

E-learning

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E-learning & Artificial Intelligence

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Faculty of Arts and Education Sciences
in Cieszyn

E-learning

Vol. 15

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Monograph

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INTRODUCTION

The 15th vol. of the Series on E-learning monograph is "*E-learning & Artificial Intelligence*" includes articles of authors, participants from ten countries and from more than twenty universities during the scientific international conference entitled "Theoretical and Practical Aspects of Distance Learning", subtitled: "*E-learning and AI*", which was held on 23 and 24 October 2023 in hybrid mode, organized by the Faculty of Arts and Educational Sciences in Cieszyn, the Faculty of Social Sciences, the Institute of Pedagogy, the Faculty of Science and Technology, the Institute of Computer Science, University of Silesia in Katowice, Poland. Co-organizers and Partners: University of Ostrava (UO), Czech Republic, Silesian University in Opava (SU), Czech Republic, Constantine the Philosopher University in Nitra (UKF) Slovakia, University of Extremadura (UEx), Spain, University of Twente (UT), The Netherlands, Lisbon Lucíada University (LU), Portugal, Curtin University in Perth (CU), Australia, Borys Grinchenko Kyiv University (BGKU), Ukraine, Herzen State Pedagogical University of Russia,, St.Petersburg (HSPU), Russian Federation, Dniprovsk State Technical University (DSTU), Ukraine, IADIS – International Association for Development, of the Information Society, a non-profit association, Polish Pedagogical Society, Branch in Cieszyn, Polish Scientific Society for Internet Education, Association of Academic E-learning, Poland.

Experts on e-learning from 13 countries, in particular Australia, Bulgaria, Czechia, Hungary, Italy, Netherlands, Poland, Portugal, Slovakia, Spain, Pakistan, Ukraine, Great Britain reflect on *E-learning & Artificial Intelligence*, e-learning in the time of COVID-19 pandemic and after this time, presented research results, contemporary trends and scientific and educational project devoted to MOOCs, artificial intelligence (AI), augmented reality (AR), virtual reality (VR), selected Web 2.0 and Web 3.0 technologies, LMS, CMS, STEAM, mobile learning and other topics.

The speakers from the Comenius University in Bratislava (Slovakia), University of Silesia in Katowice (Poland), Plovdiv University "Paisii Hilendarski" (Bulgaria), Borys Grinchenko Kyiv University (Ukraine), Gdańsk University of Technology (Poland), Ostrava University (Czechia), Poznan University of Medical Sciences (Poland), Dniprovsk State Technical University (Ukraine), Pedagogical University in Krakow (Poland), University in Bari Aldo Moro, (Italy), Extremadura University, Spain, K.D. Ushynskiy South Ukrainian National Pedagogical University (Ukraine), Maria Curie-Skłodowska University, Lublin (Poland), Lesya Ukrainka Volyn National University, (Ukraine), The Lisbon Lusiada University (Portugal), Loughborough University, (the United Kingdom of Great Britain and Northern Ireland), Sumy State Pedagogical University (Ukraine), Technical University in Lublin (Poland), Izmail

State University of Humanities (Ukraine), MEI Cherkasy Regional Institute of Post-graduate education of Teachers of the Cherkasy Regional Council (Ukraine), and other educational institutions delivered lectures providing insights into interesting studies, presented their recent research results and discussed their further scientific work.

The authors include experts, well-known scholars, young researchers, highly trained academic lecturers with long experience in the field of e-learning, PhD students, distance course developers, authors of multimedia teaching materials, designers of websites and educational sites.

I am convinced that this monograph will be an interesting and valuable publication, describing the theoretical, methodological and practical issues in the field of E-learning in STEM education offering proposals of solutions to certain important problems and showing the road to further work in this field, allowing exchange of experiences of scholars from various universities from many European countries and other countries of the world.

This book includes a sequence of responses to numerous questions that have not been answered yet. The papers of the authors included in the monograph are an attempt at providing such answers. The aspects and problems discussed in the materials include the following:

The conference topics include the following thematic sections:

1. E-learning & Artificial Intelligence

- Contemporary trends in world e-learning in conditions of globalization, internationalization, mobilities.
- E-environment and Cyberspace.
- Artificial intelligence (AI), augmented reality (AR), virtual reality (VR).
- Legal, social, human, scientific, technical aspects of distance learning and e-learning in different countries.
- European and national standards of e-learning quality evaluation.
- Psychological and ethical aspects of distance learning and e-learning.
- E-collaboration and e-communication in e-learning.
- E-environment of the contemporary university.
- SMART universities. SMART technology in education.
- E-learning in a sustainable society.
- Comparative approach in research on e-learning.

2. E-learning: Methodology and tools developments

- E-learning and online learning.
- Blended learning.
- Innovative educational technologies, tools and methods for e-learning.
- Modern ICT Tools for e-learning in the time of Covid-19 pandemic – review, implementation, opportunities for effectiveness of learning and teaching.
- MOOCs – methodology of design, conducting, implementation and evaluation.
- Selected Web 2.0 and Web 3.0 technologies.
- E-learning and effectiveness using of Learning Management System (LMS), CMS, VSCR, SSA, CSA.
- Cloud computing environment, social media, multimedia resources.

- Methodological tools. E-tutoring. (Video)tutorial design.
 - Simulations, models in e-learning and distance learning.
 - Networking, distance learning systems.
 - Successful examples of M-learning, e-learning.
 - Evaluation of synchronous and asynchronous teaching and learning, methodology and good examples.
3. **E-learning and STEAM Education**
- Immersive learning environments. Blockchain. Bots.
 - Robots and coding in education.
 - Internet of things. 3D printing.
 - STEM education contemporary trends and challenges.
 - Distance learning in humanities and science.
 - Quality of teaching, training.
 - E-learning for science and technologies.
4. **Development of Key and Soft Competences and E-learning**
- Effective development of teachers' digital skills
 - Key competences and soft skills in the digital society.
 - Use of e-learning in improving the level of students' digital competences.
 - E-learning for humanities and social sciences.
 - E-Learning and lifelong learning.
 - Self-learning based on e-learning and Internet technology.

Publishing this monograph is a good example of expanding and strengthening international cooperation. I am very grateful for valuable remarks and suggestions which contributed to the quality of the publication. Here I especially want to thank Professor Ryszard Kalamarz for his assistance in editing and proofreading this publication. Also, I would like to say 'thank you' to the authors for the preparation and permission to publish their articles and reviewers and experts, who assessed and reviewed the manuscripts of manuscripts, which increased the quality of the monograph. I wish all readers a pleasant read. Thank you.

Eugenia Smyrnova-Trybulska



COMPARATIVE INTERNATIONAL RESEARCH IN THE AREA OF EDUCATIONAL PLATFORMS AND MOOCs: AN OPINION OF IT STUDENTS USING DATA MINING ANALYSIS

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Abstract: *In the paper, a study was conducted using data mining methods such as decision tree, Naïve Bayes classifier and the Generalized linear model to detect patterns in data obtained from a questionnaire on educational platforms. The questionnaire was conducted among students from three countries Poland, Kazakhstan and Ukraine. Questions on the frequency of use of educational platforms, various platforms that are most popular among students, the most popular topics of courses on educational platforms and the use of Git systems, and the Stack Overflow platform were analysed and some interesting relations were identified in the paper.*

Keywords: educational platform, data mining, visualization, student survey, decision tree, correlation

INTRODUCTION

Knowledge in Computer Science (CS) is essential, and companies have increased their demands for CS professionals. Despite this, many jobs remain unfilled (Spieler, Grandl, Ebner, & Slany, 2019). Thus, they may never understand the fundamental concepts of CS, have unrealistic expectations or preconceptions, and are influenced by stereotype-based expectations. Consequently, many teenagers exclude computing as a career path. (Spieler et al., 2019). In the scope of Higher Education, students face many barriers arising from different causes, as insufficient prerequisites, socioeconomic factors or lack of interest and motivation. Usually, these factors can lead to high dropout rates in some specific careers, as it happens in Information Technology (IT)-related courses (da Silva, et al., 2020).

1. RESEARCH BACKGROUND

Scholars from different countries are conducting research and presenting results related to the use of educational platforms by students to enhance their programming competences and skills as well as using the MOOCs and e-learning courses to improve their skills in coding and self-educational competences.

