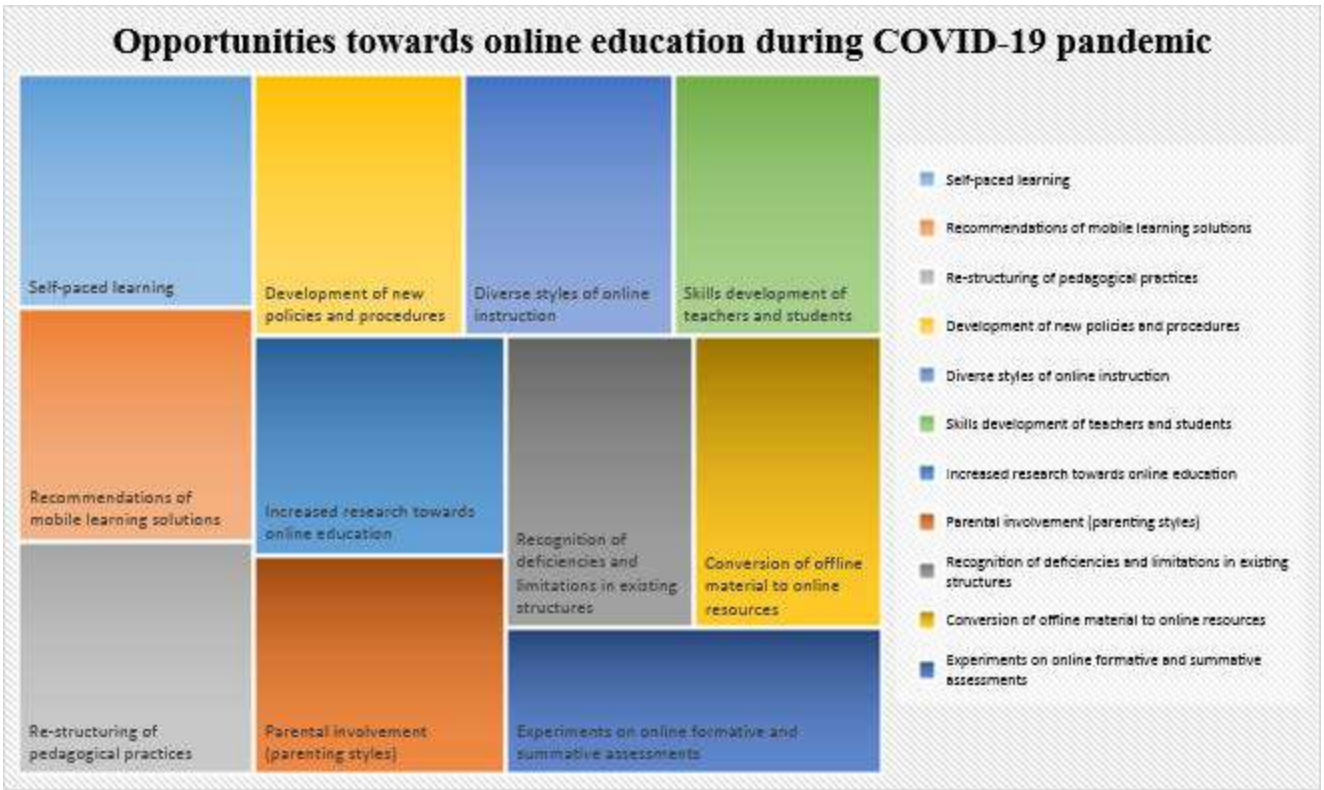

Figure 2: Opportunities towards online education during COVID-19 pandemic – key points (based on literature review, give above).

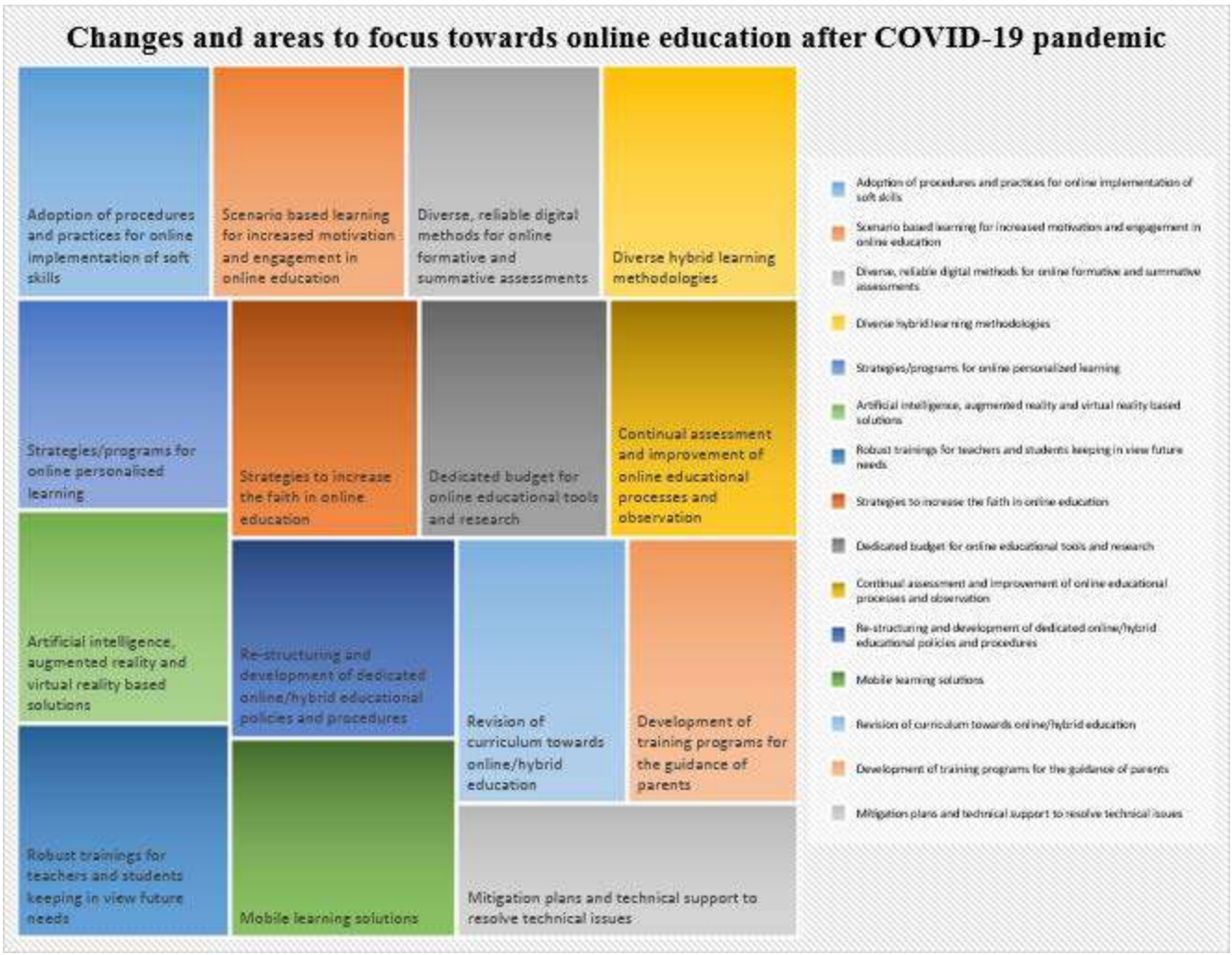

Figure 3: Changes and areas to focus towards online education after COVID-19 pandemic – key points (based on literature review, give above).

5. Precise Blend - Hybrid Mode of Education

There are open discussions about how much of hybrid education is required at present and after COVID-19 scenario. It is empirically evident that hybrid learning is effective, produces positive attitudes in learners, helps in detailed understanding and learning of course contents and supports in gaining high marks in the exams [37]. The research piloted by [26] declared that overall 57% of learners were not satisfied with the online learning during COVID-19; among those 43% were reluctant towards gaining the education through online mode of learning after pandemic. Therefore, learners' contentment is paramount in the process of education. The major apprehension is about the precise blend of hybrid education that could be adapted towards the successful learning outcomes. A combination of face-to-face and online education (hybrid mode) could be the future of pedagogical instruction.

6. Conclusions

The COVID-19 pandemic has passed shocking effects on the educational sector at international levels. Presently, online learning is not in the position to fully replace traditional face-to-face instruction. Building a successful roadmap needs efforts to develop a precise blend of face-to-face and online education towards an effective process of education, keeping in view the elements working as catalysts and moderating variables to prepare learners, educationists, field experts, parents, educational establishments and all other stakeholders, to meet current

scenario of pandemic, encounter unpredicted crisis, and accommodate the future post-pandemic requirements, globally; it is necessary to develop strategies for the online application of soft skills, mitigation plans and technical support to resolve technical issues, scenario based learning to provide learners with motivated and engaged online environments, different trustworthy ways to evaluate the students through online examinations, different hybrid learning styles, strategies for personalized learning, artificial intelligence (like Chabot), augmented reality and virtual reality based solutions, training programs for instructors and learners envisioning in future needs, strategies to increase and win the confidence of general public in online learning, financial support for the acquisition of online educational tools and online educational research, nonstop evaluation and enhancement of online pedagogical practices and revisions, targeted policies and procedures for online/hybrid learning, implementation of mobile learning practices, change of curriculum towards hybrid pedagogy, guidance and training programs for parents towards their roles and responsibilities in the pedagogical process within a hybrid learning environment.

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A Conceptual Framework of Instruction after COVID-19 Pandemic - VIAUTWGA Hybrid for VARK Learners

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Abstract: *Education sector is under the effects of COVID-19 pandemic, internationally. Post-pandemic instructional methods and solutions are required for teaching and learning. VARK is model of learning styles that tells about four types of learners, including: visual, auditory, reading/writing and kinesthetic. Micro learning is a practice of instruction that divides the course contents of learning in tiny parts, and its usage in small steps. Video podcasts, audio podcasts, Twitter and digital gamification are electronic communication tools, used for educational research in the form of micro content within hybrid learning atmosphere, and produced positive learning outcomes. This paper presents a conceptual framework, termed VIAUTWGA hybrid (video, audio, twitter and gamification based hybrid framework) that offers an appropriate image for understanding the aftermath of these electronic communication tools through micro learning technique within a hybrid learning atmosphere via experimental evidences that fits on the learner styles and simplifies the dynamics towards effective improvement of hybrid learning outcomes regarding knowledge and skills development, and offers an opening for educators, researchers and field experts to further explore the framework.*

Key Words*: Asynchronous mode, COVID-19, Hybrid education, Micro Learning, Post-pandemic solution, VARK model*

1. Introduction

Education is a process of teaching and learning that gives knowledge and awareness to humankind. The importance of education can be seen from the ongoing pedagogical practices during medical emergency of COVID-19 because it is continuous in the form of online education, and the bottom line is: knowledge is power.

There are debates about the post-pandemic solutions; because COVID-19 pandemic has strongly affected the educational industry [1]. There is a call for post-pandemic methods of teaching through the utilization of digital resources [2, 3]. A study conducted by [4] on 184 subjects clearly indicates that pure online learning is not the solution of effective instruction because 57% of participants were disappointed with online mode of education during COVID-19 and 43% of the participants had denied to carry on the process of online education after COVID-19 pandemic. Outcomes of the studies [5, 6, 7, 8, 9, 10, 11] experimentally prove that hybrid mode of education through micro learning technique produces positive learning outcomes, supports for in-depth understanding and learning of course material and assists in achieving high scores in the assessments. The process of instruction needs to be planned for all types of learners, including: visual, auditory, reading/writing, and kinesthetic learners (VARK model of learners) [16, 17]. Flipped learning is a pedagogical practice of instruction that flips traditional face to face mode of education with a method of learning which happens outside of classroom, where learners are provided with educational content before the class, and classroom interactions are utilized for discussions and interactions about the targeted course topics [26].

Consequently, on the basis of present scenario of education during COVID-19, the major question is: what kind of framework could be effective for post-pandemic setup, through the combination of online and face-to-face instruction that fulfills the needs of all the types of learners? The proposed framework in this paper tries to find out the answer of this question. Next sections of the paper speak about review of literature, VARK model of learning styles, experiential evidences of effectiveness about the use of audio podcast, video podcast, twitter and gamification as tools of micro learning with hybrid learning atmospheres, proposed conceptual framework of hybrid education, conclusions and references.

2. What is Micro Learning, Hybrid Learning, Asynchronous and Synchronous mode?

Micro learning is a new method in the field of education that divides the learning content in small pieces and utilizes in small steps [12, 13, 14].
Hybrid mode of education is a technique that combines digital content and resources with traditional method of face-to-face instruction [15].

Asynchronous mode of online education is based on performing any kind of electronic learning activity according to a feasible schedule (anywhere, anytime), such as, reading and writing electronic text and messages,

listening of recorded auditory and video materials, and playing online educational games [25]; however, synchronous mode of online education is based or real time communications, such as online chat sessions and video conferencing [25].

3. VARK Model – Different Learning Styles, Benefits and Usage

Researchers [16, 17] categorized learning modes of students and developed VARK model, as shown in figure 1 that is the abbreviation for 'Visual', 'Auditory', 'Reading/Writing' and 'Kinesthetic' learners, as following:

3.1. Visual learners

These learners use the information in a greatest manner if it is offered in visual form, such as pictorial representations, figures, arrows and videos.

3.2. Auditory Learners

These learners produce outstanding results if they are provided the information to listen in auditory (audio) form.

3.3. Reading/Writing Learners

These learners perform their best in reading/writing mode because written words are their first and favorite choice towards successful learning.

3.4. Kinesthetic Learners

These learners perform their best through hands-on (practical based) activities.

Figure 1: VARK ('Visual', 'Auditory', 'Read/Write' and 'Kinesthetic') model of learners [16, 17]

Use of technology in the process of teaching stimulates the pedagogical practice of learning with a pleasant experience for learners [18]. Auditory learners perform their best with the provision of auditory material [16, 17]. Audio podcast is the form of recorded information that can be listen at any location and any time, and works as catalyst for the construction of knowledge [19]. The material of study based on video content is advantageous for visual learners [20]. Reading and writing learners love to read and write during the process of learning [16, 17]. Twitter is a social networking tool, working on the rule of micro-bits of information, specially used to read/write and share short text messages [21]; and tweets are restricted to 280 characters in length [22]. Games and gamification based methods for instruction are favorable for kinesthetic learners towards better learning [23, 24]. Therefore, keeping in consideration the VARK model, global educational industry is looking forward to have a post-pandemic framework that works for auditory, visual, reading-writing and kinesthetic learners through electronic communication tools for online instruction in combination with face-to-face teaching within hybrid learning atmospheres.

4. Empirical Evidences of Effectiveness about the use of Audio Podcast, Video Podcast, Twitter and Gamification

Researcher had conducted several research experiments [5, 6, 7, 8] based on the use of audio podcast, video podcast, educational gamification and twitter as effective tools of micro learning within hybrid learning atmosphere; for each experiment there were two groups, including: an experimental group and a control group. Both groups of each experiment studied a course module. Each experimental group was experimented with micro learning content (all the course contents were divided in small portions) and provided as asynchronous mode with face-to-face instruction as additional resources for the purpose of revisions, including: (i). first group (with recoded audio podcasts of course contents less than four minutes). (ii). Second group (with recorded video podcasts of course contents for less than four minutes). (iii). Third group (with gamification [game based website] less than five minutes for each attempt). (iv). Fourth group (with Twitter through tweets; each tweet was less than 280 characters), and all experimental groups were requested to use one micro content/topic at one time and to give a gap before using the next micro content/topic; however, control group went under formal face-to-face instruction, only. Examination was conducted for both the groups at the end of studied module and comparisons were done on the group means (averages) of exam results. All the four experimental groups, including: audio podcast, video podcast, gamification and twitter gained high scores (higher group means of exam results) as compared to control groups, respectively. Moreover, all the four experimental groups were furnished with survey questionnaires to provide their feedback at 'Before' and 'After' the use of electronic communication tools. The survey outcomes indicate that overall, online learning through these four electronic communication tools via micro learning technique within hybrid learning atmosphere was proved to be friendly and comfortable while using, counted the use of electronic tools as an essential part of the instructional process, and these tools had helped the learners in understanding and learning the

in-depth ideas of the studied content, supported them in the preparation of exams of the studied content, and learners counted micro learning through these electronic communication tools within hybrid learning atmosphere (online education supported with instructor [face-to-face]) as favorite mode of learning.

Table 1 shows the empirical evidence of efficacy concerning the electronic communication tools used for the experiments, including: video podcasts [6], audio podcasts [5], twitter [8] and gamification [7]. These tools were used with micro learning technique through the division of course contents/topics in micro parts via micro steps to be used by the participants of experimental groups within hybrid learning atmospheres; that fulfills the requirements of VARK model of 'Auditory', 'Visual', 'Reading/writing' and 'Kinesthetic' learners. The outcomes of these studies are published in a peer reviewed international journal and a prestigious conference. Based on the names of electronic communication tools, this proposed framework is given the name of **VIAUTWGA**; an abbreviation of '**Vi**deo podcast' plus '**Au**dio podcast' plus '**Tw**itter' plus '**Ga**mification'.

Table 1: Constructive outcomes of research studies for 'Video podcast' [6], 'Audio podcast' [5], 'Twitter' [8] and 'Gamification' [7] as micro learning tools within hybrid learning atmospheres.

Electronic communication tool (for experimental groups - VIAUTWGA)	**Micro learning technique (conversation of course content in micro form) – tool used**	**Request to use each micro content/topic after different interval of times**	**Exam results of experimental group (group means of exam marks)**	**Exam results of control group (group means of exam marks)**	**Difference: Group means of exam marks for experimental group – control group**
Video Podcast	Video recordings of less than 4 minutes *Tool used: (Video recordings based on PowerPoint slides, supported with audio content)*	Use of single micro content/topic at one time for all the experimental groups of VIAUTWGA: 'Video podcast', 'Audio podcast', 'Twitter' and 'Gamification' – participants were requested to give a gap between the use of next micro content/topic.	65.8%	58.3%	7.5%
Audio Podcast	Audio recordings of less than 4 minutes *Tool used: (Audacity; a free software for audio recording)*		66%	55.3%	10.7%
Twitter	Tweets of course content as micro text messages (maximum 280 characters for each tweet) *Tool used: (formal tweets through Twitter account)*		64.9%	55.5%	9.4%
Gamification (game based learning)	Playing the game for less than 5 minutes. *Tool used: (A free website available for game based learning)*		71.9%	57.1%	14.8%

Summary of survey questionnaire for four experimental groups towards key areas:
A survey questionnaire (based on 5-point Likert scale) was used to receive the feedback of participants from each experimental group for two stages; 'Before' using electronic communication tool and 'After' using electronic communication tool plus attending the exams, including: video podcast, audio podcast, twitter and gamification groups, through micro learning technique within a hybrid learning atmosphere, concerning seven key areas: (i). Opinion about the use of electronic tool as 'Friendly' (ii). As 'Comfortable'. (iii). As an 'Essential' part of hybrid based instruction. (iv). Help of electronic tool in 'Understanding' the course contents. (v). Help in 'Learning' the course contents. (vi). Help in 'Preparation of exams' (vii). Opinion about favorite 'mode of instruction through the use of electronic communication tool via micro learning technique and supported with instructor within a hybrid learning atmosphere'.
Group means of experimental groups were taken for each experimental group for 'Before' and 'After' stages and differences were calculated on the basis of both stages. Overall, seven key areas received positive feedback with a huge size of change from 'Before' to 'After' stages, towards all the four experimental groups.

5. VIAUTWGA Hybrid - A Conceptual Framework of Post-Pandemic Instruction for VARK Learners

Owing to experimental attestations given in Table 1; Figure 2 shows the proposed VIAUTWGA hybrid framework of teaching for VARK learners' model, as a post-pandemic solution for educational institutions.

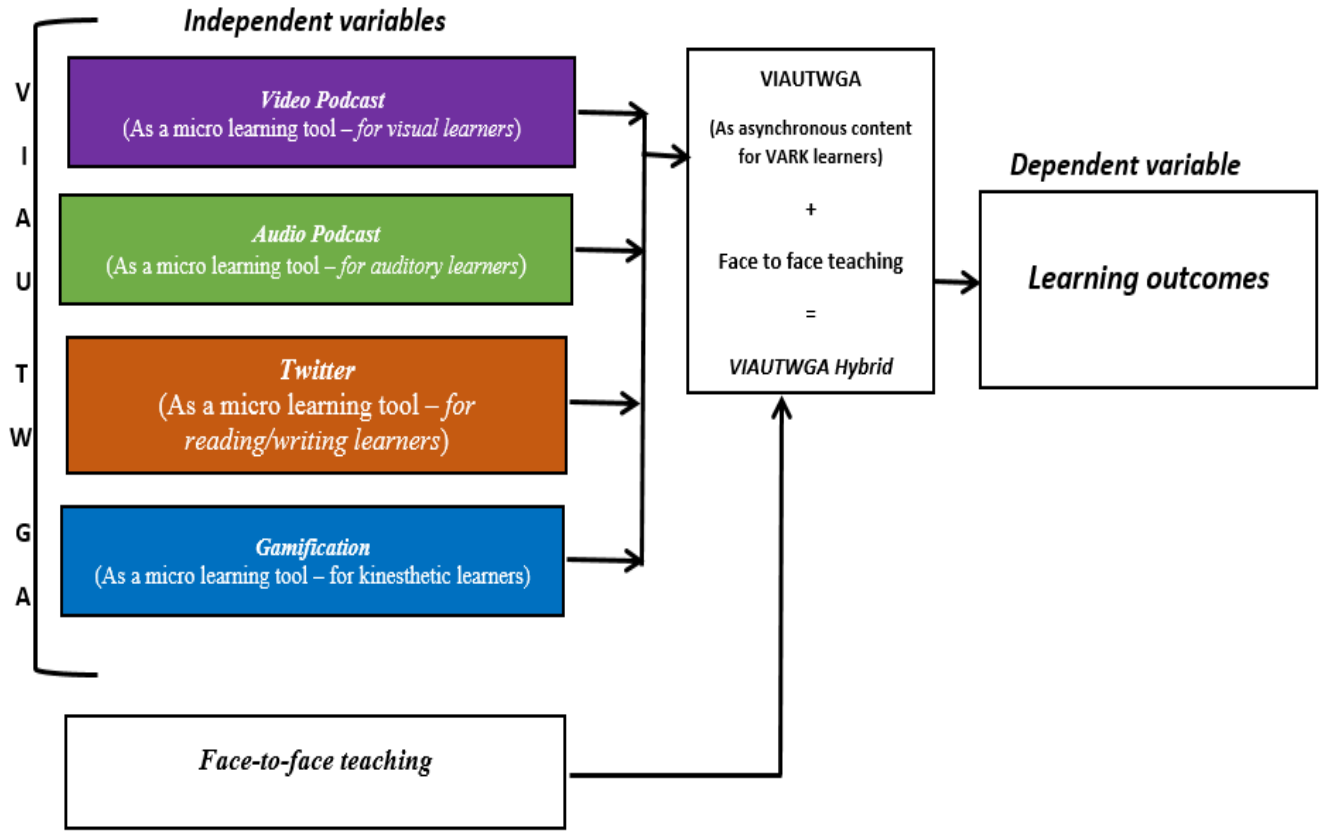

Figure 2: VIAUTWGA hybrid framework of instruction for VARK leaners

Figure 2 illustrates proposed VIAUTWGA ('Video podcast', 'Audio podcast' 'Twitter', 'Gamification') hybrid framework of instruction for the famous model of learners' categories: VARK ('Visual', 'Audio', 'Reading/writing', 'Kinesthetic' learners model) through micro learning method (division of learning content in small parts and used in small steps) within hybrid educational atmosphere, towards post-pandemic solution. Audio podcast, video podcast, twitter and gamification (game based instruction) are independent variables that need to be integrated with face-to-face teaching as hybrid mode of instruction (VIAUTWGA hybrid); and to impact in a constructive manner on the dependent variable 'Learning outcomes'.