The research (Glazunova, et al., 2018) deals with theoretical and practical aspects of self-educational competence formation of IT students. It determines the concept and structure of self-educational competence, analyzes the information resources and services that are used to develop it. The study, conducted by Ukrainian scholars, offers the system of ICT-tools for the formation of self-educational competence of future IT specialists: the resources of the University educational portal, the online academy, massive open professionally-oriented online courses, computer-aided code verification systems, practical programming courses, cloud platforms for the development of software systems, the environment for implementing collective projects. (Glazunova, et al., 2018). Theoretical and methodological aspects of the future IT specialists' self-educational competence formation by means of using resources and services of the information and educational environment of the higher educational institution are substantiated. (Glazunova, et al., 2018)

Educators in massive open online courses (MOOCs) face the challenge of interacting with tens of thousands of students, many of whom are new to online learning. The study (Ferguson, & Whitelock, 2014) investigates the different ways in which lead educators position themselves within MOOCs, and the various roles that they adopt in their messages to learners. (Ferguson, & Whitelock, 2014). Elaborated typology can be used to explore relationships between educator stance and variables such as learner engagement, learner test results and learner retention. (Ferguson, & Whitelock, 2014). The Aim of this study (Hsueh, Daramsenge, & Lai, 2022) was twofold: first, to examine how learners' behavioral engagement types affect their final grades in an online programming course; and second, to explore which factors most strongly affect student performance in an online programming course and their connection to the types of cognitive engagement. Findings Our results demonstrate that: (1) online time and video-watching constructs had significant effects on the self-assessment

construct, self-assessment and video -watching constructs had significant effects on the final grade construct, and online document reading was not a significant factor in both self-assessments and final grades; (2) video watching had a most significant effect than other behavioral constructs in an online programming course; (3) cognitive engagement types are inextricably linked to the development of a behavioral engagement framework for online programming learning. The mediation analysis and the importance-performance map analysis supported the importance of cognitive engagement. (Hsueh, Daramsenge, & Lai, 2022).

Under the continuous impact of the epidemic, online learning methods represented by MOOC have developed rapidly. The study, described in (Li, Ge, Zhao, & An, 2022) constructs an emotional and behavioral analysis model based on online forum texts, obtains forum data from the „Python Language Programming“ course on the Chinese University MOOC platform, uses domain dictionary emotion classification method to analyze learning emotions, and based on the method of cognitive behavior coding table and knowledge construction behavior coding table analyzes learners' cognitive behavior and knowledge construction behavior. (Li, Ge, Zhao, & An, 2022) It can dynamically analyze learners' emotions, behavior changes, and evolutionary trends. This research provides opinions and suggestions on the improvement of platform interactive functions for teachers' online teaching, students' online learning, and platform management, which can effectively improve the efficiency and effectiveness of online learning. (Li, Ge, Zhao, & An, 2022)

The interesting project was described in (Spieler et al., 2019). In 2018, a voluntary lecture „Design your own app“ at the University of Graz for students of all degree programs was introduced. In total, 202 students participated. Was applied a Game Development-Based Learning (GDBL) approach with the visual coding tool Pocket Code, a mobile app developed at Graz University of Technology. For exercises and the final submission, the students need to apply game design strategies by using Pocket Code. The MOOC has several target groups – not only young gentlemen as well as young women who have little to no previous knowledge in CS. (Spieler et al., 2019). Additionally, it should help all teenagers to get a more realistic picture of CS to its basic concepts. As well as, teachers can use the course materials to lead high school classes (Open Educational Resources). Finally, the MOOC can be accessed by everyone interested in this topic, thus students of other majors can acquire CS skills. (Spieler et al., 2019).

Some recent studies point out that the adoption of non-conventional teaching practices and attitudes, especially in the first semesters, can collaborate to change not the best scenario. The goal of the research (da Silva, et al., 2020) was to present a 2D educational game for learning fundamental concepts of programming, whose narrative is based on a battle among robots and humans. Students are supposed to interact with characters through console instructions – in the virtual world, there are characters and items like robot enemies and electromechanical structures (as automated doors, moving platforms, lasers emitters and sensors), which are meant to be manipulated by programming codes. (da Silva, et al., 2020). The model MEEGA+ was applied together with a 5-level Likert-like scale survey. Results shown as very positive – the goal of offering a motivating educational game was achieved, according to students'

evaluation; during the gameplay, bosschallenge tests, mixed with choice questions about programming were presented to students, which were meant to correctly answer at least 60% of them in order to finish levels. Regarding to the perception of learning, according to the same survey, Python Domination achieved the objective of being a tool that assists in the learning process of programming fundamentals. (da Silva, et al., 2020).

The research (Valverde-Berrocso, 2020) contains an overview of literary sources on MOOC. Aldahdoh, Osório (2016) and McAuley, Stewart, Siemens, Cormier (2010) provide theoretical and practical aspects of using MOES in higher education. The study Bennett, & Kent, (2017), Fair, Harris, León-Urrutia (2019); de Jong, et al. (2019) provide comparative characteristics of the use of open online courses, statistical data on the distribution of courses between scientific fields, the number of students, registered for the course, the percentages of those who completed the course, those who completed it partially, and those who simply enrolled in the course without active activity are compared. The number of open online courses on global MOE platforms is constantly increasing (Dhawal, 2020, 2021).

The use of MOOC in the educational process in Ukrainian higher education institutions is the most relevant for students studying in the field of „Information Technologies“, because it is information technologies that are changing the most rapidly, and therefore an IT specialist must constantly be in line with these changes, quickly to respond to them, to constantly deepen their professional competences, to engage in self-improvement and self-development.

Prometheus, EdEra, and the Maidan Open University should be singled out among the Ukrainian platforms on which MOOC are hosted. The article presents the results of a comparative analysis conducted by scientists of the most popular global platforms of mass open online courses (Y. Ramskyi, Tverdokhlib, Yashchuk, A. Ramskyi, 2021). Most of them contain courses in English (many have subtitles in other languages), the opportunity to get a free certificate is not provided (except some courses on the Coursera platform), the duration of the courses is from several weeks to several months.

2. METHODOLOGY

The research in this paper was based on a questionnaire survey that was done simultaneously at three universities in three different countries: Poland, Kazakhstan and Ukraine. The survey was anonymous and voluntary. The questionnaire (elaborated and available via Google Form online) was distributed to students in computer science and included a variety of questions about educational platforms.

Data mining tools such as data visualization and supervised learning algorithms such as decision tree algorithms, Naïve Bayes classifier and the Generalized linear model (Bramer, 2020, Kubat, 2021, Rokach, & Maimon, 2014) were used in the study. In order to detect patterns in the data, the possibility of correct classification/recognition of various examined features was checked based on the characteristics of students participating in the questionnaire. The analyzes were performed using tools such as Rapid Miner (<https://rapidminer.com/>) and Orange (<https://orangedatamining.com/>).

2.1. Questionnaire, purpose and research questions

Our focus was on exploring students’ attitudes toward a variety of educational platforms, recognizing which platforms are most frequently used, and what elements provided on the platforms are most valuable to students. The survey was conducted in June 2023. Students of computer science from the University of Silesia in Katowice, Poland, the Faculty of Science and Technology, the Borys Grinchenko Kyiv University, Ukraine and the West Kazakhstan agrarian-technical university named after Zhangir khan, Kazakhstan were asked to respond. A total of 158 responses were received from randomly selected respondents. Emails were sent to students at different years of studies, asking them to fill out the survey, and participation was voluntary.

Sociological metrics

In order to study the relationship between student characteristics and attitude toward educational platforms, the questionnaire included sociological questions. The sociological characteristics questions and possible responses in the questionnaire are presented below:

- gender – male, female
- degree of study – Engineer’s Degree, Master’s Degree
- age – <19–20>, <21–22>, <23–24>, <25–26>, <27–28>, <29–30>, >30

Descriptive statistics on the responses obtained related to the sociological metrics are presented in Table 1.

Table 1. Descriptive statistics on responses to sociological questions

Gender	Quantity/ Percentage	Degree of study	Quantity/ Percentage	Age	Quantity/ Percentage
Male	117/74.05	Engineer’s Degree	114/72.15	<19–20>	18/11.39
Female	41/25.95	Master’s Degree	44/27.85	<21–22>	70/44.30
				<23–24>	33/20.89
				<25–26>	8/5.06
				<27–28>	4/2.53
				<29–30>	5/3.16
				>30	20/12.66

Source: Own work.