6. Conclusions

Education is one of the major sectors affected by COVID-19 pandemic; consequently, pedagogical practices were moved to online instruction, worldwide. Educational field experts, policy makers and academicians are looking for constructive post-pandemic solutions. Overall, pure online education is ineffective and cannot replace the traditional face-to-face mode of instruction; hybrid learning is a feasible solution that can be adapted as an effective mode of education after pandemic.

According to the VARK model of learners, educational resources need to be planned for visual, auditory, reading/writing and kinesthetic learners. Post-pandemic situation requires instructional solutions towards hybrid (combination of face-to-face and online instruction) mode of education. Online instruction is based on electronic communications. The data presented in table 1 clearly indicates that experimental evidences are available to select 'Video podcast', 'Audio podcast', 'Twitter' and 'Gamification' (gamed based learning) as suitable communicational tools to produce micro asynchronous content that needs to be integrated with face-to-face mode of teaching, and to form a hybrid educational framework that fulfills the requirements of VARK learners' model.

This paper provides a suitable image to understand and connect the learners' types of VARK model with electronic communication tools through micro learning technique for visual, auditory, reading/writing and kinesthetic learns through the use of micro content in combination with face-to-face instruction and proposes VIAUTWGA (video, audio, twitter and gamification) framework of hybrid education. After the conversion of all the learning contents in micro forms for all the four types of learners, micro materials have to be provided and required to be used as asynchronous materials in micro steps that could be for preparations and revisions of the course topics, or as flipped learning contents for after or before every lecture, respectively, and learners could be given the choice to use one, two or all types of micro-electronic contents (videos/audios/tweets/digital gamification attempts). In addition, after the preparation of micro contents as the instructional material, these could be used in case of any educational emergency that will support towards easy transition to pure online learning, along with synchronous mode, such as, in combination with video conferencing; and leaners and teaches will be in a ready mode to move towards online education. Experimental confirmations verify that these four electronic communication tools are independent variables, holding the potential of catalysts to moderate and positively enhance the learning outcomes of pedagogical instruction. Overall, this conceptual framework is an economical solution because creating video podcasts, audio podcasts, use of a formal twitter account and utilization of a freely available website designed for game based learning are pocket friendly solutions; moreover, the conversion of course contents into micro learning topics using these electronic communication tools is an easy task because of their familiarity with everyone. Therefore, there is no need of any technical training for learners' and teachers. Besides, plenty of video based educational material is freely available on the internet that can be used and divided into micro content. Audio podcasts can be recorded in micro pieces of information through a wide variety of freely accessible software through the World Wide Web. Twitter account can be created and used for tweeting (less than 280 characters for any single micro tweet) without any cost. There are number of complimentary educational games, available online that can be played with micro attempting based strategies; additionally, if the budget of an educational institution allows then educational games can be purchased, artificial intelligence based support, and augmented reality and virtual reality based solutions can be adopted as game based instruction. Consequently, after COVID-19 pandemic this conceptual framework of hybrid education would be a successful pedagogical solution to bridge the gap towards the requirement of most effective mode of instruction. Further empirical exploration is required by the educationists, researchers and field experts towards the integration and testing of VIAUTWGA framework of hybrid education with formal face-to-face instruction.

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EXPERIENCES AND OPINIONS OF HIGHER EDUCATION STUDENTS ABOUT REMOTE LEARNING DURING THE COVID-19 PANDEMIC

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Abstract: *Covid19 crisis has resulted in school and university shutdowns around the world. Moving from face-to-face to remote learning posed many challenges for both teachers and students. This research aimed to investigate student satisfaction with conducted remote and online learning during the pandemics. Of particular interest is to identify challenges and obstacles that students were faced with, and that can be used to make recommendations for improvements. The research included 832 higher education students from two universities in Serbia. While students conducted their studies online, this research distinguishes and compares student satisfaction studying in two different modalities: remote learning and online learning.*

Keywords: *Covid19, remote learning, online learning, higher education*

1. INTRODUCTION

The spread of the Covid19 pandemic has affected all sectors in society and, in particular education. Covid19 pandemic caused school shutdowns throughout the world. Many have chosen to transfer their teaching from face-to-face to online environment. This change has caused many challenges, including teachers and students who were not prepared for this transition, as well to different concerns such as what to teach, how to teach, the workload of teachers and students, the teaching environment, and the implications for education equity [1]. Transition from face-to-face to online learning modalities has demonstrated itself as a test to many schools and higher education institutions on their preparedness to promptly respond in emergency situations. Many institutions have shown interest in investing in best teaching practices, in order to engage learners and conduct most effective teaching, while others have found many obstacles in achieving the same.

This quick transformation from face-to-face courses to online formats of teaching has generated a lot of attention, but it also generated great misconception, with equating online and remote learning. “Remote learning” implies that teachers are delivering their instruction from distance, because they are not able to deliver the instruction physically in the classroom. On the other hand, “online learning” is founded on different concepts where teaching and learning materials are always available to students [2]. Even though remote and online learning share similar components, online learning requires different design and planning [3].

Means et.al. discussed nine dimensions that should be considered when designing online learning: modality, pacing, student-instructor ratio, pedagogy, instructor role online, student role online, online communication synchrony, role of online assessments, and source of feedback [4]. In contrast to detailed design and planning, needed for the good quality online course, remote learning (in some literature used terminology is “emergency remote learning”) represents a temporary shift of instructional delivery to an alternate delivery mode due to crisis circumstances [5].

Due to the identification of the first case of Covid19 in Serbia, face-to-face teaching was transferred to remote learning in March 2020, in an effort to mitigate the spread of the Covid19 pandemic. In that moment a transition from face-to-face to remote teaching was made, i.e. teachers and

teaching assistants started to conduct live online video lectures at the same time that traditional teaching would have taken place, but from the convenience of homes and using software streaming services. In order to investigate the quality of conducted remote and online learning, study presented in this paper was conducted. The case study was conducted in two universities in Serbia, and the results of this study are presented in following sections.

2. METHODS

2.1. Data Collection Procedure

An online survey was developed through the Google Forms platform and sent to higher education students by email. Students voluntarily and anonymously filled out the questionnaire as also using in [6]. Two groups of students were asked to fill out the survey: (i) traditional and blended learning students who transferred from their respective face-to-face modalities to remote learning modality, and (ii) online students who chose this modality independently of Covid19 pandemics. The survey was active during June and July of 2020, after remote learning classes ended (at the end of the semester). Completing the questionnaire took an average of 15 minutes.

2.2. Data Analysis Procedure

The data was analysed by SPSS software. Nonparametric tests were used because our data were not normal distributed. In order to investigate statistically significant differences in the dependent variable between the two groups Man-Whitney U-test was used to, while the Kruskal-Wallis test was used in cases where three or more groups were compared. In order to determine the differences between individual groups, post hoc tests were run. Quantitative data were supplemented by qualitative data in order to create a better picture and deeper insight into students' perception of the learning process.

2.2.1. Instrument

The survey was based on the questionnaire that consisted of four parts. The demographic data (gender, university and learning environments) of the students were collected in the first part. The second part was based on Intrinsic Motivation Inventory questionnaire [7] with measures of motivation. The students rated questionnaire items on a Likert's scale from 1 (strongly disagree) to 6 (strongly agree) [8]. The third part of the survey consisted of 16 statements about remote learning. The students were able to choose items to express their agreement with a given statement, which was used to measure student responses accordingly to positive and negative aspects (as advantages and disadvantages of remote learning). Third part was developed in cooperation with the Quality Committee of Belgrade Metropolitan University during the ethical approval procedure. The final and fourth part of the questionnaire consisted of semi-structured debriefing session inspired by three open questions: (i) "Describe advantages of remote learning from your perspective", (ii) "Describe disadvantages of remote learning from your perspective," and (iii) “Give your comments (good/bad) on organization and university operations during the pandemic?”. Using Cronbach’s α the reliability for overall motivation scale (α = .795), which indicates that all items measure the same concept, was calculated.

2.2.2. Participants

In this study participated 832 undergraduate students from two universities in Serbia (75% or 626 participants from Faculty of Science, University of Novi Sad (UNS) and 25% or 206 participants from the faculties of Belgrade Metropolitan University (BMU)). The demographic data are shown in Table 1.

Table 1: Demographic data

Category	N	%
Gender		
Male	*304*	37%
Female	*528*	63%
University		
UNS	*626*	75%
BMU	*206*	25%
Learning environments		
Traditional	*633*	76%
Online	*166*	20%
Blended	*33*	4%

Notes: N– number of students, % - percent of students

Traditional teaching/learning entails teaching in the classroom at the University, with the application of different face-to-face teaching modalities and according to a fixed schedule of classes. Online teaching / learning is an educational style where each segment of the teaching and learning process is realized online, i.e. by using the internet []9. This includes interactive teaching materials presented to students in digital form, videos, forums, Q&A questions, communication between teachers and students, as well as communication between students. While blended teaching / learning represents a combination of both online and traditional learning. This form of teaching was applied in some courses, students learned learning materials related to lectures using online learning, and then had traditional learning in the classroom for recitation and laboratory work. So, these are teaching modality that took place in the period before the COVID-19 pandemic at our Universities.

3. RESULTS AND DISCUSION

3.1. The influence of demographic data on the perception of motivation

The results of Kruskal-Wallis H tests employed to examine whether there are differences in the level of motivation

between students on different learning environment (traditional, online, and blended) during Covid19 pandemic are shown in Table 2. Significant differences among three groups were evident in respect to learning environments (H = 11.313, p = .003), with a mean rank of 401.47 for traditional, 471.72 for online and 427.08 for blended learning environments. Mean ranks indicate that online students were the most motivated for the learning process, fewer motivated were students from the blended group, and ultimately the least motivated traditional students. The three groups differed significantly on the Value subscale (H = 9.909, p = .007) and Interest subscale (H = 9.224, p = .010). No significant differences between three groups were observed for subscale Effort.

Table 2: Analysis of learning environment relatedness to students' motivation

Subscales of questionnaire	Mean Ranks			Kruskal-Wallis		
	Traditional	**Online**	**Blended**	**$\chi 2$**	**Df**	***p* Value**
Effort/Importance (IMI_EI)	418.41	415.41	385.42	.610	2	.737
Value/Usefulness (IMI_VU)	402.18	467.35	435.39	9.909	2	.007
Interest/Enjoyment (IMI_IE)	403.29	466.81	416.71	9.224	2	.010
Motivation overall	**401.47**	**471.72**	**427.08**	**11.313**	**2**	**.003**

Notes: $\chi 2$ = Chi square; Df = Degree of freedom

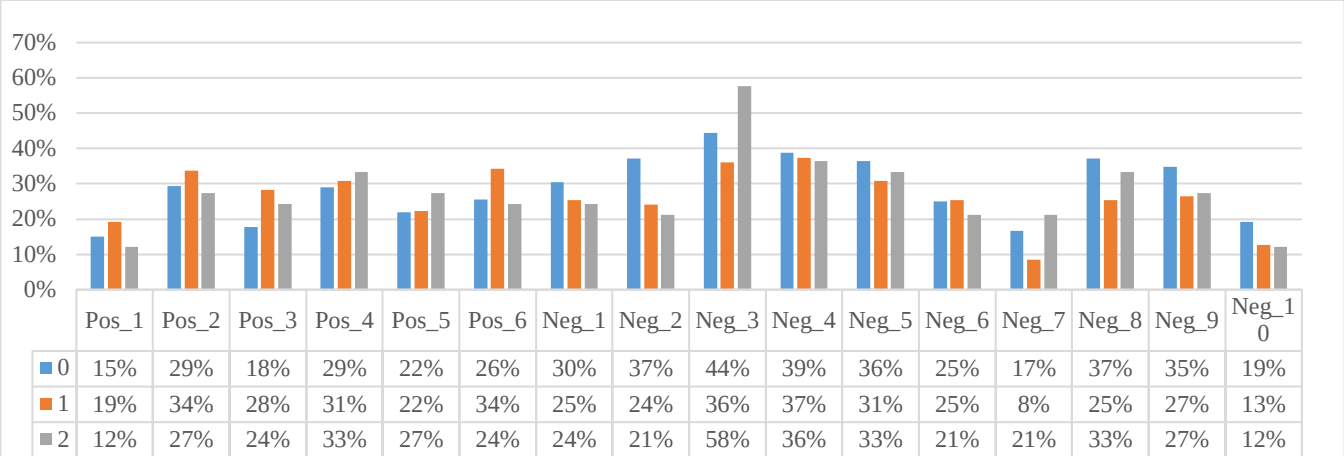
The significant results, was further examined in terms of post hoc tests and pairwise comparisons between groups using Bonferroni test. Post hoc tests showed that students from traditional group were significantly less motivated (*p* = .001) during learning process than students from online group. One of the reasons for such a result may be the fact that this type of learning was more interesting to online students and that they considered learning process useful and valuable, while traditional students group supported it to a much lesser extent.

Mann-Whitney U tests were used to determine whether the gender and Universities are related to students' motivation during remote learning at the time of pandemic. The results show no significant differences between genders regarding the motivation and its subscales (p = .213), as no statistically significant differences between the students coming from the two universities regarding the overall motivation (p = .366).

3.2. Positive and negative aspects of remote learning

Students' impressions of remote learning realized during the pandemic are presented in Table 3. Positive views of remote learning were chosen by 1206 (32%) students, while 2537 (68%) stated negative point of view towards remote learning.

The most commonly chosen statement from positive aspect was "It was much easier to attend remote learning classes than to go to university" (251 answers, 30%) while the least chosen statement from the same aspect was "I benefitted more from remote learning than going to classroom" (131 answers or 16%) (Table 3). While statements "I missed the "live word" (360 answers or 43%), and "I missed my classmates" (319 answers or 38%) were the most chosen negative aspects, which indicates a lack of socialization. Only 15% of students (126) stated that "Remote learning was boring", and 18% (146 students) pointed out that "Remote learning was very difficult for me" (Table 3). The analysis of students' responses shows the difference between the attitudes of traditional, online and blended groups of students (Imagine 1).



	Pos_1	Pos_2	Pos_3	Pos_4	Pos_5	Pos_6	Neg_1	Neg_2	Neg_3	Neg_4	Neg_5	Neg_6	Neg_7	Neg_8	Neg_9	Neg_10
0	15%	29%	18%	29%	22%	26%	30%	37%	44%	39%	36%	25%	17%	37%	35%	19%
1	19%	34%	28%	31%	22%	34%	25%	24%	36%	37%	31%	25%	8%	25%	27%	13%
2	12%	27%	24%	33%	27%	24%	24%	21%	58%	36%	33%	21%	21%	33%	27%	12%

Imagine 1: Distribution of students' impressions about remote learning according to learning environments

Analysing students' responses during the discussion (obtained by open-ended questions) it was identified that students were dissatisfied with remote learning because they felt a lack of motivation and ability to concentrate on the lecture as well as a lack of socio-emotional aspect of learning. The rapid and unexpected change has caused concern among students. The analysis of the comments indicates the most common shortcomings of remote learning are:

a) lack of live face-to-face lectures and contact with people;

b) challenge to maintain focused, as one can quickly and easily lose focus (wandering of mind due to too much freedom at home and lack of feeling that they are in class, just being in the classroom means a lot);

c) challenge to maintain high level of motivation. After a few weeks the motivation to work drops or is lost. After a few hours students get tired of working at the computer, the rhythm and dynamics are quickly lost due to lack of concentration and motivation;

d) lack of work atmosphere, as it is easy to avoid obligations in home settings with many "non-work" distractors present,

e) technical issues such as poor network connection or computer lower performance capabilities.

On the other hand, students so positive sides to remote learning as well and it entailed:

a) cost reduction on students` budgets (i.e. for food, transportation, rental housing);

b) saving time and better self-organization;

c) flexibility (at any point they can view previously recorded lessons, whether it is for learning or revisiting parts for better understanding); and finally

d) comfort and convenience (they can follow lectures in their pajamas while drinking coffee, and some theoretical lectures even in the nature).

Table 3: Distribution of students' impressions about remote learning according to learning environment

			0 (n=663)		1 (n=166)		2 (n=33)		**Total (n=832)**	
Aspect	**Code**	**Statement**	N	%	N	%	N	%	**N**	**%**
Positive aspects	Pos_1	I got more benefit than if I went to college.	95	15%	32	19%	4	12%	**131**	**16%**
	Pos_2	It was much easier to attend remote learning classes than to go to college.	186	29%	56	34%	9	27%	**251**	**30%**
	Pos_3	Remote learning suits me better than traditional teaching.	112	18%	47	28%	8	24%	**167**	**20%**
	Pos_4	I think remote learning activity could help me better to pass the exams.	183	29%	51	31%	11	33%	**245**	**29%**
	Pos_5	Remote learning was interesting.	139	22%	37	22%	9	27%	**185**	**22%**
	Pos_6	I enjoyed during remote learning very much.	162	26%	57	34%	8	24%	**227**	**27%**
	Total positive								**1206**	**32%**
Negaive aspects	Neg_1	I got less benefit than if I went to college.	193	30%	42	25%	8	24%	**243**	**29%**
	Neg_2	Traditional teaching is irreplaceable.	235	37%	40	24%	7	21%	**282**	**34%**
	Neg_3	I missed the "living word".	281	44%	60	36%	19	58%	**360**	**43%**
	Neg_4	I missed my colleagues.	245	39%	62	37%	12	36%	**319**	**38%**
	Neg_5	I missed going to university campus.	231	36%	51	31%	11	33%	**293**	**35%**

	Neg_6	Remote learning lectures were not as clear to me as in traditional classes.	158	25%	42	25%	7	21%	**207**	**25%**
	Neg_7	Remote learning was boring.	105	17%	14	8%	7	21%	**126**	**15%**
	Neg_8	Remote learning did not hold my attention at all.	235	37%	42	25%	11	33%	**288**	**35%**
	Neg_9	I could not concentrate on learning at home conditions.	220	35%	44	27%	9	27%	**273**	**33%**
	Neg_10	Remote learning was very difficult for me.	121	19%	21	13%	4	12%	**146**	**18%**
	Total negative								**2537**	**68%**

Notes: 0 – traditional group, 1 – online group, 2 – blended learning environment group

About the organization and university operations during pandemic students indicate that they are generally satisfied with the implementation of remote learning. They praised the quick adjustment in work teaching staff (some professors were especially pointed out), but also note that not all professors and assistants were equally engaged. Students suggested using one, instead of multiple software for each course, for communication would be more adequate. They also felt free to ask questions and communicate with teachers more than usual. Some pointed out that they are very satisfied with the courses where the video materials were placed so that they can study according to its own schedule. However, students clearly indicate as well the negative consequences. They felt a lack of motivation and focus, and pointed to difficulties in learning math and similar subjects. The students also expressed fear of completeness abandoning traditional teaching because they missed the socialization and socio-emotional aspect of learning. In the end, they pointed out that regardless of quality of remote learning, in most cases, preference is given to traditional teaching.

5. CONCLUSION

Presented research in this paper was empirical and it provided results based on students' experience and their views on remote learning during the pandemic. Qualitative and quantitative methods triggered a number of important points of discussion. The relationship between motivation perception and different learning environments (traditional, online, and blended) was statistically significant. The results of the research indicate the importance of previous online learning experiences. Students who attended traditional learning were significantly less motivated than students who had previously attended online learning. The results of our research indicate that there are no differences in relation to different gender, as well as institutions.

Our results show that online students had positive attitude during learning process. In fact, their environment has not changed, they have continued to study in online learning environment as they chose from the start. On the other hand, traditional students more often agree with negative items and to a greater extent indicate: dissatisfaction with remote learning, reduced motivation, lack of concentration and various difficulties. While blended students are somewhere in the middle (between the online and the traditional ones). These results indicate that traditional students are most vulnerable when it comes to developing motivation to learn and that they may need more support than other students when classrooms switch to the internet and remote learning because this way of working is very different from the one they are accustomed and which they were choose.

In terms of future research, it is important to understand the consequences of this type of learning on the success of students.

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WILL TRADITIONAL FORM OF STUDYING BECOME OBSOLETE IN THE FUTURE?

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Abstract: *During the Covid-19 crisis, most of the universities started delivering lectures online both for traditional and on-line students. This change caused the paradox situation in which traditional students were obliged to continue studying in a way they did not opt for from the beginning. The paper examines effects of this digital transition on traditional undergraduate students in the field of management, it and arts during the school year 2020/2021 and compares it with the results from the previous school year. The results of the research show us the answers related to student's satisfaction within the following categories: teaching material, lecturing and assessment. Furthermore, this paper tries to find the answer will traditional form of studying become obsolete in the future or it will stay as an independent form of studying in the higher education field.*

Keywords: *Performance measurement, on-line learning, digital transition*

1. INTRODUCTION

Organization has to adopt on any changes, challenges and risks that occurs in business. The ability to adopt and respond is essential for success to survive. One such occurrence that needs answer and response for new way of doing business is Covid 19, which began in first quarter of 2020. Social distances policy and government measures imply learning and education activities from home. All levels of education apply distance learning from home and professors and students felt the heavy impact of these changes [1].

The Covid 19 pandemic has caused major changes in everyday life and business around the world. Young populations who need to be educated were particularly affected and isolation measures prevented them from attending classes in classroom. Such changes caused a great deal of stress to students and high school students who were prepared and expected and applied to study live at the university. And it happened that they had to listen to classes from home and adapt to the new situation. The only realistic answer to this situation that could have been provided to students and to continue the process of elaboration was the application of e-learning, which has been applied in certain cases before and in situations when students opted for it. From the experience of institutions that applied e-learning even before the pandemic, most often these were students who were already employed and were therefore prevented from attending the classes in person.

Due to all the above, the education sector was forced to to turn to the application of digital technologies. Many institutions in primary, secondary and higher education had to adapt to the new situation in a short period of time. The higher education sector has been required to transition to an online learning environment to meet learner needs and ensure the continuity of curriculum and learning processes. The transition to online learning environment has not been without challenges, as many institutions and learners depend on the availability of online learning platforms. The COVID-19 pandemic has reinforced the importance of technology and virtual learning in education. While online learning environment provide learners with numerous benefits, the sudden shift to a virtual environment due to the pandemic requires detailed study. The purpose and the main objective of this study was to understand how students who enroll in traditional way of studies (traditional students) with forced study online accepted these changes. In addition, the research tries to find the answer if this form of on-line learning could reach the same level of satisfaction among the traditional students as it was in class before the Covid 19 crisis.

2. LITEARURE REVIEW

Large number of universities all over the world was forced to implement distance learning. Therefore, they try to find the best solution and manuals and directions for better implementation in short period of time for distance learning. One of such universities is The Peking University which prepared six specific instructional strategies for better interpretation of course materials during Covid 19 [2]. The study concludes with five high-impact principles for online education: (a) high relevance between online instructional design and student learning, (b) effective delivery on online instructional information, (c) adequate support provided by faculty and teaching assistants to students; (d) high-quality participation to improve the breadth and depth of student's learning, and (e) contingency plan to deal with unexpected incidents of online education platforms.