Based on the results obtained, it can be concluded that the majority of respondents were male engineering students, with the largest group aged 21 to 24 years old, constituting 65% of the respondents. As for the participation in the questionnaire of students from different countries, the largest group consisted of students from Poland (81 students), followed by 40 students from Kazakhstan and 37 students from Ukraine.

As part of our work on the survey results, we aimed to go beyond standard statistics and look for less obvious correlations in the data, discovering differences in the use of learning support platforms between countries. Accordingly, this article focuses

on methods from the field of data mining, including data visualization and machine learning. The article omits standard statistical methods under the assumption that they would duplicate the information obtained by data mining methods. The authors also assumed that the use of methods from the field of data mining offers the possibility of detecting relationships that are difficult to prove with statistical methods. The research conducted aims to answer whether there are any significant relationships between the use of e-learning platforms and the country from which the surveyed students came. The comparison was also made by analyzing the age of the respondents, their level of study, and gender. As part of the article, selected results obtained are presented.

Of the methods used derived from data mining, data visualization, decision trees were used, and machine learning algorithms were employed.

The main Research questions were contained to questionnaire and were are:

RQ1: How often do you use educational platforms to learn about programming/IT issues?

RQ2: How often students from Poland, Kazakhstan and Ukraine use an educational platforms to learn about programming/IT issues?

RQ3: Which topics of the courses students from Poland, Kazakhstan and Ukraine use on educational platforms?

RQ4: Do are students from Poland, Kazakhstan and Ukraine use code sharing platforms/tools – specifically Git systems (GitHub, GitLab, Bitbucket, etc.) – as part of expanding their knowledge?

RQ5: Do are students from Poland, Kazakhstan and Ukraine use code sharing platforms/tools – specifically Stack Overflow systems – as part of expanding their knowledge?

For questions 2 to 5 in Research Questionnaire online the possible responses in the second question were defined using 5-point scale; 1 means I do not use and 5 means I use very often.

3. RESULTS OF SURVEY ANALYSES

This section of the article presents the results obtained through data mining methods, the first part presents the overall distributions of survey data to illustrate the distribution of the population participating in the survey.

3.1. Data set description

The first section shows the general distribution of respondents, by country, age, gender and level of study. Figure 1 illustrates the distribution of surveyed students, by gender, country, age and level of study.

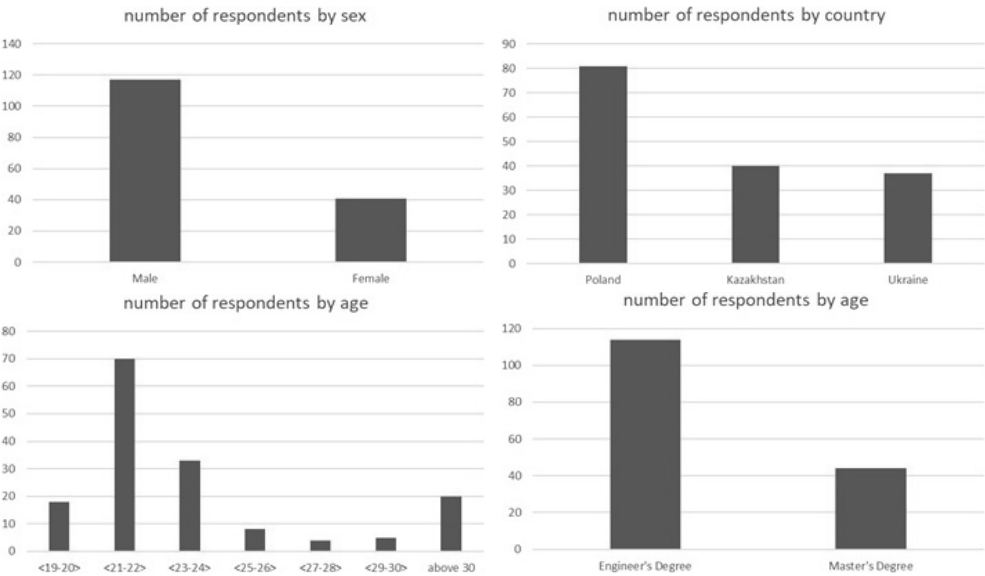


Figure 1. Distribution of survey students by gender, country, age and level of study

Source: Own work.

Based on the graphs in Figure 1, it can be seen that, in terms of the gender of the respondents, the majority of students were male. Concerning the country of origin, the largest group were students from Poland. Regarding age the largest number were students at the beginning of the study period aged up to 24 years old, pursuing an engineering level of study.

Figure 2 shows how often students use e-learning platforms by gender and country of origin of students.

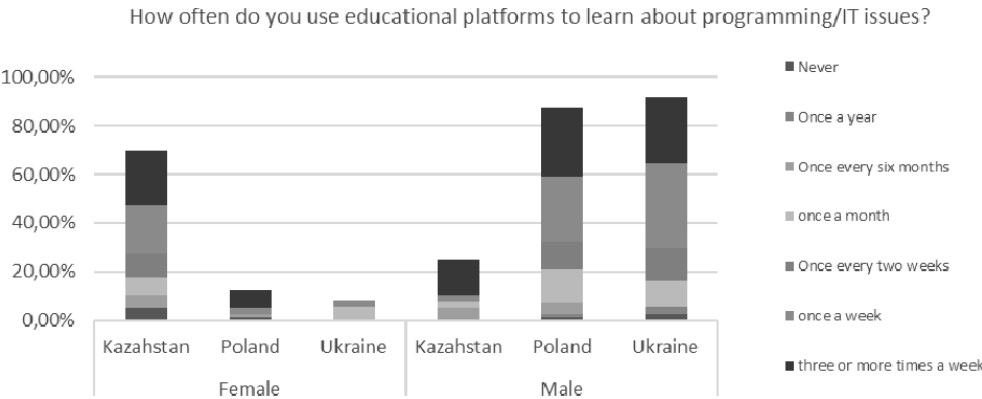


Figure 2. Frequency of using learning platforms by students by gender and age

Source: Own work.

Based on Figure 2, it can be observed that students, regardless of their country and gender, readily use. The majority of respondents use such platforms at least once a week.

3.2. Exploratory analysis of survey data

The subsection presents the results of the analyses conducted using data mining techniques.

The first element used in the data mining of survey data was to test machine learning algorithms to verify whether survey respondents can be separated into groups by parameters that characterize students. The parameters focused on were age, gender, country and level of study. The frequency of use of e-learning platforms, satisfaction with using them, and the field of computer science from which students seek courses were used as targets for prediction. In the case of machine learning methods, no satisfactory results could be obtained in any combination of parameters. This implies that there are no significant differences between countries, levels of study and genders concerning the use and evaluation of the usefulness of self-learning platforms. For all samples, a very high level of classification error was obtained with very low classification quality. Tables 1 and 2 show sample results for the Naive Bayes classifier and Generalized Linear model for a sample of classification by gender, age and country for the frequency of use of self-study platforms.

Table 1. Quality score of machine learning using Naive Bayes classifier

Criterion	Values	SD
Accuracy	32.4%	10.1
Classification Error	67.6%	10.1

Source: Own work.

Table 2. Quality score of machine learning using Generalized linear model

Criterion	Values	SD
Accuracy	36.9%	12.6
Classification Error	63.1%	12.6

Source: Own work.

The results obtained with the Naïve Bayes classifier and the Generalized linear model presented in Tables 1 and 2 were the best results achieved from all samples and parameter combinations. They are presented as exemplary results and confirmation of the thesis that there are no significant differences in the use of e-learning platforms by students from different countries. For most cases of using machine learning algorithms, the obtained classification error was about 80%. For the Naïve Bayes classifier in the case in question (Table 1), an error of 67.6% was achieved, with low classification quality. For the Generalized linear model (Table 2), the classification error was 63.1%. After verifying the models based on different parameters and for different

types of parameters for classification and obtaining similar results for all samples, the authors concluded that there were no significant enough differences in the responses of students to classify and divide into groups of students according to the criteria collected in the surveys. This means that students from different countries, of different genders, and at different levels of study use e-learning platforms equally eagerly, and for them, they are a popular source of supplementing the knowledge acquired during their studies.

Also, the popularity of individual self-learning platforms is at a similar level in the surveyed countries, Figure 3 shows the average rating of the usefulness of self-learning platforms (each platform was rated on a scale of 1–5).

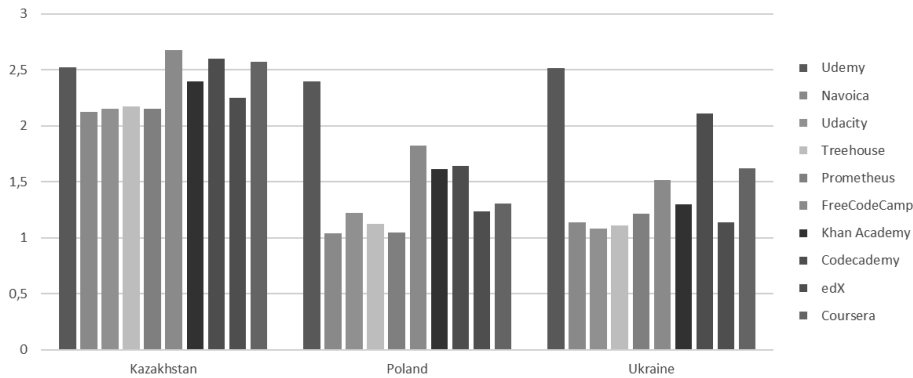


Figure 3. Assessing the usefulness of educational platforms in each country

Source: Own work.

Based on Figure 3, it can be noted that regardless of the country, the most popular and highly-rated self-study platform is Udemy. It can also be observed noted that in the case of Kazakhstan, higher ratings were achieved for the usefulness and quality of courses on other platforms than in the case of Ukraine and Poland.

Since machine learning methods failed to classify groups of students concerning selected parameters for evaluating the usefulness and quality of educational platforms, the authors decided to use decision trees as a method that usually achieves good results even for small dependencies.

Figure 4 shows a classification tree of the frequency of use of educational platforms according to gender, country, and level of study. The CHAID algorithm was used to build the tree. In the figure, we have two colored leaves (nodes in the tree that have no descendants) – one red and the other one blue. The red color denotes the pure partition, i.e. the set of respondents who gave the same answer. The blue color denotes the group of respondents for whom the answer written in the leaf was given by more than half of this group. In each leaf, the percentage of an answers that occur in the group of respondents whose characteristics are consistent with the characteristics contained in the path from the root to this leaf is also given.

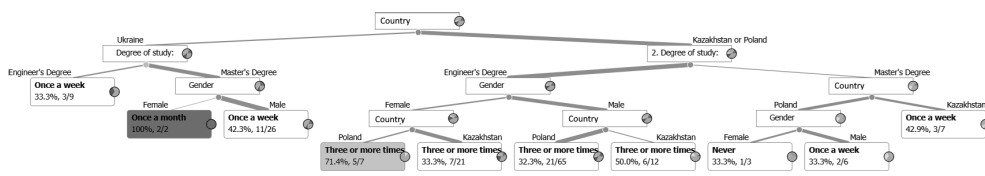


Figure 4. Classification tree of frequency of use of educational platforms

Source: Own work.

Based on the tree in Figure 4, several correlations can be seen, for example, in master's studies there are more responses about less frequent use of educational platforms. Women in Ukraine use them once a month, while women in Poland never do. In the case of engineering studies, answers several times a week prevail. It is possible that such results are due to the fact that engineering students are at the beginning of their career path, before taking their first job and therefore seek additional knowledge of new technologies, driven by their own interests, and the requirements of future potential employers. Graduate students, on the other hand, are often working individuals, already using specific technologies daily, hence their lesser desire and need to learn new things.

Figure 5 shows a classification tree for the frequency of use of educational platforms by country and gender. The colors on the leaves of the tree represent the frequency of use of learning platforms, blue – once a week, blue – three or more times, green – once a two weeks, light green – once a month, orange – once every six months, red – never.

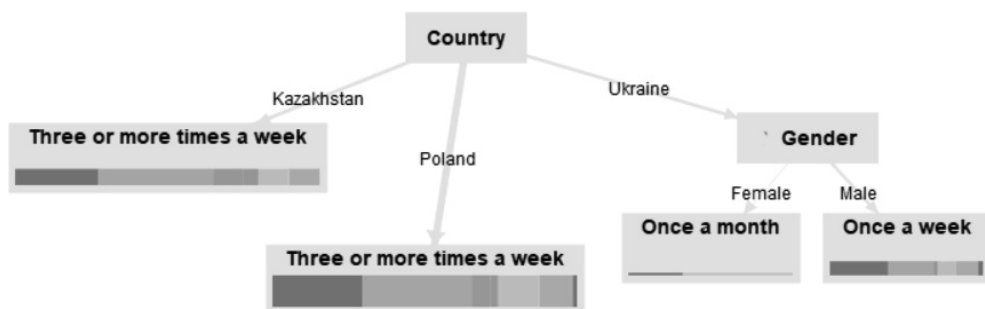


Figure 5. Classification tree for frequency of use of educational platforms by country and gender

Source: Own work.

Based on Figure 5, it can be observed that gender mattered in the frequency of use of self-learning platforms only in the case of Ukraine, where women are less likely to use such tools. Also in the case of Ukraine, a lower frequency of use of learning platforms can be observed than in the case of students from Poland and Kazakhstan. Figure 6 shows a decision tree in which the starting point is the level of study, with additional parameters taken into account being the country of origin and gender of the students.

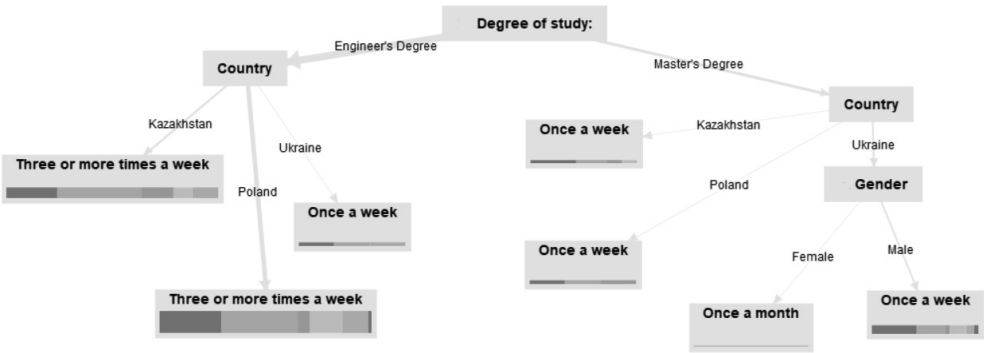


Figure 6. Decision tree of the frequency of use of educational platforms according to the level of study

Source: Own work.

Based on the tree in Figure 6, it is possible to confirm the earlier conclusion that engineering students are more likely to use self-study platforms than graduate students. Due to the greatest popularity of the Udemy platform across all student groups, it was decided to assess the quality and usefulness of the platform.



Figure 7. Assessing Udemy's usefulness according to students' age

Source: Own work.

Based on the tree in Figure 7, it can be seen that the only significant parameter by which the Udemy platform frequency of use can be separated is age. It is challenging to discern any trend in the data, such as younger people using this platform more or less often. In the figure, the group of students who used the Udemy platform most often is indicated in blue – these are students aged 27 and 28.

Another interesting question is what types of courses students are looking for on educational platforms, and whether there is a difference between students from different countries, genders, and levels of study. The charts in Figures 8–10 show the topics of courses chosen by gender, level of study, and country.