Kamble et al. [3], in their research present understanding the perceptions of learners at a university in India toward the sudden transition from traditional face-to-face learning to an instructor led online learning environments due to the pandemic-induced lockdown enforced across India in March 2020. Results in their research indicate that learners accepted the transition toward the online learning environment. Five key themes arose from the interview data: accessibility and comfort, Internet connectivity, online learning environment, effectiveness, course content, and interactions between students and instructors.

The findings of study Prasetyo et al., [4] indicated that students who participate in integrative e-learning show significant change in the level of readiness and interest in learning. Raspopovic et al., [5] presented students satisfaction with learning object system of e learning. Analysis in this research showed that students' learning experiences were cantered on problem-based learning (weekly and project assignments) and communication mainly with course instructors, and their peers. Traditional students gave high importance to establishing good communication with their classmates, while online students gave the same importance to their communication with the instructor and additional consults needed for their learning of the material.

Raspopovic et al., [6] concluded important parameters for analysis of students' motivation, personalization of learning materials, different pedagogical methods that will increase interactivity, optimal deadline policy for assignment, and suitability of the particular study area to be delivered through e-Learning. There is a difference in academic areas whether they are suited for online studies, especially as this research has shown that success for online studies is different not only for different areas, but as well as for courses that may have more of a hands-on approach as compared to the more theoretical courses. Suggestion from this research point out significance of evaluation of the presentation styles and course structure for each course material, as these indicators point out the existence of a clear distinction between things that students perceive as practical and theoretical. Most importantly, the results point in the direction that online students still require a lot of interaction throughout the course, so new methods for encouraging teamwork and consultations should be considered.

According to research of Yekefallah et al. [7] there was a significant relationship between satisfaction with e-learning and variables of gender and history of attending online classes before Covid-19. The study of Baber [8] explore students' acceptance of distance learning and it was conducted on the 375 students studying management program at the undergraduate and graduate level in universities of South Korea. The study examined the instructor characteristics (instructor attitude, competency & interaction), student characteristics (student motivation, mindset & collaboration), and technology acceptance model (perceived ease of use & perceived usefulness) on the behavioural intention of students to accept and use e-learning in the future. The moderating influence of the external factor 'perceived severity of pandemic COVID-19' was examined. The results suggested that all factors were positively influencing the behavioural intention to use and accept the e-learning system by the learners during this pandemic.

Beyond technology access rate in different part of India, Capelle et al. [9] find significant variations in adolescents' use of technology for learning purposes and their perceptions of learning, linked to the type of remote learning modality, gender, location and type of school. Also, one of the results of studies were that the exam performance of students who used a computer for online education was better than those who used a smartphone [10]. However, students reported increased stress and anxiety and difficulties concentrating, suggesting that the obstacles to fully online learning were not only technological and instructional challenges but also social and affective challenges of isolation and social distancing suggest that the outcomes for student's well-being may overshadow the positive academic outcomes [11].

Lemay et al. [11] analysis shows that the specific context of the pandemic disrupted more than normal teaching and learning activities. Whereas students generally responded positively to the transition, their reluctance to continue learning online and the added stress and workload show the limits of this large-scale social experiment. In addition to the technical and pedagogical dimensions, successfully supporting students in online learning environments will require that teachers and educational technologists attend to the social and affective dimensions of online learning as well.

3. ONLINE VS TRADITIONAL LEARNING

E-Learning often referred to as “Distance Learning” or “Online Learning” which involves the umbrella term for any learning that takes place across distance and not in a traditional classroom. Online learning is a Digital Education. The world is changing towards digitalization and transforming from traditional education to Digital education. Both students and teachers get flexibility in online learning. It is easy to get education digitally as it gives opportunity to learn from the best teachers of a particular subject (Digital class story, [12]). It is of importance for our research to test existing analysis od advantages and disadvantages of e-learning and tradition learning.

Advantages of E-Learning:

- One can learn at one’s own time.
- Students can study anywhere, with no restrictions on areas.
- Easy to choose subjects and topics.
- Students can interact with their teachers via social media, emails, SMS, etc.
- They can remain in contact with their teachers and get benefits.
- Students can even study in hazardous situations like heavy rain, storm, physical damage of body, pandemic, or epidemic situations.
- It saves a lot of time for students. Get time freedom for other activities.
- Learn only the necessary things and avoid unnecessary topics.
- It is much cheaper than Classroom learning means it is cost-effective for learning.
- No need to travel up to the study centre. Therefore, it protects from road accidents.

The Traditional Learning Advantages are as following:

- Students can remain in physical contact with their teachers and mentors so that they can ask questions directly to them and get satisfactory answers.
- They can develop a friendship with their classmates and others.
- Students can grow their network and compete with others.
- Experience different school, college and university activities.
- They have practical knowledge of various subjects in laboratories and fields. Therefore, they can have better knowledge.
- Students get their degrees physically and have better career opportunities.

Disadvantages of traditional learning are:

- Traditional way of education is more expensive because teachers can teach a smaller number of students at a time.
- Students have to travel to the educational institutions so that they have to pay travel expenses and sometimes, they have accommodation charges when they stay in a hostel or paying guest.
- They don’t get flexibility in time although they must reach the destination on time. They must attend lectures taken by the teachers otherwise, they miss them.

4. RESEARCH METHODOLOGY

For the purposes of this descriptive study, the research methodology defined by Forza [13] was used.

The following research questions were defined according to main research objective:

- Did transition to on-line learning, caused by Covid19, make a significant impact to level of satisfaction of traditional students?
- Will traditional students adopt the on-line learning model and could this on-line concept reach the level of satisfaction among the traditional students like it was in-class before Covid19 pandemic?

Our study focuses on The Belgrade Metropolitan University (MET), where distance learning was implemented before Covid 19 crisis as an option for students that was accepted largely by students. We investigate students who apply in traditional studies and that they choose option for traditional versus distance learning but considering conditions and crisis of Covid 19 was forced to study from home by distance learning.

MET for last 10 years developed LAMS (Distance learning management system) which gives the opportunity for students to get access for online materials for coursework, tests, homework, assessment etc. All of these were planned to be implemented to be visible and for usage of traditional students. The only difference was that it was planned for traditional students that they went to classroom and listen to professors but in this situation was forced to stay at home and listen lesson by zoom meeting.

Readiness to change relates to digital skills of all participants professors and students. Digital skills are needed because face-to-face interaction in class is replaced by virtual reality of classroom and teaching courses using digital technology [14].

The population of the research were BSc and BA traditional students from the following study fields: information technology (IT), general and operations management (MAN) and arts (ART). Only the students who were present on-line classes were allowed to fill the questionnaires which gave this research a highest percentage of viability.

The process of data collection was done using the questionnaire form on the student portal. This form is obligatory for all students who would like to take the exams in the following exam term and consists of 7 mandatory questions. This paper represents the results of the first part of the research for which only three main questions were investigated. In order to organise a comparative analysis, results for the school years 2019/2020 and 2020/2021 were collected and analysed.

To avoid this research to become biased, only courses which were offered and realised in both academic years were included in the research. New courses created in the school year 2020/2021 were not included. Also, elective courses which had less than one respondent and common subjects which are offered in several study programs were excluded also.

Since the survey was anonymous, it was not possible to classify the respondents profile using criteria such as gender, age, location or other factors except criteria such as study centre, study program and year of study. Level of satisfaction related to communication with peers was not a part of this study.

The following aspects of user satisfaction were investigated:

- SatisPM: Student satisfaction with published on-line teaching materials
- SatisOL: Students' degree of satisfaction with the lectures delivered on-line
- SatisGR: Students' degree of satisfaction with the quality assessment

Data analysis was done for two semesters: fall and spring. Basic statistic tools such as average value, standard deviation, variance and percentage share were used. The following parameters and formulas were defined:

$SatisXYaaaa = \sum i=1..n\ (SatisXYi)/n$

$SatisXY = (Satis\ XY_{2021} - SatisXY_{1920}) / Satis\ XY_{1920}$

The following rule was introduced:

- *SatisXY > 0,05:* The level of satisfaction has been significantly increased
- *0,05 < SatisXY > - 0,05:* The level of satisfaction has not been significantly changed
- *SatisXY < - 0,05:* The level of satisfaction decreased significantly

Pilot testing was organized in May 2021 using the data related to study program Operations Management. Research and data analysis for both semesters were conducted in June 2021. Data cleaning, gathering and analysis were organized using the basic statistical descriptive technique. The results of the research will be shown in the next section.

5. RESULTS

During the first phase of the research, courses in IT, management or arts which are offered in fall semester were analysed. In total, 79 four-year bachelor courses were assessed. Average number of respondents per course was 32.

Table 1: Level of satisfaction of traditional students – study field IT - Fall semester

IT	2019-2020			2020-2021		
	Avrg	StD	Var	Avrg	StD	Var
SatisTM	4.29	1.00	1.20	4.14	0.97	1.31
SatisOL	4.45	0.92	0.98	4.20	1.02	1.45
SatisQA	4.69	0.67	0.58	4.55	0.74	0.88
Average:	4.48			4.30		

Table 2: Level of satisfaction of traditional students- study field management - Fall semester

MAN	2019-2020			2020-2021		
	Avrg	StD	Var	Avrg	StD	Var
SatisTM	4.64	0.75	0.79	4.63	0.73	0.69
SatisOL	4.71	0.58	0.51	4.47	0.84	0.98
SatisQA	4.74	0.60	0.57	4.69	0.62	0.57
Average:	4.70			4.60		

Table 3: Level of satisfaction of traditional students – study field arts - Fall semester

ART	2019-2020	2020-2021

	Avrg	StD	Var	Avrg	StD	Var
SatisTM	4.49	0.87	1.01	4.59	0.67	0.81
SatisOL	4.60	0.71	0.67	4.57	0.61	0.71
SatisQA	4.66	0.66	0.61	4.71	0.48	0.50
Average:	4.58			4.62		

Fall semester in 2021 was the first semester in which on-line delivery of lectures was organized from the start, starting from the first week. During this semester significant changes in satisfaction with the teaching materials were not found among all of three researched study fields. Also, satisfaction related to quality assessment kept in balance with the results from the previous year. However, significant decrease in satisfaction with the on-line delivery of lectures was found among the traditional students in IT and management study fields.

Table 4: Difference in percentages between the average results of the researched categories of satisfaction in fall semester in school years 2020/2021 and 2019/2020

	IT	MAN	ART
SatisTM	-3.44%	-0.16%	2.27%
SatisOL	-5.75%	-5.20%	-0.77%
SatisQA	-2.90%	-1.02%	1.10%

In the second phase of the research, according to the criteria and rules defined and described in the third chapter of this paper, courses offered in spring semester were assessed. In total, 73 BSc and BA courses were assessed with an average of 32 respondents per course.

Table 5: Level of satisfaction of traditional students – study field IT - Spring semester

IT	2019-2020			2020-2021		
	Avrg	StD	Var	Avrg	StD	Var
SatisTM	4.29	1.06	1.19	4.47	0.61	0.61
SatisOL	4.45	0.86	1.02	4.76	0.48	0.40
SatisQA	4.62	0.76	0.85	4.43	0.55	0.51
Average:	4.45			4.55		

Table 6: Level of satisfaction of traditional students- study field management - Spring semester

MAN	2019-2020			2020-2021		
	Avrg	StD	Var	Avrg	StD	Var
SatisTM	4.58	0.83	0.96	4.68	0.48	0.38
SatisOL	4.61	0.73	0.80	4.73	0.43	0.34
SatisQA	4.64	0.74	0.87	4.75	0.43	0.35
Average:	4.61			4.72		

Table 7: Level of satisfaction of traditional students – study field arts - Spring semester

ART	2019-2020			2020-2021		
	Avrg	StD	Var	Avrg	StD	Var
SatisTM	4.52	0.83	0.88	4.37	0.95	1.11
SatisOL	4.51	0.83	0.86	4.52	0.83	0.86
SatisQA	4.61	0.78	0.73	4.41	0.94	1.01
Average:	4.54			4.43		

After one semester in which all lectures were delivered online, IT and management traditional students accepted this digital transition and made a positive remark about the quality of the on-line teaching material and quality assessment. Traditional students in management study field were more satisfied with the organisation of on-line lectures than in previous semester. On the other side, traditional students in arts were less satisfied with the on-line learning concept but not in such way that it should be defined as significant change.

Table 9: Difference in percentages between the average results of the researched categories of satisfaction in spring semester in school years 2020/2021 and 2019/2020

	IT	MAN	ART
SatisTM	4.26%	2.35%	-3.20%
SatisOL	-0.51%	2.49%	-2.14%
SatisQA	3.09%	2.18%	-1.87%

Comparing the results between two semesters in the school year 2020/201 in which lectures were delivered fully on-line, significant increase of the satisfaction with organisation of on-line lectures among traditional students in IT and management study fields was found. Also, significant increase of satisfaction with the on-line teaching material and in fact with the MET LAMS systems was found among IT traditional students.

Table 10: Difference in percentages between the average results of the researched categories of satisfaction in school year 2020/2021

	IT	MAN	ART

SatisTM	7.91%	1.17%	-4.75%
SatisOL	5.53%	5.76%	-3.41%
SatisQA	4.56%	1.26%	-4.09%

5. CONCLUSION

Traditional students were significantly not satisfied how on-line delivery of lectures was organised during the fall semester 2020 even though they already had an opportunity to experience this form of studying at the beginning of Covid19 crisis several months before. This was partially expected since traditional students did not opt for studying on on-line regime from the start.

However, after only two semesters taught fully on-line, results of the research showed that traditional students adopted the on-line learning concept. Level of satisfaction with the on-line delivery of the lectures reached the level which was before Covid 19 crisis.

Future research could show if this form of studying could be sustainable in the future in its full size or maybe in hybrid mode and how it could be implemented within different study programs. Also, further research could be driven to find if traditional students which experienced this type of studying would be interested and why in becoming an online students .

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APPLICATION AND POTENTIAL BENEFITS OF GAMIFICATION IN EDUCATION

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Abstract: *Gamification is a term used for the process of applying elements of games to contexts that are not closely related to gaming such as business and education but can also be social networks and marketing. The elements of the games used can be the design and logic of the games among others, all with the aim of achieving motivation, involvement, promoting learning and problem solving. Since 2010, interest in gamification has grown in scientific circles, although this term and practice have existed since the 1980s. Gamification is a part of the innovation in education that is related to group learning supported by Computer Supported Collaborative Learning (CSCL) technology as well. This paper primarily describes an overview of the situation in the above-mentioned field dealing with gamification and its application to education and draws a conclusion that shows the potential benefits that gamification brings to students on various levels.*

Keywords: *E-Learning, Gamification, Group Learning*

1. INTRODUCTION

The term gamification in this paper is taken from Lovrenčić et al. (2018) and refers to what gamification is in English, that is, by definition, the application of game elements to non-game-related contexts. (Deterding et al. 2011) These contexts can be business, marketing but also educational which will be the focus of this paper. First of all, we should look at the key aspects of games that have a role in gamification and enable its application to the educational process. These aspects are:

- Beneficiaries - all who participate in the gamification process (students and pupils in the case of this research but may also be employed.
- The tasks that users perform as part of the process and their progress towards meeting the objectives.
- Points accrued for successfully completed tasks.
- Levels that users pass in relation to the number of points.
- Badges that users receive based on their success in activities.
- Ranking users based on their achievements.

The most suitable area of education, as Kiryakova et al. write, for the implementation of gamification is information and communication technologies because the

process of student progress and their data can be automated so that the software creates detailed reports about it. The conditions for the existence of gamification and the steps that need to be taken to make it fully realized are discussed below. The first is to determine the users and their characteristics. The question that arises at this stage is whether students will be able to interact with the material and participate in the events that are part of this process. In the second place is the formulation of clear goals of gamification as a process and their definition so that no activity is aimless. The third is the concrete formulation of activities related to gamification and which will meet educational goals in this innovative way. These activities must meet certain conditions in order to be acceptable for the educational process. They must be such that they can be repeated, the user should be able to repeat one activity or task several times because that is where learning begins. The next is that the activities can be achieved based on the level of knowledge of the users. The level of difficulty should definitely increase and each new task should be more difficult. Finally, for the same skill, there should be several different tasks so that different types of students can fulfill them according to their own learning strategies. The fourth and final condition for gamification would be the formulation of specific elements and mechanisms of games to be implemented in the gamification process. (Kiryakova et al. 2014)

2. BACKGROUND

As Arnold (2014) writes in his paper, the logical beginning of the implementation of gamification is through online courses, their interface enables an easy transition from textual to innovative and digital. A study by The New Media Consortium from 2013 shows that whenever students need to implement critical thinking the implementation of gamification and any kind of simulation of the situation from the real world proves to be useful.

Stott et al. (2013) in their paper Analysis of Gamification in Education presents some specific case studies of the implementation of gamification in education and work with students. The first deals with Professor Clifford Lampe from the University of Michigan, who presents his course "Introduction to Information Studies" almost entirely through a video game in which students participate and thus show their knowledge. The first thing he cites as positive is that students themselves choose which tasks to do from the ones offered and thus have the freedom to choose. They do this at the beginning of the semester where they choose what their quest log will look like in which they want to participate. Also included in this is leveling which allows some higher level tasks to remain locked until the student has done enough lower tasks to get it. Another positive thing mentioned by the author of this paper is that students get a much faster response (feedback) to their work and progress in this way through the so-called grade master within the game. What mainly appears as a critique of gamification is the absence of group work, but Professor Lampe also included in his course play the possibility for students to enter groups within the game called guilds that can change during the course and thus participate in group tasks. As a result of this kind of work, Lampe states that students better retain and remember information because of the so-called 'shock value' learning that links information to experience as it is acquired.

Another case study by Stott et al. (2013) states that it is different from the first in the sense that there is no one course for which the game is used, but it is at the level of all courses attended by students at the University of Rochester (Rochester Institute of Technology). This is a game called Just Press Play and unlike the previously mentioned one which aims to improve the knowledge and memory of specific material, PPP deals with positive academic behavior among students on campus which further leads to better student results. It organizes workshops, seminars and lectures that serve students to improve their knowledge and socialization. Each student has a physical card with implemented identification via radio frequency, ie RFID (radio-frequency identification), which he uses for everything he does on campus, and this is further stored on his profile online. This can further be used by the student to provide information to his/her potential future employer as evidence of his / her academic behavior, additional content he/she attended and did during his/her studies. Stott et al. (2013) especially emphasize that this game does not have a grade or ranking, which eliminates anxiety among students to collect these achievements on their online profile. Progress allows further unlocking of some achievements and tasks that students can achieve but also to compare with other students on the platform, which ensures the motivation of students to use their PLL. The focus of this game is primarily intrinsic motivation in students.

Stott et al. (2013) also conclude from this that students through gamification are the ones who make decisions, they are not just consumers of what studies require of them and what someone else formulates. They are the ones who decide in the games which move to take, which has proven to be a good motivator for further progress. This paper also states how important the context is for the implementation of gamification, that is, who the students are, what is the subject of their studies and how they are conceived.

3. APPLICATION AND BENEFITS

Muntean (2011) in his paper Raising engagement in e-learning through gamification shows the way the application is gamified, which educational aspects are most suitable for it as well as some of the potential disadvantages of this system. The most suitable for gamification are linear e-courses which, due to the nature of the data they provide, represent the basis for gamification. The course studied in this paper is an information retrieval course for distance

learning students. Instead of dividing the course into several parts, Muntean (2011) proposes a cascading structure, where the course and course information are divided into the smallest contents of the material and that the student gets a certain number of points at the end of each part, which he unlocks by landing. The author also suggests creating avatars as the most important item that will allow the student to personalize the course as in games. Constant feedback is also important for tracking errors, as well as creating a progress bar. Defining deadlines also encourages motivation that promises that the student will return to the application periodically and relatively regularly.

Farzan and Brusilovski (2005) also suggest that gamified courses be as social as possible, that is, to allow access to other students to create a competitive atmosphere and increased motivation. This is followed by Muntean (2011) who suggests that application badges be assigned for commenting and inter-student interaction. Students should also receive notifications about what awaits them in the course because it creates a good flow of learning. What the author concludes from this paper is that the most important factor in gamification is how much users are engaged because it turned out that visits to applications, time spent on them and with materials are key to the success of a gamified course. What Muntean (2011) cites as a potentially bad side of gamification is the replacement of intrinsic motivation with a completely extrinsic, ie external, but what he proves is only the growth of extrinsic, ie external motivation.

Hakulinen, Auvinen and Korhonen (2015), Lee and Hammer (2011) and Muntean (2011) argue that gamification has positive effects on student motivation, participation, and engagement during the course as well as those students are better prepared to fail through gamified scenarios where they are allowed to fail multiple times. Dominguez et al. (2013) proved on the other hand that although the gamification of an online learning application contributes to the motivation and increase of active students participating in the learning process, there are no significant results on the final grades of those students. Hanus and Fox (2015) also conducted an experimental study where they studied students 'motivation, satisfaction, effort, and grades during a sixteen-week fictional curriculum and concluded that these students had even worse results than those in traditional courses. This was tested when Marcos et al. (2014) conducted an experiment using social networks and learning systems that used gamification. Students who are accustomed to such work and those who have traditionally studied in their courses participated. Although more motivation, competitive spirit and cooperation were observed in those who were accustomed to gamification, students who traditionally studied still had better results. Further, this is attributed to what Hwang et al. (2013) that is, with a large amount of competitive spirit that occurs in gamification on regular courses, there may be increased student anxiety. The authors also refer to Kirschner et al. (2006) on the fact that students in gamified courses sometimes receive so much information in a short period of time that they exceed the memory capacity.

4. GAMIFICATION IN EDUCATION

The initial thing that is the focus of this paper is the level of education at which gamification occurs most. All papers used for the purposes of this research cite higher education as an example, that is, university education most often. It has not been determined whether this is really the case in practice, but other levels of education are usually not included in the research. Gamification in its essence can potentially have good results at lower levels of education, especially among younger students, so it remains open for further research.

Another thing that has been noticed in the works covered in this study is the sphere of application of gamification. Case studies show that this is most often the field of technology and communication and less often the field of social sciences. The systematic nature of the material and its close connection with technology may be one of the reasons for this result. One of the successful cases of applying gamification to the social sciences is the Duolingo web application, which represents language learning by collecting points, passing levels, and getting badges, and the success of this application was recorded in a study from 2012, where the emphasis is on language acquisition speed. (Vesselinov & Grego, 2012) This represents a potential encouragement for the further implementation of gamification on learning.

What runs through almost all studies of gamification is motivation. Motivation is one of the key aspects of gamification as well as goals. An increase in students' motivation for the order was noted in all experimental works that were processed, even those in which an alleged decline in results was found. Especially in studies where two groups of students are observed, those who learn traditionally and those who learn through playful content. From the attached papers, it can be concluded that the motivation comes primarily from the competitive atmosphere with other students, which comes from the ranking of users of different gambled content. The next reason for the growth of motivation among students is the system of badges and points that unlock further content and ultimately enable students a higher place on the ranking list. Also, the anticipation that starts from collecting points to unlock new content can be a clear motivator. Control over the content of learning materials can prove to be another way to raise a student's motivation to a higher level. (Hakulinen, Auvinen & Korhonen (2015); Lee &

Hammer (2011); Muntean (2011); Marcos et al. (2014); Dominguez et al. (2013); Turan et al. (2017))

In addition to motivation, another positive outcome of gambled content is student participation in activities. Several studies show that involvement in the materials and content of games is at a high level and that students participate more in gambled content than in traditional. Some authors have questioned the possibilities of group work when it comes to gamification, however, a case study by Stott et al. (2013) show that group work can very well be achieved in gamified content through grouping students in the online world and their work on common tasks within the game. The social factor also appears in the work of Farzan and Brusilovski (2005) where the emphasis is on the fact that students in some gambled content get extra points if they comment and socialize with other students within the game, which certainly increases interest in group work. This can further create a very favorable atmosphere among students which creates a sense of belonging to their group and a positive competitive atmosphere among different groups. The gambled content is clearly goal-oriented, and this makes them different from traditional learning which generally does not have a clearly defined goal of a task or action. Some authors argue that this burdens students, and although it has been proven that the cognitive burden grows from such activities it is negligible compared to the fact that all other positive aspects of learning grow, as well as results in groups comparing playful and traditional content.

5. CONCLUSION

What is mentioned in the works on gamification as a positive side of the same is the freedom to fail because students are allowed to repeat the same task or part of the game several times, which eliminates the fear of failure for the first time. This further creates an atmosphere of security and eliminates anxiety on the first try at a task. Finally, the retention of learned content has been shown to last much longer after gambled content than after traditional, which is also if not the most positive impact of gamification on education. The application of gamification to education largely depends on the context to which it is applied, but it is indisputable that some of the benefits of this way of learning are universal for all contexts. Although most of the papers deal with university education, the research results are convincing about the strengths of gambled materials. Further research can potentially address other levels of education as well as different contexts to provide rounded information on the potential benefits of gamification on education. Also, future research may address some of the negative outcomes of gamification such as cognitive burden to determine the extent to which it is represented throughout the process. The current review of the situation shows that the good sides of this way of working still prevail.

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VIRTUAL REALITY IN ART STUDIES: DIGITAL SCULPTING IN VR

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Abstract: *In recent research, evidence shows a growing interest in the study of the application of virtual reality (VR) in Higher Education Institutions (HEI). In this paper, we will explore application of the VR environment in Art studies; more specifically, we will explore the use of VR sculpting tools in the context of distributed learning. Digital sculpting has not been acknowledged as a specific art form since it was mostly connected to gaming, video, and animation production. In 2020 and 2021, because of the expansion of the NFT art market, more affordable 3D printers, and social media promotion, digital sculpture has gained more widespread acceptance.*

We wanted to explore the impact of the available VR sculpting tools on the existing 3D production workflows and all the prospects for their future implementation in Academic Art Studies. We will also review the ergonomics of VR headsets and controllers, and all the challenges that this immersive medium (VR) would impose on the digital classroom in terms of user experience (UX), collaboration tools, and accessible e-learning technology for the students and lecturers.

Keywords: *E-Learning, VR, 3D modeling, Digital Sculpting, Art Studies*

1. INTRODUCTION

Digital sculpting is a 3D modeling paradigm where free-form surfaces are manipulated with tools that mimic real-life sculpting of soft materials, e.g. clay. This paradigm is particularly effective when designing organic shapes, since artists do not have concerns about mesh connectivity and topology details, working always with high-resolution irregular meshes [1].

Digital sculpting / 3D modeling has been taught for more than 15 years in various Universities as a part of digital art studies, interactive and graphic design studies, multimedia studies, game art, and other various interdisciplinary studies. Many institutions have also begun offering an option for online studies, although (physical) studio-based learning is still the dominant education model in art related faculties. However, introducing Virtual Reality (VR) systems in the **E-learning systems** of the HEI that we are exploring in this paper is a new configuration for studying art. Most HE institutions have VR systems available on the premises (in laboratories and studios), but we want to explore the possibilities of future implementation of VR systems in the **online learning** model in the domain of 3D sculpting and modeling. 3D sculpting is only one part of the 3D Art curricula but since it mostly relates to simulation of traditional sculpting, we found it an interesting subject to explore.

As noted in [2], in Art and Design Studies we had a dominant **design studio education model** for a long time, but technological advancements and widening participation in Higher Education (HE) caused physical studios to evolve and blend with the virtual and online educational environment. The VR environment anticipates

the evolution of the design studio education model, so this paper also examines the current state of collaboration and participation tools that are offered as a part of the existing VR sculpting software.

The recent development of commercial VR sculpting software and fast advancement of VR technology resulted in growing development of the community that practices 3D sculpting in VR. Generally, there is a very large community of 3D artists connected through various social networks, so we used this potential to distribute our questionnaire to 3D artists.

We gathered anonymous responses from 54 people with backgrounds in 3D art. 80% of participants declared as professional 3D artists, 13% are Art teachers / professors in formal institutions, while 12% are other artists who work in 3D often (concept artist, graphic designer, technical artist, VFX artist, game designer, game producer). 11.4% of participants checked two or more positions that are overlapping with 3D artist: art teacher, researcher, art director, 3D printing, concept artist, graphic designer. Most of the participants had between 10-20 years of experience (35%) or 1-5 years of experience (30%) in 3D modeling. Furthermore, 18% declared 5-10 years of experience, 11% had less than one year of experience, and 6% noted more than 20 years of experience working as a 3D artist.

We will refer to this questionnaire and literature in order to explore opinions on all the aspects of the VR sculpting that are the subject of this paper.

2. VR ENVIRONMENT

In 2015, several companies announced mass production of affordable VR headsets (also called Head Mounted Displays – HMD) and display devices, which are worn on the head with a display optic in front of the eyes. The most popular among them were the HTC Vive with optional hand controllers and the Oculus Rift. These devices require support of computers with powerful processors and graphic cards in order to render immersive 3D graphics and 360 degree videos, while simultaneously tracking the motion of the user. During the same year, we were introduced to even more affordable mobile VR headsets - Samsung Gear VR and Google Cardboard viewers that can be combined with compatible smartphone devices [3]. In 2021, stand-alone VR headsets are available for purchase, such as the very affordable Oculus Quest 2, the rather expensive 'all-in-one' Vive Focus, as well as the Sony PlayStation VR (PS VR), Valve Index and Windows Mixed Reality headsets.

In [4], VR can broadly be broken down into two main categories: desktop VR (D-VR), and immersive-VR (I-VR). D-VR is typically classified as non-immersive, in that a headset is not used, and the participant controls and manipulates the virtual environment on a computer screen with traditional keyboard and mouse hardware. On the other hand, I-VR is typically multi-modal in nature, providing a sense of immersion in the environment through 360° visuals by aid of an HMD, auditory stimulation through the use of earphones. The review defines an HMD as a device worn over the head which provides a stereoscopic computer-generated or 360° video image to the user. This includes tethered (connected to a computer), stand-alone (no computer needed), or mobile VR headsets (mobile/cell phone connected to an HMD.

Moreover, VR is also considered to be an immersive, interactive, multi-sensory, spectator-centered 3D environment, with the combination of the technologies necessary to build these environments, or that allow the navigation and viewing of a world in three dimensions and in real time, with six degrees of freedom. **VR is a clone of physical reality** [5].

In [6], we have found an updated breakdown of tools for painting, sculpting, and animating in VR. In **Image 1** we can see the list of available software tools as well as platforms that support them. In the Feature Focus column they are each marked based on the workflows they primarily cater to.

	Platforms			Feature Focus		
	Quest	*PC VR*	*PSVR*	Drawing	Modeling	Animation
Tilt Brush	✓	✓	✓	✓	×	×
Dreams	×	×	✓	×	✓	✓
Quill	×	✓	×	✓	×	✓
Adobe Medium	×	✓	×	×	✓	×
Kingspray Graffiti	✓	✓	×	✓	×	×
Gravity Sketch	✓	✓	×	×	✓	×
Tvori	×	✓	×	×	✓	✓
AnimVR	×	✓	×	✓	×	✓
Blocks	×	✓	×	×	✓	×
SculptVR	✓	✓	✓	×	✓	×
Masterpiece VR	×	✓	×	×	✓	✓
Adobe Substance 3D Modeler (closed beta)	×	✓	×	×	✓	×

Image 1: commercial VR sculpting in 2021.
Source: www.roadtovr.com

From the available tools we would like to point out Adobe (Oculus) Medium, Gravity Sketch, Kodon VR (not included in the table), Adobe Substance 3D Modeler, and Masterpiece Studio. These apps are concentrated on sculpting and "real feeling sculpting" in VR. Further development of these tools depends on their business model and commercial success, so at this phase we must conclude that there is still a long way to go before some of them become standard in producing 3D graphics.

Many respondents in our questionnaire included some VR tools in the list of their preferred 3D sculpting tools such as Adobe Medium, Gravity Sketch, and Kodon VR. The most dominant desktop sculpting tool is ZBrush (70% respondents noted that they use it), followed up by Blender (41%), Maya (35%), and Mudbox (18.5%). It is interesting that some participants mentioned the mobile application Nomad Sculpt, which is mostly used on tablets, as well as the browser- based tool Sculpt GL.

Most artists (70%) that responded to our questionnaire checked 2-5 tools they use for 3D modeling. Considering that modeling is just one of the aspects of 3D art, and that artists use additional tools for texturing, lightning, staging the scene, animation etc., it is clear why the production workflow can be overwhelming for beginners and why HE institutions might have a difficult time deciding which software licenses they should buy in order to teach students 3D art.

3. USER EXPERIENCE AND ERGONOMY OF VR HEADSETS

Concerning the ergonomics of VR headsets and working in these environments, our survey resulted in the conclusion that 55% found the VR environment more dynamic, 33% found it more exhausting than the desktop environment, while only 12% found it to be the same as the desktop environment.

VR sculpting tools assume the use of controllers, and we asked our participants how they felt about them. 72% responded that controllers were fine, while 18% found them complicated, or they thought there was a lack of tactile feedback and that the user experience could definitely be improved.

The **interface** is the bridge between the human and the effective use of their tools. In the beginning, the user interface for computers was text-centric, and later, two-dimensional graphical user interfaces (2D GUIs) using the WIMP (windows, icons, menus, pointer) metaphor have enabled many uses of computers in everyday life. Several post-WIMP interfaces operate outside these bounds, operating on human touch and voice modalities for multi-touch, tangible, sketching, and voice interaction. In addition, Reality-Based Interfaces incorporate the human's body and natural understanding of the world into the interface as exemplified by three-dimensional user interfaces (3D UIs) in Virtual and Augmented Reality (VR/AR) [7].

In [8], the authors presented a wearable augmented reality (AR) 3D sculpting system called AiRSculpt in which users could directly translate their fluid finger movements in air into expressive sculptural forms and use hand gestures to navigate the interface. Their premise was **that mediation via devices puts users at a visual and spatial remove** from the virtual content since most free-form 3D sketching or sculpting systems that had previously been implemented in a VR environment for 3D interaction research utilize input devices, such as the 6-axis SpaceMouse, sensors, physical props, or special VR gloves to track finger trajectory or hand movement. By removing the device, they reached more intuitive interaction with hand gestures.

Much of Virtual Reality (VR) is about creating virtual environments that are believable and successfully simulate reality, but in [9], it is argued that better immersive technology, however, does not necessarily provide a better VR experience. Asking "how much immersion is enough," Bowman and McMahan point out the possibilities, but also the limits, of simply investing more in improving the match between visual fidelity and reality. Their research showed that this does not always, for example, improve the results of learning. We can conclude that the development and UX design of VR sculpting tools can also be goal-oriented and content-driven. We can see this influence in [10], where the user experience design and features of the sculpting app are illustrated through production workflow. Most VR sculpting software developers recognized the importance of cross-device functionality and compatibility with other software. There are also some technical issues and functionalities that are important for improving VR sculpting tools, like mixing voxel and hard surface modeling in the same tool, including mesh modeling, cloth simulation, et cetera.

4. E-LEARNING AND COLLABORATION IN VR

In [11], authors have identified two distinct problems in implementing VR technology in HE institutions: technical and pedagogical. It is inevitable that **technical issues** will arise with any rapidly developing or complex technology, and 3D technologies are indeed both. Furthermore, institutions of higher education are often slow to adopt innovations, particularly innovations in pedagogy. Among the technical problems, we can distinguish hardware and software issues like powerful computer configurations and graphic cards with updated drivers, supported by fast internet connection if we want our teachers to use collaborative VR sculpting environments. After configuring the hardware and software to work correctly, next comes the learning curve for figuring out how to use it. In the innovation's theoretical framework, we always count on categories of *innovators* and *early adopters* who tend to enjoy experimentation and have the resources to expend on doing so. In the context of higher education, this often means faculty members and students with innovative projects who are comfortable with technology and are willing to devote time to learning to use it. **The pedagogical aspect** of implementing new

technology requires faculty members to figure out how to integrate it in one's courses so that the technology provides clear benefits.

In [12], the authors examine the current crisis in physical art and design studio learning in higher education as a consequence of the COVID-19 outbreak and the sector's response to the fast-track conversion of blended learning to a distributed model: "Universities are focusing on virtual community building where group work, 'crits' and presentations are being carried out online. Moving assessment and engagement to online formats has consequences for practice-based art and design courses: distributed learning changes how we teach and learn." This research concludes that there are different variables that would determine whether students would prefer blended (combination of studio-based learning) or online learning environments.

On the other side of the distributed learning model, we have students who need to provide their own VR units along with powerful computers and internet connections in order to be able to create and share their 3d models. 65% of respondents in the survey think that VR station is a big investment, and 35% disagree. We did not include students in the survey, but since they mostly do not have personal income, we could assume that they might perceive it as a big investment, although a Game-ready PC is usually considered to be a solid configuration for VR as well (VR ready).

If we assume that collaborative VR sculpting environments can simulate studio-based learning, VR technology should in that case be implemented in the distant learning model. In a virtual studio, students could learn the basics of sculpting and modeling, practice figurative sculpture, human and animal anatomy; they could analyze and copy works of old masters, and so forth. However, not all the content of traditional sculpting classes should be transferred from the physical into the virtual studio—as we noted in the previous chapter—since there are many other aspects of 3D art, and we should adapt the content of the classes and include those aspects as well.

Collaborative Digital Sculpting in VR has already been featured in many VR sculpting tools, such as Gravity Sketch, VR Art Studio, and Masterpiece VR. Adobe Medium provides studio share for only two users and they cannot share models, they can work only on their own models.

Nevertheless, our questionnaire showed that 52% of participants did not try collaborating in VR, but the 40% who did try it were rather satisfied.

Collaborative systems are not well established in computer graphics, compared to software development. Usually artists work alone and share their final models by sending files [1]. Collaboration does not necessarily mean working on the same file, but for students, it is important to learn how to collaborate.

In an E-learning environment we should find ways to **motivate students** to finish their studies, since they often have feelings of isolation, lack technology support, lack clarity in instruction direction or expectation, and lack social interaction [13]. Collaborative VR environments could likely provide tools to overcome these downsides of distant learning.

Accessibility is also a subject that needs to be addressed in the context of implementing VR sculpting in HE institutions. Technology has to be accessible for teachers as well as for students. There is also the question of accessibility of existing interfaces and controllers that has not yet been addressed. In [14], the authors want to adapt Web Content Accessibility Guidelines (WCAG) to fit VR. Some Universities, like The University of Melbourne [15], have already made accessibility guides for VR environments.

5. NFT MARKETPLACES AND OTHER EMERGING TECHNOLOGIES

NFTs are blockchain-traded rights to any digital asset; this includes images, videos, music, and even parts of virtual worlds [16]. The most popular cryptocurrency for NFT trading is Ethereum. These markets opened new possibilities not only for 3d artists, but for all digital media creatives, since they can now sell their digital art works more easily and their career and employment won't be solely directed towards the gaming and film industries. In our survey, we got rather even results on the question of if they thought that the NFT market would change the way we perceive, make, and teach art: 54% said Yes, and 46% said No.

We also asked respondents if they thought that technologies like 3D scanning and AI are threatening for 3D sculptors. 50% of respondents found them quite helpful, 26% did not find them threatening, 13% found them threatening, and 11% found them "a little" threatening.

The final question asked whether we should teach 3D art students to code. 46% said No, 19% said Yes, and 35% said 'a little'.

6. CONCLUSION

The current review found that the technology advancements and pedagogical frameworks for 3D sculpting in VR environments can be implemented in HEI E-learning systems by using some of the available VR

software tools. Implementing VR systems in HEI could be challenging from the economical and technological point of view, but the most important aspect is that technology provides clear benefits.

Content of Digital sculpting classes in the VR environment could be perceived as new studio-based learning that follows the teaching methodology of traditional sculpting classes, but with additional features that are necessary for the education of 3D artists. Collaborative VR environments could also help in motivating e-learning students to finish their studies, since they drop-out more often than traditional students.

Many of the respondents in our survey added some personal comments on the subject of Digital sculpting in VR and the future of Art studies. Many commented that VR creation tools will be essential in 5 years, as well as more Augmented, Extended or Mixed reality tools, since they provide less detachment from the real environment and do not provoke dizziness and nausea as VR headsets tend to. Over the coming years, technological advancements and more accessible interfaces will contribute to the implementation of VR sculpting tools in online Art Studies, but it is essential to ensure that they are used correctly and to their full potential.

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UNIVERSITY EDUCATION IN DIGITAL ENVIRONMENT

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Abstract: *The use of educational platforms in education is not a novelty, but its increased importance is manifest since the pandemic outbreak. The faculties have very swiftly improved and introduced new modes of work that support distance learning. This paper addresses the current topics of education in digital environment. Along with an overview of educational platforms and tools used at Belgrade faculties during the 2020/2021 academic year, the benefits and drawbacks of online education are underscored. In order to obtain the answers as to how much the education in digital environment has managed to meet the expectations and requirements, the standpoints of professors and students have been analyzed. The results confirm that the form of education impacts the content and methodology which implies a new paradigm of education.*

Keywords: *educational platforms, digital environment, online education, university education, pandemic*

1. HISTORICAL BACKGROUND

Throughout the history, humans have been trying, by using machines, to make their labor easier and to improve all fields of work. In the history of education, the use of technology is nothing new. Online learning in its contemporary sense dates back to the second half of the 20th century. PLATO (Programmed Logic for Automated Teaching Operations) is considered a forerunner of this type of sharing knowledge, developed in 1960 at the University of Illinois, that enabled students to learn with the aid of interconnected computer terminals [1]. It was followed by the first individual online courses (the first online educational programme was launched in 1981 in the School of Management and Strategic Studies at the Western Behavioral Sciences Institute in La Jolla, California, the first fully online course was implemented in 1984 at the University of Toronto). The development of information and communication technology is accompanied with a growing number of universities and associated faculties that implement the modern technology in educational process to certain extent. MIT launched the Athena project in the 1980s that represented an experimental research on the use of computers in education [2]. In early 1990s, the Open University in Britain was one of the first to commence online learning courses, even though it started "testing of viewdata (videotex) system OPTEL, on a DEC-20 mainframe" [3] ten years earlier. It is presently among the top-rated distance learning universities, and it proudly states on its website: "The Open University is the UK's largest academic institution and a world pioneer in distance learning. To date, we've taught more than two million students worldwide10" [4]. How seriously and timely they realized the importance of investing in this type of education is testified by the fact that in 2005 they were prepared to allocate GBP 5 million for improving the educational application Moodle (Modular Object Oriented Dynamic Learning Environment), to become later available to all members and users of the Moodle platform free of charge. Practical and concrete examples are accompanied with the works of theoreticians published in professional magazines. The introductory note of the magazine *American Journal of Distance Education* No. 1 of 1987 reveals that distance learning is not a novelty and that it is gaining momentum [5]. The magazine was launched ten years after the British Open University was already in operation and magazines with similar topics had been already published in Australia [6] and Canada [7]. A major breakthrough was made by Google in 2014 by launching its Google Classroom, which has seen its full-blown practical use during the pandemic.

When our country is concerned, it is noteworthy to mention the endeavors on setting up the Academic Computer Network (AMRES), which started developing in the first half of the 1990s, yet a significant progress could be noted only in early 2000s. In the second half of the 2000s, the Moodle platform started being used at the faculties of the Belgrade University, initially followed by an organized training course within the Computer Centre of the Belgrade University (RCUB). Today, according to the data available on its official website, Moodle has 280,000,000 registered users from 246 countries and 37,000,000 courses [8]. As an instance of good practice in preparation and implementation of online education, Metropolitan University was one of the first to introduce complete online

master studies. This experience helped its becoming the first to move to online education in March 2020, within merely 24 hours (when the state of emergency was pronounced in Serbia due to the pandemic) [9].

The development of technology is followed by the appearance of new modes of learning. One of innovative approaches is personalized e-Learning which, notwithstanding the challenges, brings more efficient learning and satisfied participants in educational process [10].

2. RESEARCH ON EDUCATIONAL PLATFORMS AND LEARNING IN DIGITAL ENVIRONMENT

As of the corona pandemic outbreak in 2020, the use of various learning platforms for educational purposes inevitably increased. A growth in the number of papers and research covering this topic is evident. Some of them offer a broad view of students' (dis)satisfaction with distance learning [11], [12] and show how teachers adapted during online education [13]. Some texts are dedicated to specific platforms, such as Hangouts Meet, Zoom and Microsoft Teams [14] or they address the use of educational tools for successful acquisition of curriculum in specific subjects, such as the application of Moodle in learning foreign languages [15].

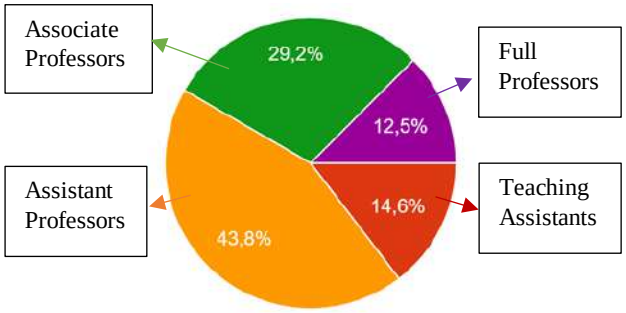
Aspiring to make a comprehensive overview of the application of educational platforms on the university level, to disclose facts, perceptions, views and statements of respondents regarding the educational platforms that support online learning, two anonymous surveys have been created – for teachers and for students separately. The survey was made by using google forms (for employees: forms.gle/1JV4TEZmhGh6Ce229 and for students: forms.gle/uwUXgrcB9SiFsEmc6) distributed by email at the end of second semester of the 2020/2021 academic year. What makes this survey specific are the respondents themselves. Namely, professors and students from state faculties within the Belgrade University took part in the survey (the Faculty of Philology, the Faculty of Electrical Engineering, the Faculty of Teachers Training, the Faculty of Economy, the Faculty of Physics and the Faculty of Geography) and from private universities – Metropolitan University (the Faculty of Management) and UNION - Nikola Tesla (the Faculty of Diplomacy and Security, the Faculty of Sports). Starting hypotheses: (a) respondents have used educational platforms, (b) they are positively inclined towards their application, (c) the use of new technologies changes the form and content of work and (d) in the future, respondents desire the education that at least partly supports distance learning.

Results and Discussion

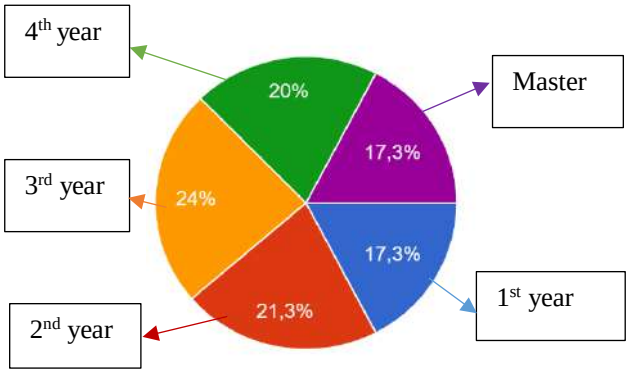
In the study 123 respondents took part (48 professors and 75 students). Since five employees and three students have not used educational platforms in the observed period, the answers of 115 respondents have been analyzed. As the reasons why the employees have not used platforms (one full professor, two associate professors, one assistant professor and one teaching assistant) it was stated that they preferred conventional teaching, teaching smaller groups which enables traditional education, or that online courses were not convenient due to the type of curriculum. Students (one student of the first year, one student from the fourth year and one master student) mostly had practical reasons – due to work, difficulties in balancing real-time lectures and professional/private obligations, but they also said that such method of teaching was not convenient and that they experienced a lack of motivation.