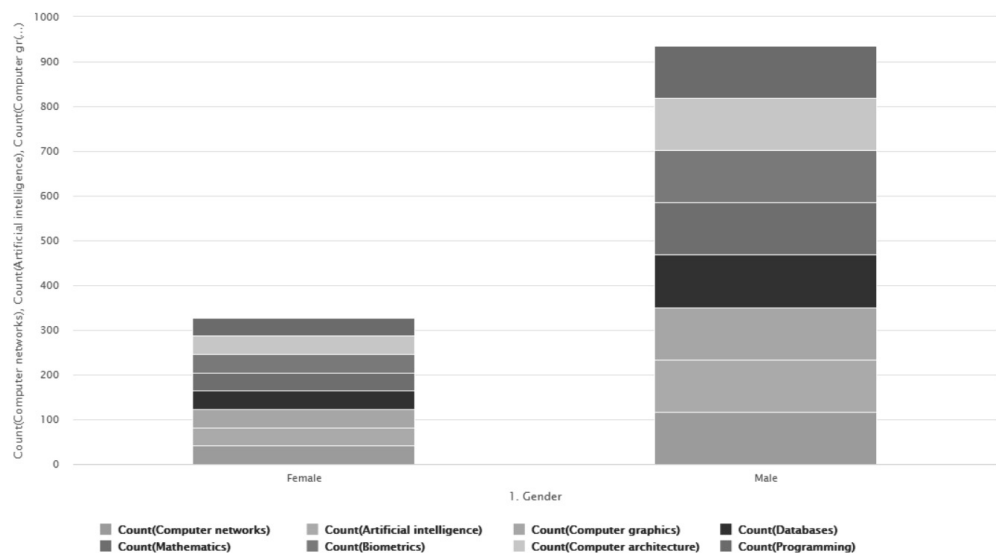


Figure 8. Selected course categories based on gender

Source: Own work.

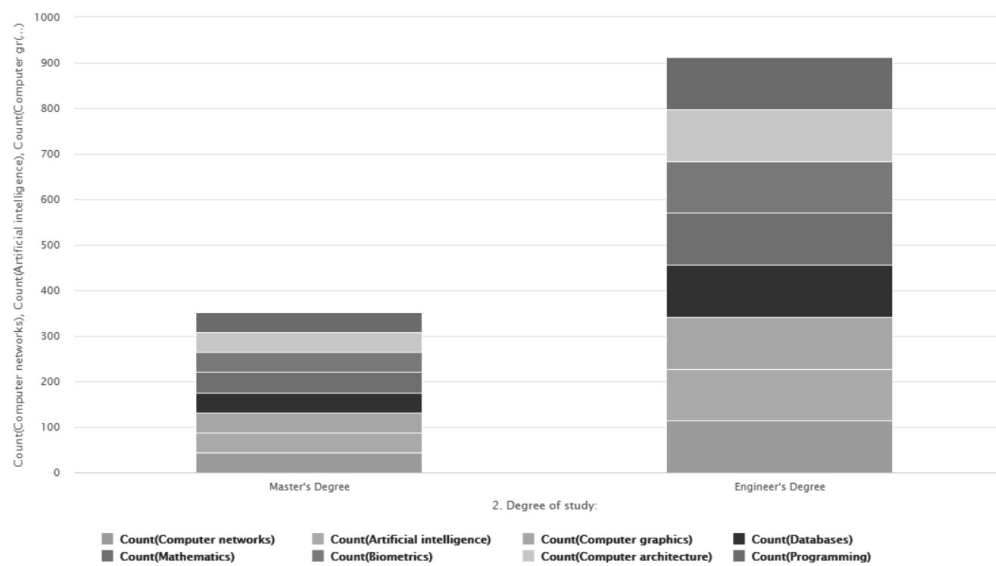


Figure 9. Selected course categories based on study level

Source: Own work.

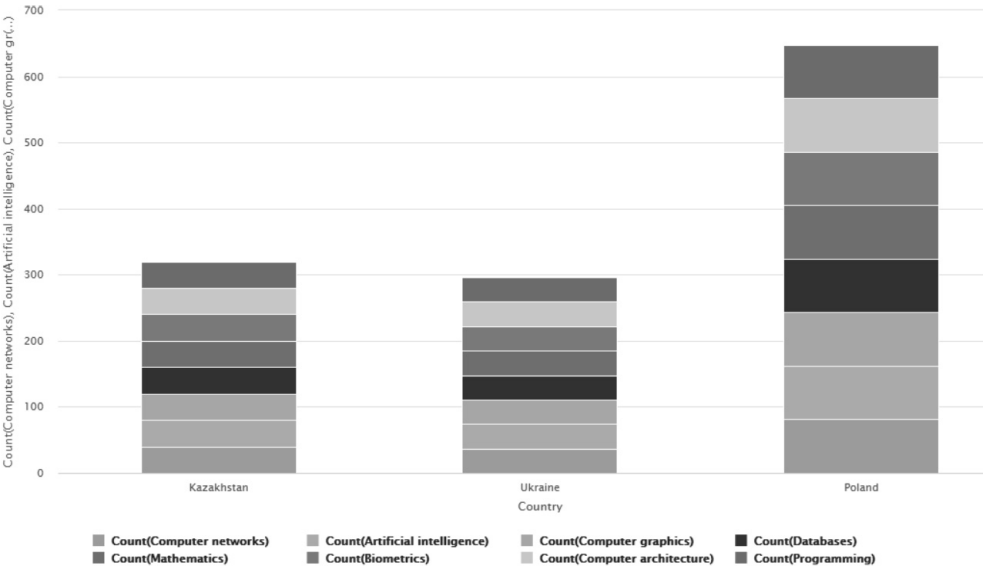


Figure 10. Selected course categories based on country

Source: Own work.

Based on the charts in Figures 8–10, it can be seen that the topics of courses that students choose are more or less equal in each category of courses, with no single category being more popular relative to the others. Also, no significant differences can be observed when it comes to the choice of course topics by men and women, engineering and graduate students, and for individual countries. Another verified element, as no significant differences were detected in the use of educational platforms by students from different groups, was the calculation of correlations. Table 3 shows an excerpt from the correlation matrix.

Table 3. Correlation matrix for selected parameters

	Gender	Degree of study	How valuable are course on platforms	Do you use Git systems	Do you use Stack Overflow
Gender	1	0,019	0,13	0,074	0,251
Degree of study	0,019	1	−0,132	−0,144	−0,149
How valuable are course on platforms	0,13	−0,132	1	0,332	0,415
Do you use Git systems	0,074	−0,144	0,332	1	0,616
Do you use Stack Overflow	0,251	−0,149	0,415	0,616	1

Source: Own work.

Based on Table 3, one can only observe the relationship between the use of Git systems, and the Stack Overflow platform, which seems to be quite obvious, especially for programmers.

4. DISCUSSION

As evident from the specialties in the engineering studies at the University of Silesia, a considerable emphasis is placed on programming and the design of information systems. The motivation of students to enroll in courses on educational platforms, expanding topics covered in university classes, can also be attributed to the high popularity of educational platforms among Polish students. There are no regulations at the University of Silesia to provide grades or exemptions from exams based on a courses completed on educational platforms. Therefore, it should be assumed that students do not receive any grades or benefits based on such courses. Academic teachers at the University of Silesia do not include this in the module credit; students are obliged to take regular exams. However, the knowledge and practical skills gained through completing courses on educational platforms enhance students' competencies, potentially boosting their confidence and better preparing them for exams. It would be necessary to investigate whether this also affects the achievement of higher grades, but such a study requires separate questionnaires and is planned in the future research.

Additionally, designing digital analytical educational systems involves training students in the processes of developing and creating tools and technologies for collecting, processing and analyzing large amounts of data to identify patterns and trends and predict future events. Career opportunities for specialists in the design of digital analytical systems are vast, spanning various industries such as finance, marketing, healthcare, telecommunications, information technology centres, research institutes, computer testing centres, educational institutions, and various private organizations. This educational program is exclusively available at the Kazakh National Women's Teacher Training University.

CONCLUSION

The paper presents an analysis of the results obtained from a questionnaire on courses on educational platforms, conducted among computer science students from three different countries: Poland, Ukraine and Kazakhstan. The assessment included the frequency of platform use, specific platforms used most by students the most popular course topics, and whether students use code-sharing platforms.

Based on the data mining analysis conducted on the data collected from student surveys it can be concluded that the level of use of educational platforms does not differ significantly among the analyzed groups of students. Another interesting observation is that master's students use educational platforms less frequently than engineering students. In the case of Ukraine, a lower frequency of use of learning platforms can be observed compared to students from Poland and Kazakhstan. Data mining techniques could not identify a leading course topic chosen by students in all countries.

There is a positive correlation between the use of Git systems and Stack Overflow; students who use one of these platforms often use the other.

Future work plans include expanding the study to other countries and examining the impact of using educational platforms on academic progress and grades in higher education. Additionally other data mining models, such as neural networks or clustering algorithms, will be employed to detect patterns in the results obtained.