We appreciate the time and efforts of the respondents who contributed to the achievement of the study goals.

The survey was compiled from a combination of questions – open and closed types, multiple choice options, while the Likert-type scale was applied for scaling responses. The answers to the identical questions for both groups, comprising a major part of the survey, were compared. In the first part, personal data were collected – years of age, vocation, or the year of study (graphs 1 and 2).



Graph 1: Structure of respondents by academic achievements

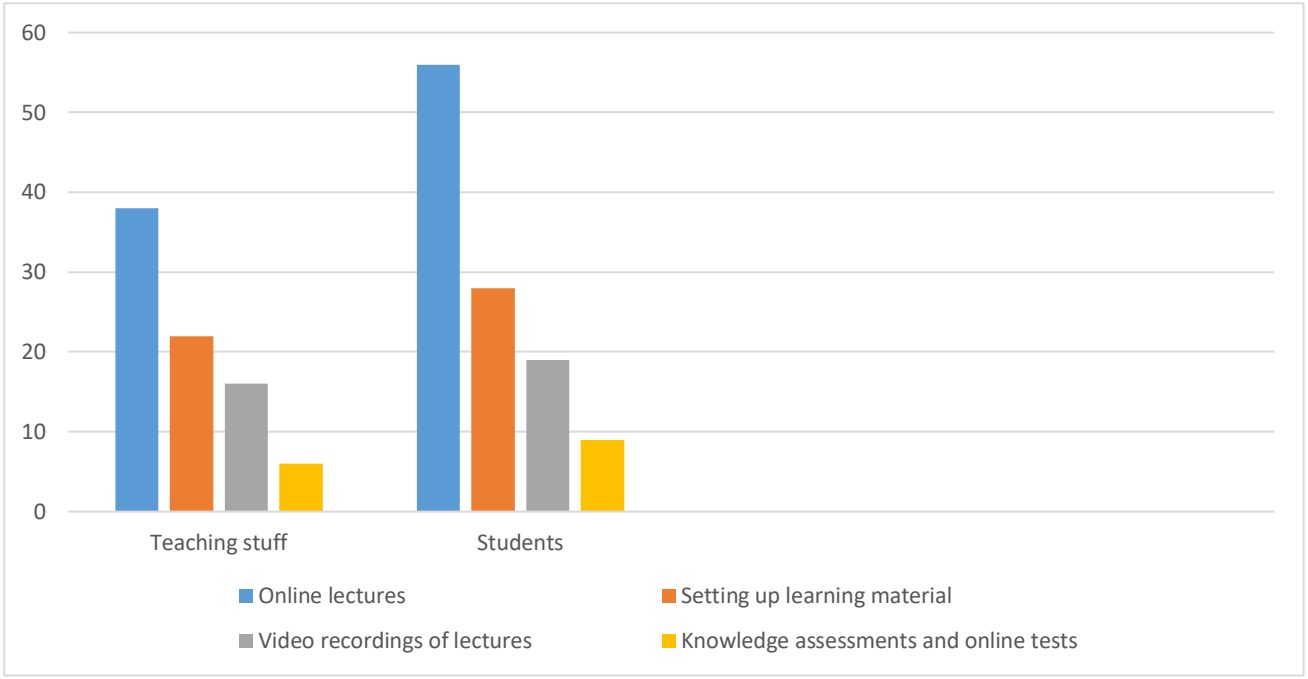


Graph 2: Structure of respondents by the year of study

The second, major part of the survey referred to the used platforms, the reasons for their use, benefits and drawbacks... Most of the employees, 26 of them (60.5%) has used educational platforms even before the pandemic,

whereas 17 (39.5%) have first encounters with the platforms during the transition to online education. UNICEF has provided a proposal of educational digital tools, including a brief description, for interactive education and online learning, online resources for coding and developing and educational video channels [16]. Some of them have been applied in our educational system. If we compare the answers, we can deduce that both groups of respondents most frequently use Zoom (67 respondents) and Moodle (37 respondents), followed by Skype (23), Microsoft Teams (17), Google meet (15), Edmodo (6), Google Classroom (6), BigBlueButton (4), BigMarker (2), LAMS (Learning Activity Management System – 3 respondents) and Jamboard, Webex, Voov and Viber one respondent each. The teaching staff mainly opted for the platforms recommended by the faculty, i.e. the faculty itself holds software and licenses. Most of the students opted for Zoom due to its ease of use. This platform has been mostly used for lectures in real time, whereas Moodle had more of a passive role, since it was predominantly used for uploading data and educational material. Important sources of information for students were also faculty websites, professor's websites and social networks. It is evident that the students of private faculties used Skype and Google Meet more often, while the Belgrade University, besides Zoom, used also Moodle to large extent. Moodle is an *open source* software which is why it was widely used before the pandemic, too. Many faculties integrated Zoom in order to be able to facilitate online lectures within Moodle, which is why these two platforms are often stated together in the answers provided.

The answers (multiple choice) about the reasons for using educational platforms overlap within both groups of respondents (Graph 3). They are mostly used for online lectures, followed by using/setting up learning material and video recordings of lectures, and they are least used for knowledge assessments and online tests. Even though online education was mostly implemented in real time, most of the students (63.4%) prefers to playback the recorded material later at the time that suits them best.



Graph 3: Reasons for using educational platforms

This type of work called for certain changes and adjustments. Teaching stuff stated (multiple choice was provided as an option) that they had to adjust the method of work (75%), to conform the content of lectures to the new type of teaching (27,5%), to stop keeping the attendance records (22.5%), to change the valuation of pre-exam obligations (17.5%), while one segment of respondents (17.5%) has not changed anything compared to traditional mode of education.

The question that referred to benefits and drawbacks was of an open type. Table 1 (Educational platforms and teaching) features the most common answers. Based on these answers, we can conclude that both groups of respondents perceive similar benefits and drawbacks. One the one side, there is mobility, the possibility to attend lectures from any place and to have a postponed access to material, but the major drawback is a lack of direct communication, motivation, establishing interpersonal relations and socialization.

Table 1: Educational platforms and teaching

	Advantages	Disadvantages	Evaluation of online education
Teaching stuff	- Higher mobility - Higher attendance - Availability of material - Higher flexibility - Work from home, time saving in commuting to and from the faculty	- Lack of interaction, discussion and exchanging views - Lack of non-verbal communication - Technical prerequisites - Objective testing not viable - Lack of focus and motivation on students' part	- Fully satisfied (30.2%) - Partly satisfied (51.2%) - Neither satisfied nor dissatisfied (14%) - Dissatisfied to large extent (4.6%) - Dissatisfied (0%)
Students	- Possibility to follow the courses from any place - Possibility of subsequent playback of classes and access to learning material - Time and money savings - Study and work - Convenience of studying at home	- Internet connectivity prerequisite - Lack of motivation - Lack of sense of studying - Lack of familiarity with professors and students - Too much screen time	- Fully satisfied (23.3%) - Partly satisfied (34.2%) - Neither satisfied nor dissatisfied (27.4%) - Dissatisfied to large extent (11%) - Dissatisfied (4.1%)

Likert-type scale was used for assessing online education (1 – fully satisfied, 2 – partly satisfied, 3 – neither satisfied nor dissatisfied, 4 – Dissatisfied to large extent and 5 – dissatisfied). The provided answers (as shown in Table 1) reveal that majority of respondents is partly or even fully satisfied with this type of work. However, what is surprising is that the percentage of satisfaction among students is lower, but it should be taken into account that this group of respondents is larger. Based on these results, the expected answers to the last question – How would you like education to unfold in the future (not only during pandemic)? The majority is for a so-called hybrid, or mixed model (teaching stuff 70.8% and students 61.3%) – a combination of online and traditional education, while the exercises are to be preferably held in classrooms. Each of these models has its benefits and drawbacks, yet the best of each should be adopted, and many shortcomings can be overcome by using various digital tools [17]. Their application requires certain skills, computer, IT and digital literacy. Almost equal percentage is only for traditional type of education (27.1% professors and 28% students). Despite a noticeable disappointment with online education, more students (10.7%) support online education alone, as compared to employees (2.1%).

3. FINAL OBSERVATIONS

The development of information and communication technologies has affected all segments of work. The model of education departs from long-held, traditional frameworks. New technologies have seen the application in education even before the outbreak of the corona virus pandemic. The pandemic has only accelerated the implementation of educational platforms and quickly showed all benefits and drawbacks of this type of work. In applying state-of-the-art technology, its opportunities and strengths should be considered. Education is *de facto* undergoing changes, but nothing can replace direct communication. That is why the initial expectations have been confirmed – an optimal mode of work is a combination of traditional and new in the future. Technological advance inevitably imposes modernization and reform of education. The research showed that e-Learning brings changes in the work, but the participants in the educational process have embraced novelties and assessed them positively to large extent. These and similar research should encourage consideration of a fundamental change in the concept of education, both regarding, both in terms of its form and its content and methodology.

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ON THE THERAPEUTIC USE OF SERIOUS GAMES IN SELECTED MENTAL DISORDERS

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Abstract: *Serious gaming is used in various areas such as education, healthcare, marketing and other businesses and industries. The power of serious games is that they are entertaining, engaging and immersive. Mental disorders affect a person's memory, thinking, perceptions or behavior. This type of disability makes it more difficult to create games for people suffering from it. The paper presents an analysis of the serious game applications for people with mental disorder, depression, post-traumatic stress disorder, autism spectrum disorder, attention deficit-hyperactivity disorder, cognitive functioning disturbances, and alcohol abuse. In addition to mitigating symptoms, serious games that target people with mental disorders can have several objectives, for example, to encourage them to be more physically active, as some diseases promote sedentary behaviors; to help them learn concepts, etc.*

Keywords: *Serious game, Mental illness, Accessibility, Learning, Adaptation*

1. INTRODUCTION

Computer games are ubiquitous and can be utilized for serious purposes such as health and education. Serious games are designed to engage the player and include teaching in the game experience. One of the definitions of serious games is: "Serious games are games that do not have entertainment, enjoyment or fun as their primary purpose" [1]. As a result, they offer a fresh way to introduce and engage service users in therapy, especially when engagement has been unsuccessful in the past.

These serious games are often applicable across healthcare simulation education and training, with the learning tools able to accurately convey how a procedure or skill is meant to be performed in the field. By combining elements of entertainment with healthcare simulation, learners can master these skills in an engaging environment which is risk-free and promotes patient safety.

Serious games and gamification (gaming elements used outside of games) have the potential to increase the impact of mental health internet interventions via three processes. First, by extending the reach of online programs to those who might not otherwise use them. Indeed, not just "serious games", but "gaming" itself does not have a single definition. Prensky [2] defined gaming as having six structural elements: rules; goals and objectives; outcomes and feedback; conflict, competition, challenge or opposition; interaction; and representation or story. Accordingly, we defined "serious games" as interventions that are games or utilize elements of gaming as an integral and primary method for achieving their purpose [2].

Our search string was a combination of serious games-related terms, such as "serious games," "game-based," "videogames," "computer-assisted therapy," "virtual reality intervention," "gamification," "gaming simulation," and mental health-related terms, such as "mental health," "depression," "anxiety," "problem drinking," "schizophrenia," and "obsessive-compulsive disorder." Duplicate items were removed from the records that were identified through literature search. The remaining items were screened by two independent raters on the basis of title, abstract and keywords.

The objective of the present article is to provide an empirical overview of serious games applied to mental disorders.

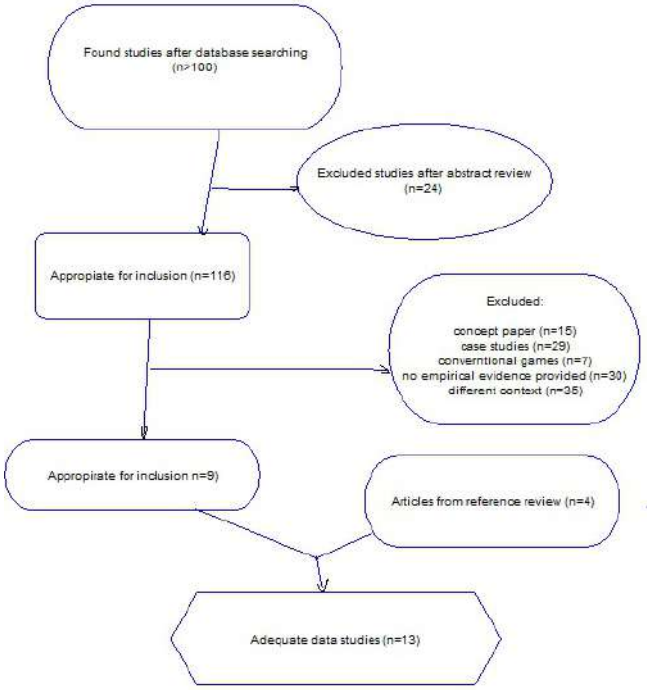

Image1: PRISMA flow diagram of the inclusion/exclusion process used in this review

2. GAME DESIGN AND TYPES OF GAMES

The game design part is divided into two interrelated parts – game mechanics (features such as character, plot, points, control stick, or graphics that the player utilizes to engage game content) and service user involvement in the design and development of game mechanics. Most of reviewed articles refer to the importance of design for the game's ability to engage players and achieve intervention outcomes.

All games demonstrated high user acceptability, and players considered their formats to be authentic and realistic. These games also demonstrated good retention rates and were effective in delivering their intervention outcomes. Having a choice and variety of options, appropriate levels of challenge, easy-to-follow instructions, and familiar, intuitive control devices corresponded to player enjoyment, confidence that they can play the game, and successful fulfilment of game purpose.

We divided the variable game genre into goal-oriented, problem-solving, cognition training, and so-called exergames. Goal-oriented games focus on tasks and the end results of those tasks. Problem-solving games challenge players to find solutions for problems. Cognition training games train the players' working memories by a series of similar brief challenges that usually have to be tackled within time constraints. Exergames are games that combine physical exercises with game elements. No exergames were identified in the current study. Six studies used serious games in the cognition training genre [3, 4, 5, 6, 7]. Three studies used serious games that can be categorized in two genres, namely, goal-oriented and problem-solving [8, 9, 10, 11, 12]. One study used a serious game that was goal-oriented only [13]. We aimed to review serious gaming interventions for depression. Studies were eligible for inclusion if they were English language peer-reviewed articles, published after the year 2000 (given that reviews older than 15 years had identified no serious games for depression). The intervention had to be delivered online and/or via digital technology, including via a CD-ROM, a tablet, the internet, computer, smartphone, Nintendo console, or any other computerized device. In this analysis, we included interventions that utilize elements of gaming as an integral and primary method for achieving their purpose.

Table 1: Game characteristics in the papers included in our research

Title of game	Reference	Serious game genre	Serious game purpose
Games selected from Lumosity (cognitive training platform)	Ballesteros et al. [12], Sweden	Cognition/brain training	Training (physical/emotional/cognition/skills)
Think Feel Do	Stallard, et al., Chi;e [30]	Goal-oriented and problem-solving	Training (physical/emotional/cognition/skills)
Junior Detective Program	Beaumont and Sofronoff [6] Australia	Goal-oriented and problem-solving	Psychoeducation and training (physical/emotional/cognition/skills)
ReachOutCentral	Coyle et al [32],Australia	Goal-oriented and problem-solving	Training (physical/emotional/cognition/skills)
SPARX-Rainbow	Lucassen et al. [31] New Zeland	Goal-oriented and problem-solving	Psychoeducation and training (physical/emotional/cognition/skills)
Braingame Brian	5t al. [13] Netherlands	Cognition/brain training	Training (physical/emotional/cognition/skills)
SPARX	Fleming et al. [2], New Zealand	Goal-oriented and problem-solving	Psychoeducation and training (physical/emotional/cognition/skills)
Tetris	Holmes et al. [9] UK	Cognition/brain training	Training (physical/emotional/cognition/skills)
Tetris	Holmes et al. [8], UK	Cognition/brain training	Training (physical/emotional/cognition/skills)
SPARX	Merry et al. [3] New Zealand	Goal-oriented and problem-solving	Psychoeducation and training (physical/emotional/cognition/skills)
"Path-finding game"	Rezaiyan et al. [11] Iran	Cognition/brain training	Training (physical/emotional/cognition/skills)
Let's Face It!	Tanaka et al. [7] USA	Cognition/brain training	Training (physical/emotional/cognition/skills)
Guardian Angel	Verduin et al. [14]USA	Goal-oriented	Training (physical/emotional/cognition/skills)

2. IMPACT ON SELECTED DISORDERS

We grouped the studies that were included in our analysis according to the disorder investigated. The use of serious games has been attempted as a therapeutic tool in a relatively wide array of conditions: depression, post-traumatic stress disorder (PTSD), autism spectrum disorders (ASD), attention deficit-hyperactivity disorder (ADHD), cognitive functioning disturbances and alcohol

abuse (AA). Serious games have been used either by themselves or as a means to facilitate standard psychotherapy.

Depression

We found two RCTs dealing with depression. Both utilized the same serious game: SPARX, a cognitive behavioral therapy (CBT)-based product [14] featuring a goal-oriented, problem-solving approach [8, 10]. The target population consisted of adolescents (age 12 to 19 years). The version of SPARX used in both studies was designed to be played on a PC without internet access (although an online version is now also available). The game is set in a fantasy world, with the player controlling a specially adapted, personalized character charged with the task to restore the balance of that world. In order to do so, they have to solve various problems, and also (literally) shoot down negative thoughts (as part of CBT). The player is guided through the game by a virtual character who offers instruction on dealing with depression and defines the respective objectives for each of the seven levels (or modules) of the game. Each level requires approximately half an hour to complete. In one study [8], there was minimal supervision of the players by educational service providers during gameplay, while the other study [10] was conducted in a primary healthcare or school counselling center. Both studies used the Children's Depression Rating Scale Revised [15] as primary outcome measure to assess the reduction of symptoms. Similarly, a further study by the same group described an open trial of an adapted version of SPARX for young people attracted to the same sex (both genders), or those questioning their sexuality [12]. More than 80 percent of users felt less discomfort and relief after playing SPARX.

In another paper [16], authors made a serious game that can address stigma faced by patients suffering from depression and other mental illnesses. The game enables players to experience and strive to overcome the disempowering aspects of depression during the journey to recovery. Through the game's interaction, players may gain a better understanding of the relationship between themselves and their disease, which in turn may help to change their moral model with the disease model, and thereby diminish the stigma of depression. The objective is to learn thoughts and actions that lead to positive outcomes. The background music changes according to the user's mood; the choices of possible thoughts and actions determine what happens next.

In paper [11] authors have demonstrated the effectiveness of computerized CBT (cCBT) for depression and anxiety in adults, but there has been little work with children and adolescents. Twenty participants aged 11 to 16 with depression or anxiety were randomized to receive cCBT immediately or after a delay. Standardized measures were used to assess self-reported anxiety, depression, self-esteem, and cognitions, as well as parent-rated strengths and difficulties. A feedback form was also completed to assess young people's views of the program. A total of 15 participants completed the pre- and post-intervention assessments in the trial, and 17 provided feedback on the intervention. Paired-sample t-test demonstrated significant improvement on 3 subscales in the control condition, compared to 7 subscales in the cCBT condition. Feedback showed a moderate to high satisfaction of participants.

Autism Spectrum Disorders

Serious games were used as a tool to mitigate the symptoms of ASD in two studies [9, 6]. Both used facial expression as primary outcome measure, and both were based on presumed improvement of emotional understanding and social skills through training. Junior Detective Training Program, the game used in the first study [9], is a goal-oriented, problem-solving game directed at improving social skills [9]. It is playable on a PC without internet connection. The game story is set in 2030, and the player finds themself in the role of a junior detective whose task is to deduce the thoughts and feelings of their suspects (rendered as cartoon characters). This is to be accomplished by understanding facial expressions, body postures, as well as various non-verbal and environmental clues. Game situations include bullying and cooperative play with others. Having completed three levels, the player is awarded graduation from the "Detective Academy". Participants in the study were asked to play for an hour in the first two of seven sessions and for 45 minutes per session in the following two sessions. The remaining sessions also included training time for parents. Primary outcome measures were based on emotion recognition (facial expression, body posture) and emotion management: a test of coping with bullying ("Dylan is being teased") and a test of coping with anxiety ("James and the Maths Test") [9]. The intervention appeared to be effective in enhancing the social skills and emotional understanding of children with ASD.

The game used in the other study [6], Let's Face It!, is directed primarily at enhancement of recognition skills, with the aim of improving poor facial recognition as a typical ASD-related symptom [6]. The game is freely available at the University of Victoria website (http://web.uvic.ca/~letsface/letsfaceit/), although it is recommended that players be supervised. It can be played on either a PC or a Mac with no internet connection. The player is given a series of tasks involving face processing (matching faces with a person's identity and grouping together pictures of the face of the same person). The participants in the study were exposed to the game for at least 100 minutes/week until the total intervention time of 20 hours was reached. The researchers provided advice to the participants' parents regarding the individual choice of games to play, based on the data collected on each child's playing style and preferences. The game includes two types of subtests: those pertaining to faces (face dimensions, short-term memory for faces, identity matching, masked

features, expression, and part/whole identity) and those pertaining to other objects (house dimensions and short-term memory for cars) [6]. Data were collected before and after the interve ntion and its average duration was 19.1 weeks. The main finding was that, relative to the control group (N = 37), children that underwent face recognition training demonstrated reliable improvements in their analytic recognition of mouth features and holistic recognition of faces based on the characteristics of eyes [6].

Post-traumatic stress disorder

Two studies were focused on post-traumatic stress disorder [3, 17]. One of these was actually an attempt to overcome the limitations of a previously conducted study [17]. Both studies utilized the well-known game of Tetris in order to relieve symptoms related to PTSD. The rationale for this choice of game was based on neurobiology of memory and the wider framework of cognitive science. Notably, flashbacks that are commonly experienced after traumatic events are understood as a combination of sensory/perceptual and visuospatial mental images. Therefore, if visuospatial tasks are performed within the timeframe of memory consolidation (with respect to the traumatic event or its recall), a competition for mental resources is expected, with conseqent interference that should reduce the likelihood and intensity of flashbacks. Even though Tetris had originally been developed for entertainment [18], this game has all the necessary characteristics to be useful as therapy in this context. Tetris is now available on various devices and platforms (*e. g.*, smartphone, tablet, gaming consoles). In both studies, participants played the game on a PC in controlled laboratory settings, with no internet connection. The design of Tetris scarcely needs recapitulation: a random sequence of geometrical shapes made out of four square blocks fall through the playing field. The player's goal is to form uninterrupted horizontal lines by moving the blocks left and right while they fall (and rotating them at will). Upon the completion of a full line, it is automatically removed. The game is lost when piled up blocks reach the top of the field. In both reviewed studies, Tetris was played for 10 minutes immediately after viewing a film with appropriate traumatic scenes. In all three studies, playing Tetris after the traumatic memory-evoking film reduced flashbacks. The observed beneficial effects were still observable after four hours, giving practitioners a certain temporal window to administer this type of treatment after real-life trauma.

Cognitive Functioning Disturbances

Two separate studies looked into possible use of serious games in the treatment of cognitive functioning disturbances [19]. One was directed at limited attention capacity [19], while the other investigated the age-related decline in cognitive performance, notably the impairment of working memory, processing speed, and cognitive control [12].

The study of Rezaiyan and coworkers [19] was based on the insight that attention power can be improved by playing some video games based on strong internal motivation [19]. In order to produce this effect and thus reduce symptoms of cognitive decline, the researchers used a cognition-training program/game focused on pathfinding, with difficulty level proceeding from easy to hard [19]. The game was played by participants for 35 sessions of 20-30 minutes' duration. The results showed that immediately after the intervention the average attention scores of the experimental group were significantly higher than those of the control group. However, this effect appears to have faded after five weeks [19].

The other study, that of Ballesteros *et al.* [4], targeted children with symptoms of cognitive decline, as determined by the Toulouse Pierson Scale. Here the choice of game was based on the concept of neuroplasticity [4]. The authors aimed at reduction of cognitive decline symptoms through the use of commercially available cognitive training PC platform called Luminosity [4]. It is also available on mobile devices. In the study, participants played the game for 20 one-hour sessions. Most of them experienced at least some improvement [4].

Attention Deficit-Hyperactivity Disorder

We found one study specifically aimed at symptoms of ADHD [5]. Here the game design was based on the hypothesis that functional deficits in ADHD are mainly the result of impulsivity, hyperactivity, and attention problems [20–27]. To mitigate the ADHD-related symptoms, the researchers used a cognition-training PC game called Braingame Brian [28]. The players/participants find themselves in the role of Brian, a young inventor who assists other game characters by creating various inventions. Gameplay in the study included a working memory task, a cognitive flexibility task, and an inhibition task. There were 25 sessions of 25-50 minutes. Children with the fully active condition showed a marked improvement of measured variables.

Alcohol Abuse

One study looked into possible treatment of AA [13]. The participants were patients of a veterans' outpatient medical center. The game, called Guardian Angel [29], was based on a CBT approach [30], with the aim to relieve AA-related symptoms. The participants played the game at the medical center, using a laptop. The player acts as a "guardian angel" whose goal is to guide a character towards recovery from AA by giving them support in their everyday decisions in terms of maintaining total abstinence. In order to fulfill their task, players need to recognize risk factors for relapse and act preventively. The emphasis of the game is on relapse prevention techniques and interventions, including identification of high-risk situations, capacity to refuse offered drink, stimulus control, and craving management. The game was played for eight sessions of one to eight hours over the course of 12 weeks. Interestingly, while

relapse rates did not differ between groups, those who played the game showed overall reduction in obsessive-compulsive symptoms, as well as higher ratings of self-efficacy [13].

In paper [31], unselected population of volunteers is included with the aim to prevent alcohol misuse and psychological distress, as well as improve coping skills and resilience are included. In the game that is used for this purpose, named ReachOut Central, the objective is to successfully settle and integrate in a new town. Interpersonal challenges are presented and users have to use problem-solving; they have to engage in activities that improve their mood in order to make progress through the game. The game appeared to have a protective effect against the need for early intervention in participants [31].

4. OVERALL BENEFIT OF SERIOUS GAMES IN PSYCHOTHERAPY

Few systematic reviews on therapeutic benefit of serious games in psychiatric disorders have been published to date [32, 33]. The quality and quantity of total available data do not yet allow a formal meta-analysis. Nevertheless, the 13 studies we reviewed in this paper may serve to demonstrate the potential usefulness of the technology, even though most games presented here should be considered a work in progress.

All of the games included showed at least some degree of effectiveness in relieving the symptoms of the targeted disorder or group of disorders, while (9/13, 69.2%) proved to be highly effective, potentially surpassing the benefit of CBT or other types of psychotherapy alone. Study participants reported a generally satisfactory experience, at least some reduction of symptoms, and a positive impact on their sense of wellbeing. However, any attempt at drawing a more general conclusion is hindered by an exceedingly high variability among the studies, in terms of both study/game design and the obtained results. It is also evident that there is a certain synergism between serious games as therapeutic tools and traditional psychotherapy, since all analyzed games are essentially based on the same theoretical premisses underpinning the latter, particularly CBT. The range of possible therapeutic applications of serious games is, accordingly, vast. However, no study that we are aware of, as yet, featured a direct comparison of effects of games/psychotherapy alone vs. their combination, which is indispensable if we wish to determine the degree of synergy between these therapeutic modalities.

A serious limitation of all presented studies were their primary outcome measures, consisting of symptom reduction as verified by an appropriate (validated) scale. In order to assess the full therapeutical potential of serious games, this should be supplemented in future studies by wider behavioral and clinical outcome data. Furthermore, the wide heterogeneity of utilized game mechanisms, together with the relative paucity of studies published, precludes any attempt to systematize data on correlations between particular types of game design and observed outcomes. It is evident, though, that all studied games had clear rules, an engaging narrative, and high levels of interactivity. Games that were well-designed and easily linked with the game's technology had higher degrees of practicality and acceptance, as well as more success in engaging players in the game storyline and attaining treatment goals. A game's success was not influenced solely by the technologies employed. Accordingly, it did not matter if the game used system-based technology or custom technology. Furthermore, effectivness did not appear to significantly depend on the targeted mental disorder, game genre, or the presence or absence of a supervising therapist. Finally, one must not overlook an expected (but not readily measurable) positive effect of playing serious games on the patient's sense of self-efficacy, irrespective of game type and other details, and even of the impact of the game on disorder symptoms *per se*.

5. CONCLUSION

Studies we analyzed offer preliminary evidence of a positive impact of serious games on patients with selected mental disorders. Using serious games as interventions for reducing mental health problems appears feasible. Due to the limited number of RCTs that we have been able to include in this analysis, this review can only give an idea of the potential of serious games for treating mental disorders in the future. More RCTs are needed to determine the effectiveness of serious games. Future studies should not lose the technological development out of sight. Smartphone-based serious games for mental health need more exploration. Further, the effect and use of serious games for mental health that let players connect with other players using an internet connection need to be investigated.

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FEEDBACK SUPPORTING DEEP AND STRATEGIC APPROACHES TO LEARNING AND STUDYING: A CASE STUDY ON PRODUCTION COST

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Abstract: *Feedback has one of the highest effects on learning. To benefit from its use, it should provide information important to students. This information may support activities applied in deep and strategic approaches to learning and studying. Bearing in mind that the production of quality feedback can be a costly enterprise, this paper examines the actual implementation cost of feedback techniques that provide such information. Although this cost may appear high at first sight, it becomes (much) lower if the developer task is consider as a "fill in a form" task because only modest extra work beyond the typical is needed. An example how this task might be done is included.*

Keywords: *E-Assessment, Feedback, Implementation cost, Learning approaches*

1. INTRODUCTION

Feedback has one of the highest effects on learning (e.g., [1]). To benefit from its use, feedback should provide information important to students (e.g., [2]). Bearing in mind the features of deep and strategic approaches to learning and studying – deep: "intention to understand, relating ideas, use of evidence, and active learning"; … strategic: "study organisation, time management, alertness to assessment demands, and intention to excel" ([3], p. 433) – this information (i.e. the feedback techniques providing it) may support activities applied in these approaches. For example, assessment feedback techniques regarding a deep approach may display (1) how certain questions from the test are related to the content which needed to be learned; and (2) which test contents are related to other contents that are studied in the course. Those regarding a strategic approach may show (1) a reminder of the most important facts about the knowledge and skills assessed by the test; and (2) student's individual results and the average result on completion of the knowledge tests.

Concerning e-assessment, our recent research focused on the importance of feedback techniques supporting activities applied in deep and strategic approaches to learning and studying [4, 5]. In the last study [5], ten feedback techniques were considered using a group of five techniques for each approach (for these techniques, see the Appendix). The examination of these techniques was done by students who assigned importance to each technique using a scale 0–10. A high average importance was assigned to both groups of techniques (above 7). This study also revealed that when the importance of all these feedback techniques was considered in a specific way, their potential relevance to achievement and motivation could be demonstrated. All these supported the claim that the use of this specific feedback based on learning approaches may result in certain learning benefits.

However, the production of quality feedback is usually a costly enterprise (e.g., [6]). This means that to have grounds to recommend the implementation of this specific feedback (i.e., feedback techniques supporting learning approaches that comprise it), apart from underlying possible learning benefits of applying it, consideration of its production cost should also be undertaken, hopefully resulting in a reasonable production cost. This contribution thus examines this cost in terms of the development time needed for feedback producation.

2. FEEDBACK PRODUCTION COST

To provide feedback to traditional test questions (multiple choice; true or false; and fill-in-the-blank with one word only), this study considered feedback techniques listed in the Appendix, whose production cost may at first sight appear as a costly enterprise, especially regarding feedback techniques D1–D5. However, if the test developer's task is

consider as a "fill in a form" task, the cost in question becomes (much) lower because only modest extra work beyond the typical is needed. In other words, to keep the cost in question reasonable, the test developer may use a form-based editor to enter and update certain feedback data, as is often done when certain information is best represented in a form-based format (e.g., [7]). Assuming the use of a form-based editor, the whole developer's work, including extra work, is described in the following paragraphs.

Typically, the developer has to enter the names of lessons, their parts, and learning objects comprising them; the descriptions of learning objects in terms of knowledge and skills involved; the content of questions used to assess these objects coupled with their correct answers. Enough for the assessment system to produce feedback techniques S2 and S3 provided that some basic statistics was already built-in in the system.

Assume that the value of each of these six attribute entered in a form are coded by the assessment system. Assume these codes for the second part of the third lesson are: L3, P3.2, LO3.2.1, LOD3.2.1, Q3.2.1.1, A3.2.1.1. Of course, there may be several learning objects (e.g., LO3.2.1, LO3.2.2, …, LO3.2.6), as well as several questions used to assess each of these objects coupled with their answers (e.g., Q3.2.1.1, A3.2.1.1; …, Q3.2.1.5, A3.2.1.5).

Some attributes (i.e. fields that accept their values) on this form are hierarchically arranged (i.e. a field hierarchy is present in the form). For example, when one learning object is selected (e.g., LO3.2.1), only questions assessing it are displayed (e.g., Q3.2.1.1, …, Q3.2.1.5). When one learning object is selected (e.g., LO3.2.1) and one question assessing it (e.g., Q3.2.1.5), the answer to this question is only shown (e.g., A3.2.1.5). In other words, assessment data need to be entered/updated/showed at different levels of granularity (e.g., [8]). Of course, for multiple choice questions, several responses to them, including correct ones are displayed.

By using such inheritance-keeping codes, feedback techniques D1 and S5 could easily be produced by the assessment system. How can this be done?

- Consider feedback technique D1. Assume it was applied to a 6-item test whose items were Q3.2.1, Q3.2.2, …, Q3.2.6 regarding three learning objects LO3.2.1, LO3.2.2, and LO3.2.3 (with two questions for each object). If answers to both questions regarding one learning object are correct, the underlying learning unit has been successfully mastered; otherwise it requires additional learning.

- Regarding feedback technique S5, the system can easily generate information similar to the following one: Assessment 1.1 regarding L1 (P1) includes LOD1.1.1, LOD1.1.2, and LOD1.1.3; Assessment 1.2 regarding L1 (P2) includes LOD 1.2.1, LOD 1.2.2., and LOD 1.2.3; etc. Of course, all these codes are replaced by the respective titles or descriptions.

The developer is required to undertake modest extra work to enable the production of feedback techniques D3, D4, S1, and S4. Let us finally briefly describe this extra work.

For these feedback techniques, each lesson part needs to be previously coupled with the content of four additional descriptors (e.g., P3.2.R – related learning objects; P3.2.D – way to implement from different point of view; P.3.2.R – reminder of the most important facts; and P3.2.L – what lessons appears before and after the current lesson). For D3, only codes of relevant learning objects need to be added (e.g., LO5.1.1, LO8.2.2). For S4, only codes of relevant lessons may be provided (e.g., before: L1, L2, L3; after: L5, L6, L7). For D4 and S1, only links to previously stored information may be added. Note that each additional descriptor may be considered as specific lesson feedback.

Although the content of the previous paragraphs contains many technical details (possibly confusing for those unfamiliar with software development), it is hopefully clear that the feedback techniques applied need to be connected to various assessment entities at different levels (whole course S5; lesson D4, D5, A1, S4; learning object D1; question D2). At present, general feedback can be provided for each question (e.g., S1), whereas specific feedback can be provided for one or several responses to it (e.g., D1), which is, for example, supported by Moodle, (https://docs.moodle.org/311/en/Quiz_settings).

* * *

To summarize: The previous examination showed that if test developer task is consider as a "fill in a form" task (provided that a suitable form-based editor supporting a field hierarchy was previously implemented in the assessment system), the cost in question becomes (much) lower than that perceived at first sight. This is because, as shown above, only modest extra work beyond the typical is needed. Also, in terms of development time, producing D1–D5 may not be considerably costly than that of S1–S5.

3. CLOSING REMARKS

Feedback has one of the highest effects on learning, and to benefit from its use, it should provide information important to students. Bearing in mind the features of deep and strategic approaches to learning and studying, this information (i.e. feedback techniques providing it) may support activities applied in these approaches. On one hand, the use of these techniques may have certain learning benefits. On the other, the production of quality feedback is usually a costly enterprise. Hence, before one recommends the implementation of this specific feedback, a consideration of its production cost should be undertaken. This consideration showed that if the developer task is consider as a "fill in a form" task, the production cost

would be reasonable because only modest extra work beyond the typical one is needed. However, a suitable form-based editor supporting a field hierarchy needs to be previously implemented in the assessment system. Furthermore, this form needs to enable one or more feedback techniques to be connected to various assessment entities at different levels (whole course, lesson, learning object, question). All these would increase (possibly not much) the overall production cost.

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Appendix – Feedback techniques supporting deep and strategic approaches to learning and studying

Deep approach

D1 – Information is obtained about areas that I have successfully mastered in the current knowledge test versus areas that require additional learning.

D2 – A link is given to a file whose content shows how certain questions from the test are related to the content which needed to be learned.

D3 – A link is given to a file whose content indicates which test contents are related to other contents that are studied in the course.

D4 – A link is provided to a file whose content indicates how knowledge and skills that are the subject of the test can be implemented from different point of view.

D5 – Information is obtained about which areas in the current knowledge test I could receive special learning assistance for from the professor.

Strategic approach

S1 – A link is provided to a reminder with the most important facts about the knowledge and skills assessed by the test.

S2 – Information is obtained about how successful I was in solving the tasks in relation to the success of other students who had already solved the test.

S3 – Information is given about my individual results and the average result on completion of the knowledge tests.

S4 – A link is given to a file that, according to the order of presentation, locates the part of the course (lesson) that is the subject of the test in relation to other parts that appeared or will appear in other tests.

S5 – Information is obtained about the order in which individual knowledge and skills will be assessed at tests that should be completed during the semester.

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ANCHORING AND ADJUSTING IN STUDENTS' RESPONSES TO A QUESTIONNAIRE ABOUT THE IMPORTANCE OF GIVEN E-FEEDBACK TECHNIQUES

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Abstract: *An answer to an item in a questionnaire may provide a cognitive anchor that limits respondent's adjusting to answer the next questionnaire item. This paper examines the issues of anchoring and adjusting in response to a questionnaire about the importance of listed e-feedback techniques. Two measures of anchoring and adjusting were applied, which revealed not only whether more anchoring and less adjusting were present, but also which respondents might apply more anchoring and less adjusting in their responses. Addressing these questions, especially when responses to two sets of items are similar overall, may be an important step in completing an appropriate discussion of questionnaire-based findings.*

Keywords: *Adjusting, Anchoring, E-Feedback, Questionnaire*

1. INTRODUCTION

In responding to items in a questionnaire, the answer to an item may provide a cognitive anchor that limits respondent's adjusting to answer the next item [1]. For example, by using a 5-value Likert scale from *Fully disagree* to *Neutral* to *Fully agree*, a student may respond to statement "I like to use technology in my studies" with *Agree*, and repeat the same answer to the next statement "I prefer on-line assessments rather than the traditional paper-and-pencil ones", even if answers *Neutral* or *Fully agree* may be more accurate in the assessment context.

When responses to two sets of items are similar overall (e.g., when expressed numerically, their respective means or medians are close to each other), it is important to examine to whether this outcome might be the result of considerable anchoring (or a little adjusting) in responding. Anchoring can be defined as reliance on the answer to the preceding item, while adjusting takes place when this answer is adjusted according to the context of the item at hand. It may also be important to find out which respondents (in terms of background variables, such as gender, education, and employment) might apply more anchoring and less adjusting in their responses. Bearing these two questions in mind, this paper considers the issue of anchoring and adjusting in students' responses to a questionnaire about the importance of the use of certain e-feedback techniques.

2. EQUAL IMPORTANCE OF TWO SETS OF E-FEEDBACK TECHNIQUES

Having in mind that feedback has one of the highest effects on learning (e.g., [2]) and that to benefit from its use, feedback should provide information important to students (e.g., [3]), we continued our empirical research on different feedback techniques in e-assessment endorsed by students [4], focusing on comparing the importance of feedback techniques supporting activities applied in two related approaches to learning and studying (a deep approach *vs* a strategic one). This subsequent research, presented in detail elsewhere [5], used a convenient sample of twenty second-year undergraduate students who completed an online questionnaire which measured the importance they assigned to each feedback technique given as well as the values of some background variables including academic

achievement. It was found that feedback techniques supporting activities of a deep approach were equally important to students as those supporting activities of a strategic approach (the given feedback techniques are listed in the Appendix). In particular, considering raw scores (the importance was expressed on a 0–10 scale for each technique), the median of the average importance assigned to feedback techniques supporting a deep approach was 7.30, whereas the median of this importance for feedback techniques supporting a strategic approach was 7.70, and these medians although different numerically, were not different statistically ($z = –0.984$, $p = 0.325$). Because of the small sample, nonparametric statistics were applied (e.g., [6]); reliability (Cronbach's alpha) of these averages (i.e. underlying variables) was satisfactory (0.73 for both approaches).

Why were these medians not different?

Two sets of feedback techniques might be viewed as beneficial to each other by the participants because, in general, deep and strategic approaches might contribute to each other positively. Undoubtedly, a strategic approach may overlap a deep approach to some extent. Consider, for example, a possible relationship between relating ideas (an activity in the deep approach) and good study management (a feature of the strategic approach) [7]. Good study management may enable (result in) focusing on relating ideas, and for focusing on relating ideas, good study management may be needed. Such a positive relationship was found as there was a high positive correlation between the two variables whose medians are reported above (Spearman's rho was 0.831, $df = 18$, $p = 0.000$). This outcome is in accord with the finding of another study [8], suggesting that the measures of deep and strategic approaches may positively correlate in general.

Another (possibly complementary explanation might be that the equity in question was a result of applying more anchoring and less adjusting in response to items in the questionnaire used. This issue is examined in the following section.

3. ANCHORING *VS* ADJUSTING

The Appendix contains ten items: five items with feedback techniques supporting activities found in a deep approach (D1 – D5) and five items with feedback techniques regarding features of a strategic approach. These items are listed in the questionnaire in the following order: D0, S1, D1, S2, D2, S3, D3, S4, D4, S5, D5, S0 (D0 and S0 denote discarded items). Intermixing these items was applied because there may be certain advantage of this approach when related constructs are measured within a particular context (e.g., [1]). If the participants applied more anchoring and less adjusting in response to these items, correlations between relevant pairs (S1 and D1, S2 and D2, …, S5 and D5) would be high and statistically significant. Such an outcome was not found because these correlations (Spearman's rho was calculated) were: 0.308 (S1–D1, $p = 0.187$), 0.540 (S2–D2, $p = 0.014$), 0.444 (S3–D3, $p = 0.050$), 0.001 (S4–D5, $p = 0.997$), and 0.396 (S5–D5, $p = 0.084$). This means that overall the participants did not apply more anchoring and less adjusting in response to these items. This outcome increases the validity of our explanation that the equity in question might be the result of two sets of feedback techniques being viewed by the participants as beneficial to each other. This position was supported by the empirical data because the absolute value of the difference of the means of two importance variables was not greater than 0.8 for 15 (75%) participants (recall that a 0 – 10 scale was used). We can thus confidently claim that two sets of feedback techniques might be viewed beneficial to each other by most participants.

Although the results of the correlative analysis presented in the previous paragraph provide evidence that the equity in question was not caused by anchoring, they do not reveal which respondents might apply more anchoring and less adjusting in their responses. To address this question, the mean of absolute differences between the responses to these item-pairs was calculated for each participant (e.g., [1]). (The sum of absolute differences is usually called Manhattan distance or the taxi cab metric; e.g., https://en.wikipedia.org/wiki/Taxicab_geometry.) This mean ($M = 1.86$, $SD = 1.37$) was greater then 1.00 for 12 participants (60%), which confirms the outcome of the correlative analysis undertaken. Furthermore, the mean positively correlated with course achievement (Spearman's rho was 0.574, $df = 18$, $p = 0.008$), which means that participants with lower course achievement (in particular those whose final mark was 6, 7 or 8 out of 10) responded to adjacent item-pairs in a more similar way (i.e., with more anchoring and less adjusting) than did participants with higher course achievement (those whose final mark was 9 or 10).

4. CLOSING REMARKS

This study was concerned with anchoring and adjusting when responding to a questionnaire. It examined these issues concerning a questionnaire about the importance of e-feedback techniques given, especially because equal importance of two sets of such techniques was found. Correlative analysis showed that overall participants did not apply more anchoring and less adjusting when responding to these items. Additional correlative analysis, which made use of Manhattan distance, revealed that participants with lower course achievement responded to adjacent item-pairs in a more similar way (i.e., with more anchoring and less adjusting). Addressing the issues of anchoring and adjusting in responding to a questionnaire, especially when responses to two sets of items are similar overall, may be an important step in completing an appropriate discussion of questionnaire-based findings.

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Appendix – Questionnaire items used to assess the importance of feedback techniques

Deep approach

D1 – Information is obtained about areas that I have successfully mastered in the current knowledge test versus areas that require additional learning.

D2 – A link is given to a file whose content shows how certain questions from the test are related to the content which needed to be learned.

D3 – A link is given to a file whose content indicates which test contents are related to other contents that are studied in the course.

D4 – A link is provided to a file whose content indicates how knowledge and skills that are the subject of the test can be implemented from different point of view.

D5 – Information is obtained about which areas in the current knowledge test I could receive special learning assistance for from the professor.

Strategic approach

S1 – A link is provided to a reminder with the most important facts about the knowledge and skills assessed by the test.

S2 – Information is obtained about how successful I was in solving the tasks in relation to the success of other students who had already solved the test.

S3 – Information is given about my individual results and the average result on completion of the knowledge tests.

S4 – A link is given to a file that, according to the order of presentation, locates the part of the course (lesson) that is the subject of the test in relation to other parts that appeared or will appear in other tests.

S5 – Information is obtained about the order in which individual knowledge and skills will be assessed at tests that should be completed during the semester.