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EXPLORING VIRTUAL REALITY: A THEORETICAL REVIEW OF EDUCATIONAL GOALS, LEARNING DESIGN, AND EVALUATION

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Abstract: *The article provides a comprehensive overview of the basic principles for effectively integrating virtual reality (VR) into education. It is divided into separate sections, each focusing on a specific aspect of the integration process. The initial step in incorporating VR into education involves aligning the capabilities and applications of VR with the learning objectives of a particular subject or study program. The alignment includes defining the types of knowledge that VR use should support, emphasizing the critical need to synchronize these goals with a chosen VR application. The following section discusses the concept of educational design and explains the common strategies used for selecting or developing VR applications in an educational context. The third section delves into evaluating user experience design and learning outcomes, including a comprehensive typology of different learning outcomes. This can serve as a basic framework for evaluating the effectiveness of VR in educational settings. The article concludes by providing a set of basic guidelines to help educators and designers select or develop VR applications that align with educational goals.*

Keywords: virtual reality, education, immersion, learning, virtual environment

INTRODUCTION

Virtual reality (VR) technology has been gaining attention in recent years, not only within the entertainment industry but also in formal and informal education. According to research (Kardong-Edgren, Farra, Alinier, & Young, 2019), VR has emerged from a period of disillusionment in recent years, and the initial interest has transformed into a realistic understanding of what can be achieved with immersive technologies. Currently, VR is positioned on the slope of enlightenment on the Gartner

Hype Curve, and a secondary wave of innovation is underway as new and effective ways of utilizing the technology are being validated.

Definitions of VR are generally based on the combination of a virtual 3D environment and several forms of user experience. VR is a computer-generated, three-dimensional graphical representation of a real or an imaginary environment in which users experience a strong sense of presence and immersion (Chen, Zhou, & Zhai, 2023). This is achieved using a special headset or a series of display walls.

Modern head-mounted displays (HMDs) represent a promising technology. These devices are becoming increasingly affordable, and their ability to isolate users from the external environment contributes to an enhanced sense of presence (Grassini & Laumann, 2020). Furthermore, contemporary HMDs offer users unrestricted movement, made possible through wireless communication with the computing system or through the intricate integration of the computing device directly into the HMD. An alternative to a simple and inexpensive HMD solution is the CAVE (Cave Automated Virtual Environment). A CAVE is usually a $10' \times 10' \times 10'$ cubic room in a larger darkened space. Its side walls comprise canvases with rear projection, sometimes supplemented by floor projection. Advanced CAVE systems can also project scenes onto the ceiling to create a six-sided configuration (Muhanna, 2015). The scenes displayed on the screens adjust and rotate based on the user's movement among the individual display elements. Users typically wear stereoscopic eyewear and interact using hands, data gloves, joysticks, or other input devices.

The immersive nature and sense of presence engage students in learning activities and help them acquire cognitive, emotional, and physical skills more effectively. In VR, communication allows users to interact with virtual objects through different senses, such as sight, touch, and manipulation (Huang, Rauch, & Liaw, 2010). This involvement of multiple sensory channels facilitates the complex acquisition of learning experiences and supports the continuous and permanent development of knowledge and skills (Ustun & Tracey, 2020).

Many studies highlight the educational benefits of VR, but some aspects are often sidelined or overlooked. Some research points to the tendency of researchers to be initially charmed by the novelty and excitement of using advanced technology, which often leads to over-refining the results or focusing on the wrong elements.

This article comprehensively explains the theoretical foundations for designing and implementing VR technology in education. The article is structured into several key sections, each dealing with a specific aspect of the integration process.

In the first part, the article focuses on the importance of defining educational goals and the types of knowledge that VR should seek to develop. It emphasizes aligning these goals with the specific VR application in question. The second section deals with the definition of educational design and provides insight into the various strategies commonly used to select or develop VR applications in the educational process. The third section explores the evaluation of user experience design and learning outcomes, including a typology of different learning outcomes. This section outlines the basic principles of evaluating the effectiveness of VR in education.

In conclusion, the article presents a set of basic guidelines to help educators and designers select or develop VR applications suitable for educational purposes.

1. EDUCATIONAL GOALS

Using VR in educational contexts should be a carefully considered step, avoiding spontaneity. Given the complex requirements of content creation and methodology development, the incorporation of VR should be guided by a thoughtful approach, carefully aligned with the overall learning objectives, to ensure that it enhances and complements the established curriculum without detracting from it (O'Connor, 2020). As a rule, the primary, measurable efficiency indicator is the results of education. In the process of integrating VR into educational paradigms, educators are tasked with effectively using its immersive appeal to strengthen and expand students' understanding of basic concepts, critical cognitive skills, and the ability to navigate complex problem-solving scenarios (Shi, Wang, & Ding, 2022), (Pottle, 2019), (Chang, Hsu, & Jong, 2020).

In line with Bloom's Taxonomy (Bloom, 1984), educational objectives typically fall into three categories: cognitive, affective and psychomotor objectives. By integrating insights from these sources and incorporating (Radianti, Majchrzak, Fromm, & Wohlgenannt, 2020), (Vukić, Martinčić-Ipšić, & Meštrović, 2020), (Diab & Sartawi, 2017), and (Makransky & Petersen, 2021), a more comprehensive understanding of educational goals in a VR environment can be obtained. This can be achieved by evaluating learning objectives through the lens of Bloom's taxonomy, which defines different levels of cognitive complexity. From this point of view, it is possible to determine specific categories of knowledge and skills based on a combination of several pedagogical theories (behaviourism, constructivism). The aim is to provide a more precise terminology for the types of knowledge and skills acquired when using VR resources.

- **Declarative knowledge** contains factual and conceptual knowledge. Factual knowledge is represented by basic (isolated) information related to intellectual abilities and knowledge acquisition, usually involving the understanding and retaining of specific information, details, and concrete facts. In science education, factual knowledge refers to the actual details of scientific facts rather than abstract ideas, concepts, or personal interpretations (Hew & Cheung, 2014). Conceptual knowledge is characterized by understanding complex, structured forms of knowledge that may include classifications, categories, principles, and generalizations. This category is sometimes expanded to include complete theories, models, and overarching structures (Makransky & Petersen, 2021).
- **Procedural knowledge** is understanding how to perform specific procedures, processes, or activities. It means understanding how to perform a task, follow prescribed procedures, master various techniques, or perform a specific function. Procedural knowledge includes the ability to perform tasks with fluency and accuracy. According to (Radianti et al., 2020), VR is most often used to build this type of skill. Acquiring procedural knowledge has been a typical element of VR since its introduction, especially when training for complex or dangerous real-world scenarios such as medical interventions (De Ponti et al., 2020), (Javaid & Haleem, 2020), safety operations (Morélot, Garrigou, Dedieu, & N'Kaoua, 2021), (Çakiroğlu & Gökoğlu, 2019), etc.

- Acquiring **analytical and problem-solving skills** is an integral part of most VR applications. By immersing students in interactive and dynamic scenarios, their active involvement, critical thinking, and creativity in solving challenges become intrinsic to activities in the virtual world (Araiza-Alba, Keane, Chen, & Kaufman, 2021). In VR, problem-solving is not solely about theoretical understanding, as students are placed in complex situations where they must analyse information, devise strategies, and make decisions. The overall functionality of the concept of building this type of skill is explained by (Vimal Krishnan & Onkar, 2019), while a significant result is that students with less favourable attitudes towards learning benefited more from the activity than students with more positive attitudes (Wu, Guo, Wang, & Zeng, 2021).
- **Communication and collaboration skills** are not originally included in Bloom's taxonomy but represent a necessary component of educational and work processes. VR environments offer a unique platform to enhance this skill by facilitating immersive and interactive experiences that simulate natural social dynamics. The utilization of these skills is frequently an integral aspect of problem-solving (Planey, Kim, Mercier, & Lindgren, 2023), engineering, or technical education (Tuttle, Savadatti, & Johnsen, 2019), (Hatzipanayioti et al., 2019). Some activities and research specifically focus on improving collaboration and communication skills while comparing them to their real-world counterparts (Dzardanova, Kasapakis, Gavalas, & Sylaiou, 2022).