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A SYSTEM FOR INTERACTIVE LEARNING ADVANCED TOPICS IN DATA STRUCTURES

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Abstract: *The gamification of learning has led to the development of interactive courses used both in commercially available online platforms and Higher Educational Institutions alike. With interactive learning methods, students are more likely to overcome even difficult topics which could not be presented in such a way in written textbooks. Students of Computer Science (CS) and Software Engineering (SE) are often met with a topic which includes a high level of abstraction which can be difficult to grasp, especially if taught in undergraduate years. Advanced topics in data structures such as trees and graphs are often hit-or-miss – students either fully understand them or not at all. In this paper, we present an interactive system for online learning of advanced topics in data structures. Our system, consisting of three parts – theory, animation, and assignments, coupled with support for assignment autograding aims to help CS and SE students in understanding both fundamental and advanced topics in data structures. We compare our system to several other available systems and point out the main differences. We show that the main advantages of our system are that by incorporating the three-part learning structure, a student can learn data structures by using existing structures as prime examples, and later built their own advanced data structures from scratch.*

Keywords: *autograding, data structures, eLearning, graphs, trees*

1. INTRODUCTION

Undergraduate students in Computer Science, Information Technology and similar fields are introduced to the basics of a programming language early in their studies – often in the first semester. In such introductory courses, students learn variable types, conditionals, loops, and basic file import/export. During their studies, specific courses cover complex data types such as arrays, and shift from a procedural programming paradigm to an object-oriented (OO) one, where classes, objects, and instances are covered. Furthermore, advanced courses cover abstract data types (ADTs) and data structures, which can cover one or more ADTs.

Based on data from GitHut.info, The Java programming language ranks the second most active programming language on the GitHub repository [1, 2], and often ranks in the top three programming languages in use. However, while Java programming language is widely used at higher education institutions (HEIs), students often have difficulties to master advanced topics, such as the OO paradigm or algorithms that use ADTs [3-5].

As pointed out in [6-8], the gamification of education has led to an increase of student motivation, engagement and achievements throughout their studies. In the authors' previous works [9-12], we have firstly analyzed potential obstacles and possible solutions for learning the basics of a programming language, and drafted a system for covering topics in data structures in Java.

The remainder of the paper is organized as follows. Section 2 covers the importance of learning data structures for CS and IT students. In Section 3 we propose a system for interactive learning advanced topics in data structures, and compare them to a popular existing online web-based tool in Section 4. Finally, in Section 5 we present our conclusion and discuss our future work.

2. DATA STRUCTURES IN COMPUTER SCIENCE

In the context of Computer Science, ADT is defined as a mathematical model for complex data types. Abstract Data Type (ADT) is a data type, where only behavior is defined but not implementation and that's why it is called abstract. An abstract data type is defined indirectly, only by the

operations that may be performed on it and by mathematical constraints on the effects (and possibly cost) of those operations.

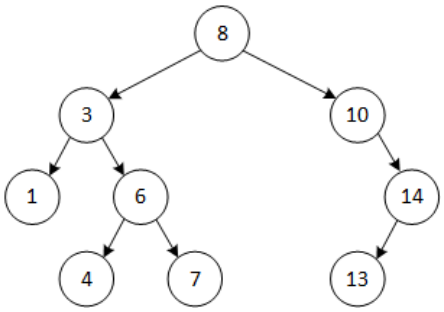

Image 1: Binary Search Tree.

Data structures [13] can implement one or more particular ADT, which specify the operations that can be performed on a said data structure and the computational complexity of those operations. A data structure is being viewed as a concrete implementation of the space provided by an ADT, not unlike classes and objects in the OO paradigm.

Data structures are important, as they provide a means to manage large amounts of data efficiently, e.g. large databases or Internet indexing services [13]. Efficient data structures are therefore crucial in the design of efficient algorithms, as they can be used to organize the storage and retrieval of information which can be stored in both main and secondary memories.

As an example, we present a binary search tree (BST) [13], which is an advanced data structure. A binary tree is made up of nodes that contain links that are either null, or point to other nodes. Each parent node has exactly two links, which are called left and right child links. In a BST, each node also has a key and a value, with an ordering restriction to support efficient search. This restriction states that the keying any node is larger than the keys in all nodes in that node's left subtree and smaller than the keys in all nodes in that node's right subtree, as shown in Image 1.

BSTs are often used in search an application where data is constantly being imported and exported i.e. data is dynamically changing. In the Java programming language, map and set objects use BST, as well as libraries for many other programming languages. Another example of using BSTs is routing tables in network routers. Binary trees can be used for various artificial intelligence algorithms, such as classification algorithms in expert systems and machine learning. The binary tree data structure is used to emulate the decision-making process. In data compression, BSTs are used to compress data, with the most notable being Huffman coding algorithm.

Another example is a graph, which can be defined as a set of vertices and a collection of edges that connect a pair of verities, as shown in Image 2 [13].Graphs are used for path optimization algorithms. These algorithms are primarily used to find the best connection that fits some predefined

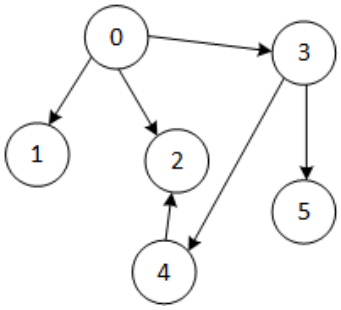

Image 2: Graph.

criteria e.g. speed, safety, fuel etc or set of criteria, e.g. procedures or routes.

In unweighted graphs, the shortest path of a graph is defined as the path with the least number of edges. The Breadth First Search (BFS) algorithm is used to find the shortest paths in graphs. In BFS, a node is reached from another node in the fewest number of edges in breadth graph traversals [13]. The Depth-first search (DFS) algorithm is used to traverse or search data structures such as trees or graphs. The DFS algorithm starts at the root node (selecting some arbitrary node as the root node in the case of a graph) and explores as far as possible along each branch before backtracking [13].

Introductory courses in a programming language (i.e. Java, Python, C++ etc.) do not cover the majority of concepts related to data structures, with the exception of arrays (or lists in Python).

3. PROPOSED MODEL

We have proposed a system to primarily help understand the concepts of advanced data structures to students that have already mastered topics in an introductory Java course, such as trees and graphs.

Our proposed system is based on a previously implemented autograder system used implemented for the purpose of learning basic programming concepts, but also objective-oriented programming [9-12]. This system consists of the following, as shown in Image 3 on the next page:

- Baseline: The student completes a self-assessment on the topic of data structures, to build a baseline. This test can be in the form of a short quiz, or multiple-choice.
- Theoretical part: The student learns a topic in advanced data structures through a lesson, given in written, video and animated form.
- Assessment type 1: An easy-to-medium difficulty assignment is given to the student. The student inputs code within a text editor (a Java compiler is running as a server-side application) in-browser with part of the code given to the student.

- Assessment type 2: A medium-t-hard assignment is given to the student. The student inputs code within a text editor with no code previously given to the student, i.e. the student writes from scratch.

After each of the topics' assessments, an autograder system informs the student if they have passed the current topic successfully, and can only continue with the next topic if the previous is passed. At the end of the whole course, the student completes the same (or similar) baseline test to self-assess their progress.

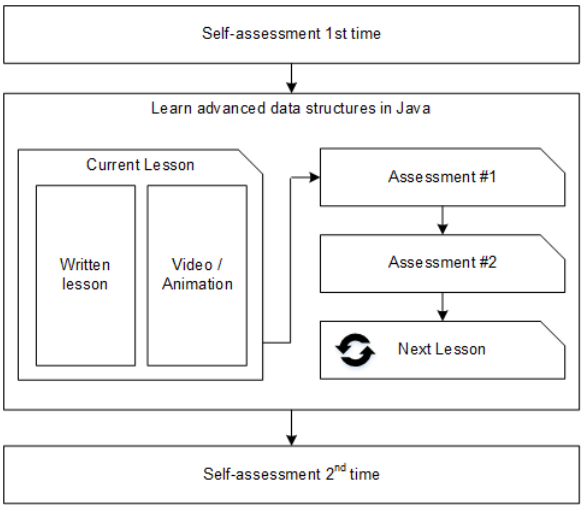

Image 3: Components of the learning system model.

Image 4 shows the UI diagram for our proposed system, while Image 5 shows the assignment screen for a DFS problem. The assignment screen is divided into three areas. The upper left area presents the assignments itself, with highlighted text for necessary keywords. The upper right presents the input part, where the student writes their code. Finally, the lower part of the screen is the output of the autograder, which runs multiple tests after the student, submits their code. All passed tests are highlighted in green, while failed tests are highlighted in red, with an accompanying message regarding why the test failed. This approach allows more complex assignments to be made, as well as enabling support for different programming paradigms. Speed tests show low latency in the result response, although our solution is currently running on a home server.

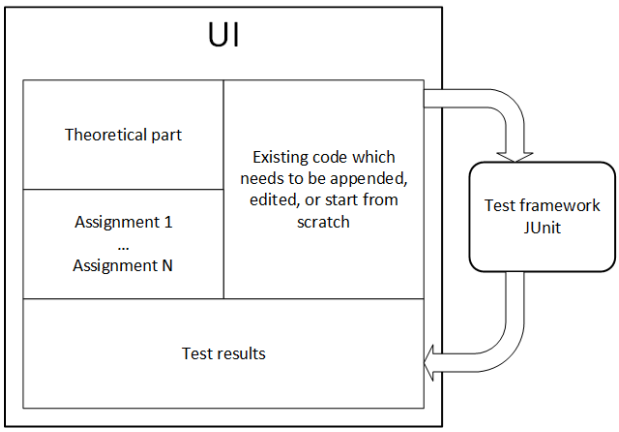

Image 4: UI diagram.

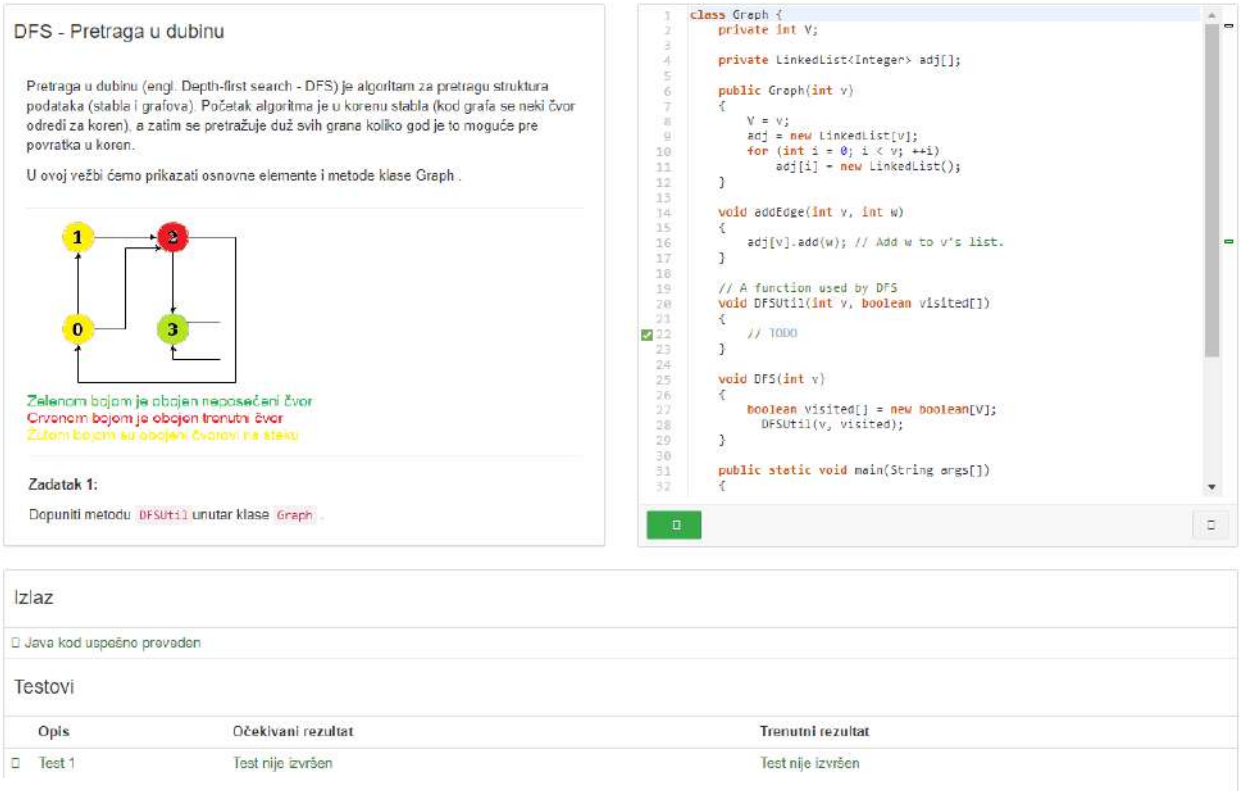

Image 5: The UI of the data structures in Java learning web-based application.

Table 1: HackerRank assignments in Data Structures with difficulty levels

Data Structure	Number of problems and difficulty
1D and 2D Arrays	6 (4 Easy, 1 Medium, 1 Hard)
LinkedLists	15 (14 Easy, 1 Medium)
Trees and Balanced Trees	20 (8 Easy, 4 Medium, 2 Advanced, 5 Hard, 1 Expert)
Stacks	9 (2 Easy, 5 Medium, 2 Hard)
Queues	5 (3 Medium, 2 Hard)
Heap	4 (2 Easy, 2 Hard)
Sets	4 (1 Medium, 3 Hard)

4. COMPARISON WITH OTHER SOLUTIONS

In this Section we analyse and compare our solution with several platforms, free and commercially available.

CodingBat [14] is a free tool developed by Stanford Professor Nick Parlante to test assignments in Java and Python, as shown in Image 3. The assignments are divided into multiple topics, each including a simple written lesson, and a group of assignments for each topic.

This web application has a simple user interface (UI), the assignment text at the beginning, an editor to write the code, and a button to test the solution. The complexity of the available assignments is very low, and CodingBat currently supports only a small number of data structure assignments for Java, and none for Python. The data structures supported are only single dimension arrays and maps.

HackerRank [15] is not a classical e-learning system, and it is more adequate for students who are already familiar with data structures concepts. It covers the following data structures: 1D and 2D Arrays, Linked Lists, Trees, Balanced Trees, Stacks, Queues, Heap, Sets. The UI of HackerRank is richer than CodingBat, and it also supports a larger number of problems. The number of problem and difficulty levels in HackerRank is shown in Table 1. Problems can be filtered in categories such as solved/unsolved, easy/medium/hard, and by subdomain of data structure. Assignment evaluations are done in real time within the web browser. However, as with the case with CodingBat, there is a lack of the theoretical part, just the assignment is presented. In addition, to be able to attempt to solve the problems, the student must be logged on into their system.

Table 2: Comparison with CodingBat, HackerRank and Codecademy for topics in Data Structures

Supported Feature	Coding Bat	Hacker Rank	Code cademy	Our Solution
Written Lesson	✔	✔	✔	✔
Video and/or animation	✘	✘	✘	✔
Self-assessment	✘	✘	✘	✔
Quiz	✘	✘	✘	✘
Simple topics	✔	✔	✔	✔
Advanced topics	✘	✘	✔	✔
Simple autograder	✔	✔	✔	✔
Advanced autograder	✘	✘	✔	✔

Finally, Codecademy[16] offers several courses in data structures, one in Java and multiple in Python. The Java course (Java: Algorithms) offers topics in simple data structures, such 1D and 2D arrays, used in sorting algorithms. The Python courses offer more complextopics, such as hashmaps heaps, trees and graphs. Thiscourse is notfreely offered though, and required a subscription for CodecademyPro.

Ofthe three compared solutions, Codecademyha stherichest UI, and is overall most intuitive. However, evaluation response is greater than the previous two solutions. In addition, thelessor par of the course, i.e. the theoretica lpart, is given in textform, and no animations or videos are used, which we consider as a disadvantage, as visual aids for understanding complex data structures is prefered.To compare our proposed solution with the three previously analysed solutions, each of the components will be listed as supported or unsupported in Table 2and explained in detail below. It should be noted that our solution is still in development, and only main functionalities have been implemented.

All solutions have the topics covered in written form, while our solution has an added feature for a video lesson and/or animation covering the given topic, with a self-assessment at the beginning and end. All solutions have examples and assignments in simple data structures like one-dimensional arrays; however, our solution has specific parts regarding trees and graphs for Java, while Codecademy has a Python equivalent, however access to this course requires a paid subscription. Autograder support is present in all solutions. In general, anautograder will run multiple inputs to check if the code is correct. For all solution except Codecademy, the simple design of the UI and makes this autograder very fast, i.e. the response latency is very low. The correctness in Hacker Rank and Coding Bat is measured only if the program can pass all the input tests, and the expected outcome is shown either way. For instance, passing all the tests can be achieved by hard coding inputs. A more complex autograder will not show the solution, but rather display a specific error message, depending on the type and location of error. Codecademy and our solution support this type of autograder.

In addition, in CodingBat and HackerRank, a student can arbitrarily choose which problems to try, while our solution has a step-by-step approach, with each step increasing in difficulty. Furthermore, several other commercial solutions do exist in the form of different tutorial websites or courses in Massive Open Online Courses; however, their features and performance are beyond the scope of this paper.

5. CONCLUSION

In this paper, we have presented a solution to learn advanced data structures in Java with all previous knowledge being incorporated in the form of theoretical background and assessments, which are automatically graded. Our solution is the first step in the development of a user-frienly0yet-powerfull web-based learning system, and future improvements include adaptive learning assignments of the autograder, several beginner and advanced level courses, such as blockchain [12], as well as multiple language support.

ACKNOWLEDGMENT

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A SYSTEM FOR INTERACTIVE LEARNING OF THE PYTHON PROGRAMMING LANGUAGE WITH AUTOGRADING SUPPORT

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Abstract: *The steady rise in popularity of the Python programming language has shown a need to incorporate Python in all levels of education. Indeed, the simple-yet-powerful syntax of Python has proven that the language is suited for all programming paradigms, with various use-cases and applications. However, most educational institutions are just starting to incorporate Python in their curricula, often with an approach which cannot fully unlock the potential of Python. In this paper, we present an interactive tool for learning Python that we have developed, which addresses the issues often found on other, mostly online courses. In addition, we have incorporated an autograding system which can check the learner's solutions for multiple test cases, supporting different paradigms as well. We analyse our solution by comparing its content to multiple commercially available solutions, both in the form of topics covered and the presentation approach, and point out the advantages and disadvantages of each.*

Keywords: *autograding, E-Learning, Python*

1. INTRODUCTION

The Python programming language is often regarded as the most-demanded programming language [1]. According to Tiobe [2], Python holds rank #2 in August 2021, and has been the language of the year in 2007, 2010, 2018, and 2020 [2]. As a general-purpose programming language, Python supports different programming paradigms, i.e. procedural, object-oriented, functional and reflective. With simple-yet-powerful syntax, Python is one of the more easy-to-learn and easy-to-use languages, and is suitable for beginners and experienced programmers alike. Python 3.x is modular, and has an extensive library that supports common commands and tasks. As a scripting language without a compiler, it allows programmers to test code as they go, reducing the amount of time wasted on compiling or creating and testing long sections of code.

The rise in popularity over the last decade has shown a need to incorporate Python in all levels of education, most recently as a first programming language for first year students of studying computer science (CS), information technology (IT), electrical engineering (EE) and software engineering (SE) [3-5]. Higher education institutions (HEIs) which are starting to incorporate Python in their undergraduate curricula often copy curricula from other, usually C-like languages, and this approach cannot fully unlock the potential of Python. Furthermore, with the rise of Massive Open Online Courses (MOOCs), learning Python, even at a beginner level, can be overwhelming for students, as different courses for the same language are often tought with different approaches.

In this paper, we present an interactive web-based tool for learning Python 3.x, based on identified shortcomings of other, mostly online courses. Our goal was to deploy a solution which can be easily accessed in-browser by multiple users, not needing a separate compiler, libraries or an integrated development environment (IDE). To track the progress of students and to check the students' inputs, our tool supports an automatic grading system, referred as an autograder in the rest of the paper. For the syllabus, we have followed the course Scripting Languages tought at Belgrade Metropolitan University (BMU) on the third year of IT studies, which is equivalent to a begginer-to-intermediate Python course offered by other univercities or MOOCs.

The rest of the paper is organized as follows. Section 2 gives a detailed history in autograders. Section 3 presents our solution, and Section 4 compares it with several autograder-supported commercially available solutions, and those offered by MOOCs. Finally, in Section 5 we discuss future work, and Section 6 concludes the paper.

2. AUTOGRADERS

Autograders are programs that help teaching staff (professors and teaching assistants) by reducing their work load of having to manually grade all students' assignments, and by also removing the teaching staff's bias. This is especially important for CS and EE students, as the majority of the assignments are in the form of writing a computer program to run a specific task. The idea of autograder systems, especially in EE and CS dates back to over fifty years ago [6, 7]. These early autograder programs were able to check only very simple programming assignments, and they supported procedural programming paradigms. A simple autograder would output only "correct" or "incorrect" as an answer, often by checking a strict set of successive instructions written by the student.

The next generation of autograders employed different tools, which came with the operating system, to build new tools. The use of C-like programming languages, i.e. C, C++, and Java, were used to build these autograders, which would also check problems only in their respective language [8].

The current generation of autograders emerged with the rise of the high-speed Internet and modern web development technologies [9-14]. In such systems and platforms, a web application is hosted on a server with a user interface (UI) to the student. A student can write their program in a browser, without the need of an interpreter or compiler (depending of the programming language) or an IDE installed on their home computer. This also reduces the hardware requirement of students' home computers or in-campus computers. Furthermore, this generation of autograders can often have support for different programming languages and several programming paradigms, such as object-oriented programming, or functional programming, while previous generations mostly supported the procedural programming paradigm.

As pointed out in [12], many existing autograder tools exist; however, the majority of them are often a custom-tailored solution for specific programming languages and requirements only. In fact, apart from specific tools developed for HEIs, several MOOCs and commercial solutions with autograder support exist for only specific courses, e.g. learning the basics of a programming language.

Autograders in general have two main issues – technical and pedagogical [6]. Technical issues include regard overall security and protection from potential malicious code written in the assignment, as well as integration with HEI's LMS, if any exists. Pedagogical issues include a non-uniform grading system, often set by the autograder's developers. Some autograders still use the same correct/incorrect system, while more sophisticated autograders use a step-by-step testcase grading system. As of writing this paper, the authors could not find a uniform model or a recommendation for grading.

3. WEB-BASED APPLICATION FOR LEARNING PYTHON

We have developed web-based application for the learning of Python 3.x language. Based on different existing solutions, like the free-to-use CodingBat [15] and the commercially available Codecademy [16], which take on different approaches to learning a programming language, our solution aims to take the best of both worlds. A more detailed comparison of the thee tools is given in Section 4. As of writing this paper, our application is still in-development, although the majority of the features have been implemented.

Our application is comprised of two parts, the former being an actual lesson, presented in text and/or video, and the latter being the assignment within the lesson [17, 18]. The UI diagram of the application is presented in Image 1. According to the given assignment, a student can append existing code, edit existing code, write new code from scratch. Every assignment consists of a group of tests to check the correctness of the student's solution. For this purpose, we have applied the PyTest library [19].

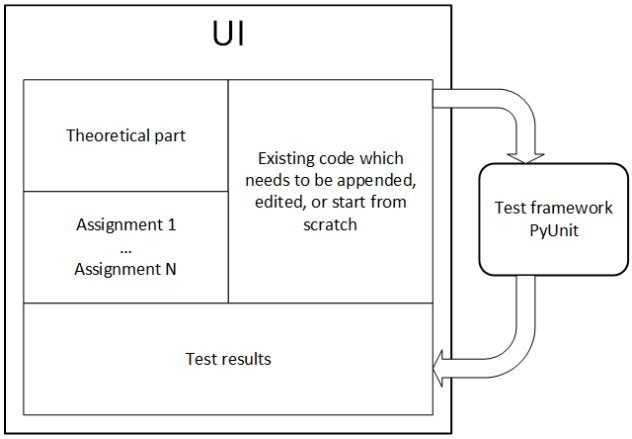

Image 1: Application UI diagram.