Many authors who conducted VR experiments overlook or do not explicitly mention the connection to educational goals in their research. However, it is essential to emphasize that setting learning goals should be the first and most crucial step when considering the integration of VR into the learning process. Before integrating VR into education, it is essential to determine if and how VR can enhance the learning process and more effectively achieve educational goals compared to traditional methods. Only in the case of a positive answer and establishing sub-goals does the design phase begin, which includes determining learning strategies and activities. This approach ensures that the experiments are not narrowly focused and that the results remain unbiased.

2. LEARNING DESIGN DEFINITION

If the initial considerations of incorporating VR into specific topics demonstrate the potential to improve the learning process, it is possible to start designing specific elements for the VR environment. The primary goal is to create a strategy for seamless integration of VR into the curriculum. The essential design components are learning strategies and learning activities. Learning strategies consist of defining the inclusion of VR in the teaching process. Possibilities may include using VR as an introductory tool, a knowledge fixation method, or a tool to facilitate practical application. Learning activities are designed to be engaging, interactive, and follow the intended learning outcomes.

Implementing VR as a learning tool involves considering suitable strategies to maximize its benefits. Referring to the established classifications detailed in (Akdeniz,

2016) and the categorization used in a review examining the use of VR in educational contexts (Pellas, Mystakidis, & Kazanidis, 2021), the following instructional design strategies were the most frequently used in higher education:

- **Presentation**, in its original form, uses a teacher-centred approach in which students use predefined content with limited interactive functionality (such as adjusting the view or viewing position). Activities typically allow students to explore learning content in detail through 360° videos without haptic controls to interact with the virtual content.
- **Activity-based** represents strategy based on activities aimed at solving tasks in which the student progresses at his own pace under the teacher's guidance (Pellas et al., 2021). The teacher continuously monitors the student and provides him with the necessary feedback. The trend of recent years is that educators are increasingly reluctant to leave learning in this form completely under the student's control (Sharma & Kumar, 2018), and therefore, VR represents a suitable environment combining the student's freedom and the teacher's control.
- **Discovery** is an instructional strategy incorporating self-directed and constructivist learning (Bruner, 2020). It offers a student-centred design that encourages inductive reasoning and progression from the concrete to the abstract based on the realization of discovery activities (Akdeniz, 2016). Typical examples are virtual laboratory experiments, geographical concepts in discovering unknown locations or studying ecosystems, creative work, solving problems, etc.
- **Inquiry strategies** provide educational approaches and techniques that support the process of discovery, questioning and seeking answers as part of the learning process. Shamsudin et al. (Shamsudin, Abdullah, & Yaamat, 2013) defined decision-making, critical thinking, adaptability, tolerance and autonomy as the most important competencies. Typical examples based on this strategy include simulation of problem situations, various types of observations (astronomical, biological, historical, etc.) with extension to experimentation, etc.
- **Cooperative / Collaborative strategies** are aimed at the student, while one of the primary goals is social interaction in study groups, work sharing or joint problem-solving (Akdeniz, 2016). This instructional strategy requires system designers to enable multiple users to simultaneously communicate with others using the same VR application (Pellas et al., 2021). These activities can be the goal of education or just a tool to achieve the goal.
- **The experiential instruction strategy** as defined by Pellas (Pellas et al., 2021) allows students to learn through hands-on practice by engaging in various tasks tailored to their personal experiences. It is a strategy based on the intersection of the approaches mentioned above.

The choice of specific activities to achieve educational goals also varies depending on the age of the target audience. The studies mentioned in (Pellas et al., 2021) used project-based, game-based, and problem-based learning for the K-12 age group. In addition, studies have been based on a teacher-centred approach within specific in-

structional design, such as observing 360° videos in the classroom and virtual field trips in informal environments.

For older students, especially in higher education, the architecture of learning activities is shifting toward monitoring student interactions within instructor-led simulations. This often involves engaging in exploratory activities to discover solutions through research and interaction with the virtual environment. Another approach involves integrating experiential learning and presentation, allowing students to follow predefined educational content and apply it through practical activities (learning by doing). Problem-based collaborative learning allows multiple users to simultaneously interact with others to solve defined problems, either in the virtual or real world.

A key aspect of implementing VR applications into the educational process is the principle of student-centred learning, which makes the most of the immersive nature of VR to create an educational environment that puts students at the centre of their learning journey. This approach not only harnesses the potential of VR for engagement but also enables personalized and enriched learning experiences tailored to the needs and strengths of individual students.

3. EDUCATIONAL OUTCOMES EVALUATION

In AR/VR-based learning activities, typical learning outcomes include content knowledge, skills, and perceptions (Chen et al., 2023). Among them, perceptions are the most frequently evaluated outcomes due to the ease of administering questionnaires to participants. When introducing a new and unfamiliar technology or device using a learning environment, the emotions and attitudes of users play a crucial role in influencing their retention of information. As a result, many reviewed studies focused primarily on evaluating user perceptions.

However, evaluating the VR application in education includes two key aspects: the user experience (UX) design of the created objects and the educational impact of achieving learning goals.

UX design evaluation

There are two basic approaches used in VR to assess UX. One uses the derivations of the **TAM** model (Davis, Bagozzi, & Warshaw, 1989), while the other uses a large group of questionnaires created and edited by researchers.

The Technology Acceptance Model (TAM) is a widely used theoretical framework in information systems and technology management. TAM is designed to help understand and predict how individuals perceive and adopt new technologies, particularly in a workplace or organizational context. The model is based on the idea that perceived usefulness and perceived ease of use are the primary determinants of technology adoption and use. The key components of the technology acceptance model are perceived usefulness, which assesses whether an individual sees value in using the technology; perceived ease of use, which assesses the perceived simplicity and user-friendliness of the technology; behavioural intention to use expresses the level of perceived usefulness and ease of use - if an individual perceives technology

as valuable and easy to use, they are more likely to use it; actual use of the system reflects whether people use technology in their work or daily activities.

One of the first models based on TAM and modified for use in VR is the model proposed by van Raaij (van Raaij & Schepers, 2008). This model builds on **TAM2** (Venkatesh & Davis, 2000) and includes moderating factors such as subjective norms, personal IT innovativeness, and computer anxiety.

Research (Ustun, Karaoglan-Yilmaz, & Yilmaz, 2023) builds on the **UTAUT** model (the Unified Theory of Acceptance and Use of Technology) defined in (Venkatesh, Morris, Davis, & Davis, 2003) and on the evaluation design uses the standard four factors (performance expectancy, social influence, effort expectancy, facilitating conditions), and modifies their items to reflect the acceptance of VR.

CAMIL (Cognitive Affective Model of Immersive Learning), defined in research (Makransky & Petersen, 2021), describes six affective and cognitive factors that can lead to VR-based learning outcomes: interest, motivation, self-efficacy, embodiment, cognitive load, and self-regulation. The model also describes how these factors lead to factual, conceptual, and procedural knowledge acquisition and transfer.

The summarization of UX evaluation models established over some standardized approaches provides valuable insight into simplifying and complicating UX evaluation based on questionnaires standardized for other technologies.

Currently, there is no direct and generally accepted model. Based on a critical analysis of the literature (Mütterlein & Hess, 2017), it is clear that in recently conducted research studies, there are significant differences in evaluating specific properties that describe virtual reality elements. The specific characteristics selected for evaluation were selected and used inconsistently and, in some cases, specified imprecisely. Presented research identifies standard features such as content quality, initial excitement, isolation, and distraction as potentially significant in VR.

The ideal user experience evaluation model may take some time to develop. While traditional UX evaluation models exist for other digital platforms, adapting them to the VR domain is challenging. Extensive research in this area shows that researchers are actively working to develop specialized VR-specific UX evaluation frameworks. Until these models are established and widely accepted, UX evaluation in VR remains an evolving and dynamic field.

Learning outcomes evaluation

Evaluation of learning outcomes in VR typically depends on the specific goals of the learning program and the content of the VR being used. There is no one-size-fits-all method or approach; evaluation should be tailored to the specific objectives, context, and content.