An assignment screen for a developed Blockchain course in Python in shown in Image 2 on the next page [20]. The assignment screen is divided into three areas. The upper left area presents the assignments itself, with highlighted text for necessary keywords. The upper right presents the input part, where the student writes their code.

Finally, the lower part of the screen is the output of the autograder, which runs multiple tests after the student submits their code. All passed tests are highlighted in

green, while failed tests are highlighted in red, with an accompanying message regarding why the test failed. This approach allows more complex assignments to be made, as well as enabling support for different programming

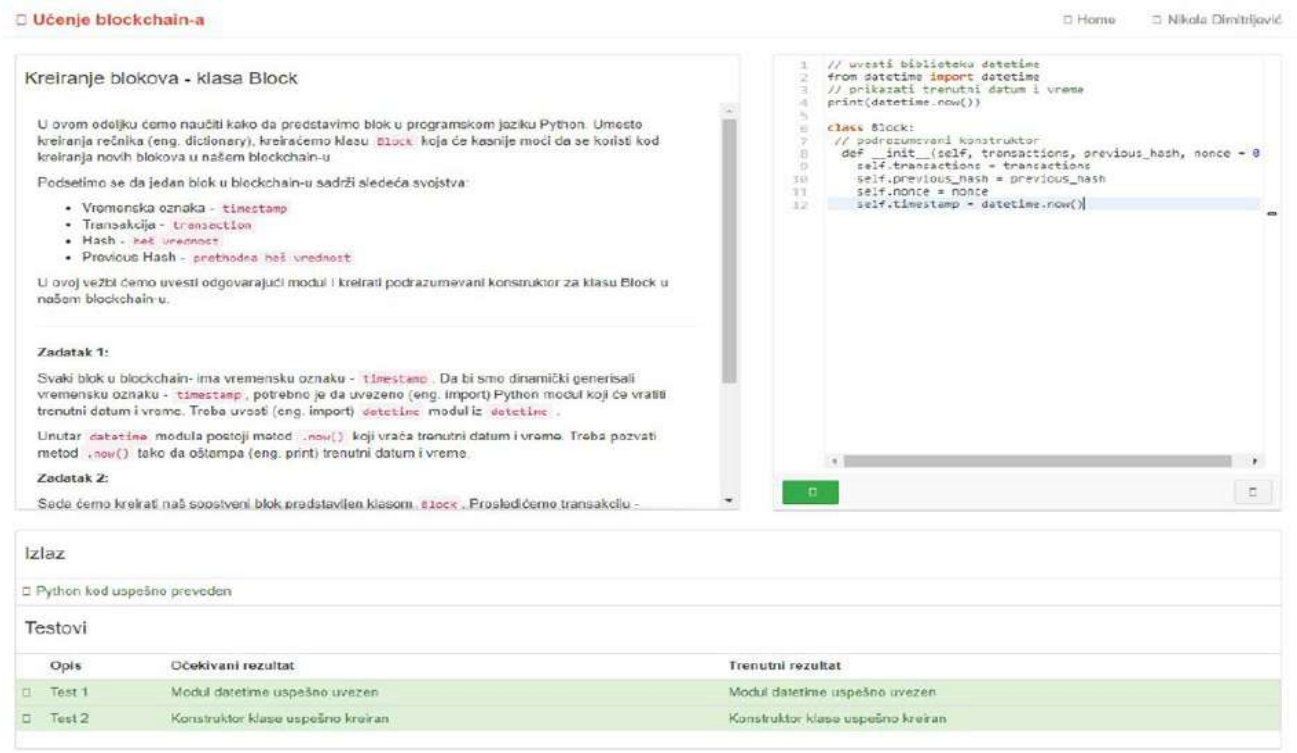

Image 2: The UI of the author's Python learning web-based application.

paradigms. Speed tests show low latency in the result response, although our solution is currently running on a home server.

For the course syllabus, we have chosen to follow the course offered at BMU at third year of studies for IT students – Scripting Languages. The topics are as follows:

- **Introduction to Python**. An overview of Python's history, comparison with Python 2.x with common conversion mistakes. Python syntax. Operators. Simple data types.
- **Procedural programming in Python**. Conditionals. Loops. Complex data types. Simple data structures – arrays. Functions. Recursion.
- **Object-oriented programming in Python**. Classes and objects. Message Passing. Inheritance.
- **Python modules and packages**. Python standard Library. Math and datetime modules. Importing custom modules. Working with databases.

The topics in the syllabus follow a beginner-to-intermediate Python course, covering many of the aspects Python is used today. Furthermore, we plan on expanding the data science with data visualization, and machine learning topics, which are to be covered with a separate course with Jupyter notebooks [21, 22].

4. COMPARISON

In this Section, we analyse our solution with one free and one commercially available solution, namely Codecademy. All three solutions are browser-based and do not require the student to install a compiler or interpreter to try the assignments.

CodingBat

CodingBat [10] is a free tool to test simple assignments in Java and Python, as shown in Image 3. This web application has a simple UI, the assignment text at the beginning, a textbox to write the code itself, and a "Go" button to test the student's solution. After writing the code, the autograder will run multiple inputs to check if the code is correct. If all inputs result in the expected output, a message "All Correct" will appear on the right, with green boxes for each test input. If one or more inputs fail to give the required output, red boxes are shown. The simple design of the UI and makes this web application very fast, i.e. the response latency is very low. However, the complexity of the available assignments is very low, and CodingBat currently supports only a small number of procedural assignments for Python. The main advantage is that this tool is free to use. In addition, CodingBat has low response time, as the result of the student's input is

displayed almost instantly. The main disadvantage is the lack of more assignments, the inclusion of the object-oriented programming paradigm, and more details on why some errors occur. Currently, an error message only indicates on which line of code the error is, without any further explanation.

Codecademy

Codecademy is a paid tutorial portal containing interactive learning materials for programming in many languages, such as Python, Ruby, PHP, Javascript and HTML/CSS. Tutorials are often completed by following instructions in a step-by-step manner, with writing the required code in the browser-based code editor [23].

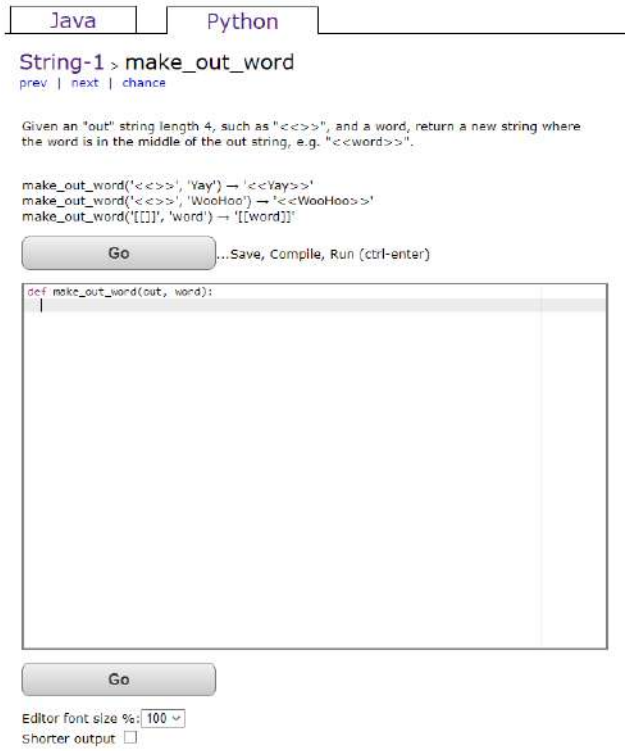

Image 3: CodingBat UI.

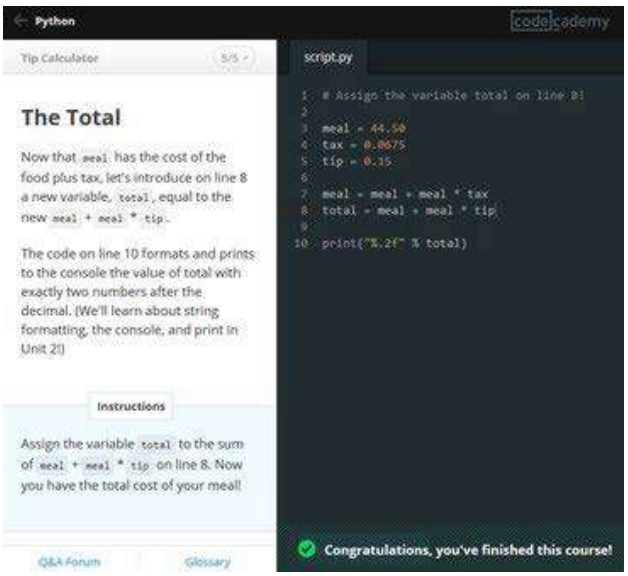

Image 4: Codecademy UI.

Codecademy offers a premium subscription plan to access all the courses, and for the purpose of this analysis, the authors have accessed only the free, basic course in the Python programming language. For the purposes of this paper, the authors only compared the free Python course offered.

While the UI is more intuitive and clearer when compared to CodingBat, as in the writing of this paper, object-oriented programming paradigm support still does not exist for the free course. Furthermore, the response latency of the platform is higher compared to the free solution, often needing to refresh the whole browser page when more complex assignments are involved. The main advantages of Codecademy is their growing support for multiple programming languages with specific topics in mind, such as fourteen courses in Python and fifteen courses in Java as in the writing of this paper. However, the main disadvantage is pricing, which is around 20 USD a month, or about 200 USD on a yearly basis.

5. FUTURE WORK

During the development of this web-based learning platform for Python, we have identified several gaps which we intend to cover in our future work. Namely, specific topics for Python, such as advanced data structures, web development and web frameworks, data science and machine learning, can be offered as separate courses. We intend to add quizzes before each coding assignment, to test the students' theoretical knowledge as well. By offering different Python courses, we can link them to offer a specialization, such as a "Python developer career path".

Furthermore, special attention will be added to constructing an auto-grader for Jupyter notebook, as they are interactive and can be evaluated on a block-of-code-by-block-of-code basis.

6. CONCLUSION

In this paper we have presented a web application for learning the Python 3.x programming language, albeit still in development, together with well as a simple comparison to a free site for with simple example assignments languages, and a free course offered by Codecademy. As of writing this paper, both online solutions with which we compared our own application offer only assignments in the procedural programming paradigm, with no support for other paradigms. The response latency of the two solution varies, which mostly depends on the number of accessed instances. CodingBat, although with a simpler UI, offers little-to-none latency while Codecademy does not. Furthermore, CodingBat offers "solutions" on what to expect on the output, allowing assignments to be written as a sequence of if-else statements. Our solution hides the answers, encouraging students to think about the problem and not getting the right solution for the specific test or tests. As the development of web application continues, we plan to add specific learning topics for Python, as well as video lectures before each assignment. In addition, this model be extended to include the learning of different programming languages.

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LEARNING THE KOTLIN PROGRAMMING LANGUAGE USING AN AUTOGRADING SYSTEM

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Abstract: *In modern curricula for Computer Science (CS) and Information Technology (IT), one of the more popular classes is mobile development. With the recent rise of the Kotlin programming language as a main contender for Android development, very few courses in Higher Education Institutions (HEIs) exist which incorporate Kotlin as a main language. Furthermore, online courses which offer learning Kotlin are very limited, or require a high subscription price. More importantly, neither online, nor HEI courses offer an automatically graded system for student assignments in Kotlin.*

In this paper, a tool for learning for learning the Kotlin programming language with is presented which supports automatic grading of assignments. As the Kotlin language is itself designed to interoperate fully with Java, this tool, developed by the authors, is aimed at CS and IT students who have already have basic knowledge of Java (or similar) programming languages, and want to switch to mobile development. Our solution focuses on the development of an interactive course in Kotlin meant primarily for Java developers. The assignments in the course also compare certain approaches to a solution in Java and Kotlin side-by-side. The solution is developed as a web application, not needing a separate compiler, libraries or an integrated development environment. Furthermore, to compare our solution with commercially available ones, we point out the disadvantages of currently available Kotlin courses, such as the level of previous knowledge needed, or a need for a specific development environment.

Keywords: *autograding, eLearning, Kotlin, Java, mobile development*

1. INTRODUCTION

Since its inception over 25 years ago, the Java programming language is currently at among the most popular programming languages [1, 2]. As a general-purpose language, Java has gained its popularity by being platform-independent, attributable to the Java Virtual Machine (JVM). The use of JVM has led to new programming languages, such as Groovy, Scala, and most notably Kotlin [3]. The increasing popularity of Kotlin is evident, as in 2017, Google announced Kotlin as one of the officially supported languages for Android development [4]. Among the reasons for choosing Kotlin, Google mentioned it is “concise, expressive, and designed to be type and null-safe” [4]. Kotlin was developed in 2010 by JetBrains in order to improve the programming experience for the JVM [5]. It is a multiparadigm language, which supporting both object-oriented and functional programming paradigms, allowing developers to use either of a combination of [6]. In addition, Kotlin has interoperability with Java, therefore both languages can be freely mixed and allowing for gradual migration.

Although officially supported for Android development, the learning curve of Kotlin can be difficult for developers not used to Java [7]. Indeed, as more Higher Education Institutions (HEIs) offer languages such as Python as a first language for students, learning Kotlin without Java can

prove difficult [8-11]. Our motivation is to present a learning tool for seamlessly learning the Kotlin language, aimed at Computer Science (CS) and Information Technology (IT) students who have already basic knowledge of Java (or similar) programming languages, and want to switch to mobile development.

In this paper, we present a web-based application for learning the Kotlin language with autograding support, suitable to follow a mobile development course offered to CS and IT students. The web application is still in development, however major components have been identified and will be detailed below. The rest of the paper is organized as follows: Section 2 covers the Kotlin course overview, required previous knowledge, course topics and syllabus. In section 3 we propose our system with its major components. Section 4 deals with future work regarding the web application, and Section 5 concludes the paper.

2. KOTLIN COURSE OVERVIEW

Although somewhat derived from Java, Kotlin is a separate language and, while sharing some similarities with Java, its distinct differences require a separate course. In the first Subsection of Section 2, we point out the major differences in Kotlin from Java, and give a course overview in Subsection 2.

Differences and similarities

Both Kotlin and Java are a static-typed language. In addition, both languages support the object-oriented paradigm, by Kotlin also supports functional constructions. Kotlin can be used both in object-oriented and in functional programming style or in a mix of both styles [12, 13]. Kotlin allows for functions declaration outside the classes, whereas in Java, static methods are used for these purposes, resulting in classes whose instances are never created but instead only static methods are called [13]. As for data types, both languages support the basic data types such as literal constants, symbolic constants and variables. Table 1 gives an overview od supported data types [13]. Primitive data types are not object, as the String and Object reference types are. Primitive data types are object in Kotlin, but some may have special representations, e.g. numeric and Boolean types can be represented as primitives at runtime.

In general, Kotlin types are divided into nullable and non-nullable. The base class Any is a super-type for all type, and it cannot contain a value of null [12,13]. However, Kotlin has explicit support for nullable types, and is represented as a question mark after the type name, allowing the variable to contain null. For the Any example, the type Any? Is used if a null value is necessary.

Both Java and Kotlin support object creation as instances of a class using constructors. Whereas Java supports multiple constructor declarations, Kotlin has a primary constructor, which is declared outside the class body, and a secondary constructor within the class body. The role of the primary constructor is to initialize the class, while the role of the secondary constructor is to incorporate additional logic. As for operations and expressions, statements, the full comparison with tables is given in [13]. Overall, although similar, Kotlin's synthase is shorter and intuitive, which can increase the productivity of the programmer.

Table 1: Data type similarities between Java and Kotlin.

Data Type	Java	Kotlin
Integer	byte, short, int, long	Byte, Short, Int, Long
Floating point	float, double	Float, Double
Boolean	boolean	Boolean
Alphanumeric (character)	char	Char
Alphanumeric (string)	string	String
Null object	null	null
Base class	Object	Any

Apart from similarities in different data types in Java and Kotlin found in Table 1, the differences between the two programming languages is shown in Table 2. Namely, Table 2 highlights the properties of Kotlin which Java does not have [14].

Table 2: Properties of Kotlin programming language which are different from Java.

Property
Lambda expressions + Inline functions
Extension functions
Null-safety and smart casts
String templates
Properties
Primary constructors
First-class delegation
Type inference for variable and property types
Singletons and companion objects
Declaration-site variance & Type projections
Range expressions
Operator overloading

- Conventions, with topics as comparison, range, and loops;

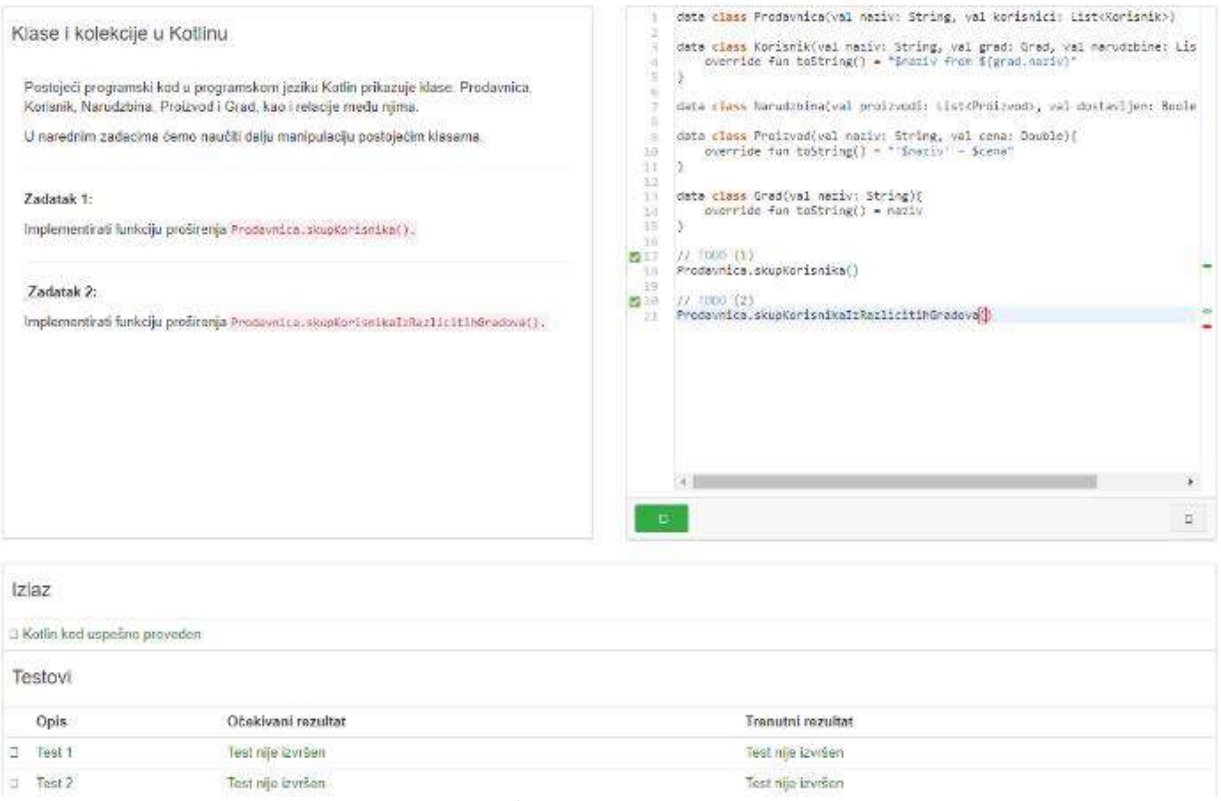

Image 2: The UI of Kotlin learning web-based application.

Data classes
Separate interfaces for read-only and mutable collections
Coroutines

Course overview

As stated in the Introduction, without the basic knowledge of Java, Kotlin can be difficult to learn and master. Furthermore, being a relatively new programming language, courses in Kotlin are few and far between. Apart from the official documentation [12], the courses offered online are either intermediate level such as the developers.android courses [15-17], or require a paid subscription fee such as the course on Codecademy [18].

We base our proposed course on Java courses taught at Belgrade Metropolitan University (BMU), as well as the Kotlin Koans online web application, developed by JetBrains as an introduction to Kotlin [19]. The syllabus is as follows:

- Introduction, with named and default arguments, string templates, nullable objects and the nothing type;
- Classes, covering data classes, smart and sealed classes, and extension functions;
- Collections, Properties, and Builders;
- Generics functions;
- Common mistakes for Java developers, with often encountered situation where the differences in the languages can lead to programming errors.

PROPOSED SYSTEM

Our proposed application starts with the actual lesson, which can be presented in text or video format, followed by multiple assignments within the lesson [20]. The User Interface (UI) diagram of the application is presented in Image 1, while the actual UI screen in shown in Image 2.

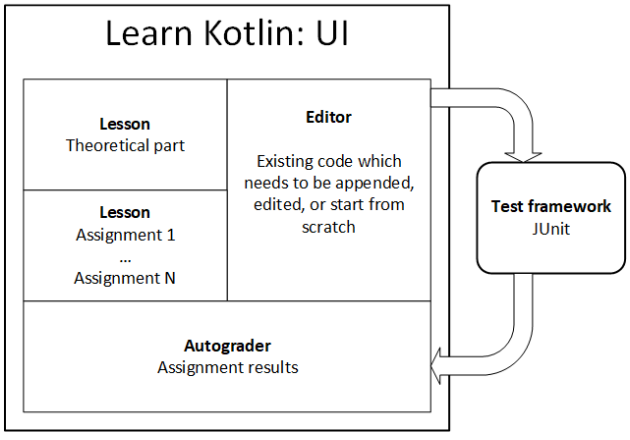

Image 1: Proposed UI for the Kotlin learning application.

The upper part of the UI screen is divided into three areas. The upper left area presents the lesson, the lower left area presents the assignments, while the right side represents the code editor. According to the given assignment, a student can append existing code, edit existing code, write new code from scratch. Every assignment consists of a group of tests to check the correctness of the student's solution.

Finally, the lower part of the screen is the output of the autograder, which runs multiple tests after the student submits their code. For this purpose, we have applied the JUnit framework for Kotlin [21].

4. FUTURE WORK

To further increase the interactivity with course takers, we plan to add a quiz at the beginning of the whole course, establishing a baseline knowledge for the Java programming language. Furthermore, apart from the code-based assignments, we plan to add simple multiple-choice quizzes at the end of each lesson to accompany the theoretical part of each lesson. These quizzes can also contain simple lines of code in Java and Kotlin, with the aim to find the correct approach to a specific problem.

Finally, we plan to combine the baseline knowledge and quiz and assignment results, forming an adaptive learning path for course takers.

5. CONCLUSION

In this paper we have proposed web application for learning the Kotlin programming language. As of writing this paper, both online solutions with which we compared our own application offer only intermediate courses for Kotlin for experienced Java developers, often not pointing out the main differences and common mistakes. Our proposed course, although aimed at those already familiar with Java, offers a simpler learning curve than those encountered by courses found online. Furthermore, with the inclusion of detailed theoretical knowledge, clips and/or animations, the offered lessons would feel lest like a step-by-step tutorial, but rather a like a full course for CS and IT students.

The addition of an advanced autorgrader allows our solution to hide the answers, encouraging students to think about the problem and not getting the right solution for the specific test or tests. As the mobile development continues, we plan to add more specific learning topics for Kotlin Android developers.

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