Research (Abich, Parker, Murphy, & Eudy, 2021) identified knowledge, skills and abilities that can be effectively trained or improved using VR and divided them into psychomotor performance, knowledge acquisition and spatial abilities. The items identified in the review (di Lanzo et al., 2020) encompass three broad and main categories: cognitive outcomes, skill-based outcomes, and affective outcomes, and each group can be described as follows:

- Cognitive outcomes aim to evaluate the dynamic processes of acquisition, organization and application of knowledge, which represents improving or enhancing students' knowledge retention and overall understanding. Assessment of cognitive skills includes tests and tasks that verify students' ability to correctly answer questions or solve problems related to the subject matter.
- Skill-based outcomes include performance assessment in simulated and training environments focusing on developing technical or motor skills that can lead to improved academic performance. Their assessment requires practical tests or simulation tasks that verify whether students can successfully perform a given activity.
- Affective outcomes assess aspects such as attitudes, motivations and goals related to learning objectives that facilitate the development of both professional and personal skills, often falling into the soft skills category. Assessment of affective skills involves measuring changes in attitudes, motivation, and emotions through surveys or student feedback assessments.

In the context of these categories, it is necessary to consider the specific type of knowledge or skills and choose the appropriate assessment methods and tools most relevant to them. Regarding cognitive skills (knowledge), the student's ability to understand, remember information or apply it in different contexts is verified. For practical skills, it is essential to determine whether the skills developed by pupils trained in different ways impact their subsequent practical application in a natural environment. Focusing on affective skills involves monitoring and evaluating changes in students' emotional and motivational spheres and verifying whether these changes positively affect their learning and performance.

Within each skill category, it is essential to define specific categories of outcomes that can be tracked and measured when evaluating the effectiveness of VR in education. Their choice depends on the goals of the research and the needs of individual characteristics to participate in the overall picture of the results. Based on the summarization of research, the following categories of measurable educational outcomes were identified (Christou, Tzanavari, Herakleous, & Poullis, 2016), (Safikhani, Holly, Kainz, & Pirker, 2021), (Abich et al., 2021), (Merchant, Goetz, Cifuentes, Keeney-Kennicutt, & Davis, 2014), (Barbot, Kaufman, & Myszkowski, 2023), (Shaw et al., 2019):

- **Quantitative results:**
 - The **accuracy and success** of the tests reflect the degree of correctness in solving tasks, quizzes, knowledge retention tests, or problems in VR.
 - **Success in achieving goals** in VR can be expressed through various metrics, including the number of attempts required to achieve a successful outcome or using a success rate that represents the level of task completion in percentage.
 - The **speed of execution**, or the **time required to complete tasks** in VR, is essential in training scenarios where the success of the activity depends on completing it within a specified time interval.
- **Qualitative results**

- **Deeper understanding** refers to the student's ability to apply the knowledge and concepts they have acquired at a deeper level.
- **Creativity** represents the ability of students to generate new solutions or approach problems creatively. The ability to think outside the box, create innovative ways of solving problems and develop new ideas can contribute to a deeper understanding and development of critical thinking.
- **Analytical and critical thinking** are closely related to creativity and deeper understanding. By singling out this category as a separate entity, the assessment of VR contribution primarily focuses on detecting changes in analytical, critical evaluation, and problem-solving skills.
- The development of **communication and cooperation skills** in a virtual environment can be effectively facilitated through various means, such as role-playing, social networks, and collaborative activities.
- **Skill level:**
 - Developing **practical skills** is a fairly common goal in virtual applications. It focuses on activities that are key to preparing students for real work situations and increasing their practical skills (Aïm, Lonjon, Hannouche, & Nizard, 2016), (Gavish et al., 2015) developed within the scope of the SKILLS Integrated Project, for industrial maintenance and assembly (IMA).
 - **Spatial ability** is one of the first abilities developed in early VR models. It represents a specific skill and is related to improving spatial orientation for general use or developing skills for people with specific needs (Moreno, Posada, Segura, Arbelaiz, & García-Alonso, 2014).

Effective measurement of the various learning objectives in VR is key to understanding its effectiveness comprehensively. These are aligned with cognitive, practical, creative, spatial, and collaborative skills acquisition. Quantitative and qualitative data, including standardized tests, time spent on tasks, success rates, interactions, responses to open-ended questions, and project evaluations, are essential for a comprehensive assessment.

By integrated evaluation of all these types of data, it is possible to obtain a comprehensive view of student development within VR applications. In addition to quantitative results, it is also necessary to consider qualitative elements and skills, such as attitude, motivation, and application of acquired knowledge in real scenarios.

4. DISCUSSION AND CONCLUSION

Incorporating virtual reality into traditional educational methods brings positive results in the cognitive, skill and affective aspects of learning (di Lanzo et al., 2020). However, a comprehensive understanding of the real benefits of VR in education is currently limited due to the small number of study participants, the absence of a formal evaluation of the proposed tools, and problems related to standardization and transparency in evaluation processes and metrics. Another notable issue is the lack of realism in the virtual environment, which can distract students from their intended learning tasks and potentially compromise the immersive learning experience.

As educational technologies continue to evolve in the context of VR, it is crucial to explore and adapt effective theories and strategies from previous educational approaches. Many studies have produced inconclusive or inconsistent findings because researchers sometimes neglect educational design and do not fully exploit the possibilities of VR.

When designing and integrating VR applications into the educational process, aligning this process with fundamental educational principles, including educational goals, the definition of educational design, and the evaluation of educational objects in VR is essential.

The learning objectives provide clear direction and purpose for integrating immersive technologies and ensure that they contribute to the overall learning objectives of the subject or program of study. VR should be integrated into the curriculum through a well-defined plan that includes using VR objects to align with specific learning objectives, content delivery methods, and pedagogical strategies.

Part of the proposal for integrating VR into the educational process should also be an assessment of whether and how VR will effectively increase the quality of the educational process. Ongoing evaluation, which includes measuring the impact of VR experiences on student learning, understanding and skill development, is the first prerequisite for ensuring the effectiveness of VR in education. Final assessment methods should be designed to align with learning objectives, allowing educators to assess the actual success of VR integration. However, ongoing research suggests that integrating complex elements into VR training can significantly increase effectiveness.

Virtual reality is a powerful educational partner that transforming traditional teaching methods into immersive and engaging experiences. As technology continues to evolve, so does the potential of VR to enrich the learning process. It brings abstract concepts to life and equips students with practical skills in a safe and controlled environment. A gamified approach encourages curiosity, creativity, and a thirst for knowledge, making learning an exciting journey. The future holds endless possibilities to evolve and integrate seamlessly into the educational curriculum.

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ADVANTAGES, PROBLEMS AND CHALLENGES IN THE APPLICATION OF AI TECHNOLOGIES IN SCHOOL EDUCATION

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Abstract: *The implementation and use of AI technologies in education offer great potential for increasing the quality of student learning, as well as assisting teachers in organizing the educational process. However, the use of AI in education (AIEd) also raises some important ethical questions. The article discusses some aspects of applying some AI technologies to improve personalization, accessibility, and interactivity in school education. The authors aim to share their experience in successfully integrating AI into the classroom while focusing on the ethical and responsible use of these technologies.*

Keywords: Artificial Intelligence in Education, Chatbots, Personalized learning

INTRODUCTION

The development of Artificial Intelligence (AI) has created conditions for changes and transformations in all spheres of life, including education. AI technologies have the potential to alter and modify traditional approaches, methods, and teaching and learning technologies. AI applications are already being used to some extent in various aspects of school education, including establishing and analyzing learning outcomes, personalizing educational resources and the learning process, providing immediate feedback, and engaging students.

The implementation and use of intelligent learning platforms that include personalized learning and assessment systems offer great potential for increasing students' knowledge, building essential key competencies, and assisting teachers in organizing personalized education. The expectations are that providing a learning environment tailored to the personal expectations, requirements, goals, and interests of each student, will lead to increased student engagement and motivation, thereby enhancing the effectiveness of the learning process.

Despite these advantages, the use of AI in education (AIED) also raises important ethical questions and issues. These issues are largely related to the exacerbation of existing inequalities in the educational system because AI algorithms often tend to perpetuate biases and distort information embedded in machine learning algorithms. Additionally, for teachers to effectively use AI in their teaching practices, they require appropriate training and support.

The article discusses some aspects of implementing certain AI tools and chatbots to enhance personalization, accessibility, and interactivity in school education. At the same time, the authors intend to focus attention on the ethical and responsible use of these technologies.

1. AI IN EDUCATION – AIED

The possibilities offered by AI are becoming increasingly tangible. It has the potential to change all aspects of public life – business, tourism, agriculture, healthcare, and education. Artificial Intelligence, as defined by John McCarthy in the distant year 1955, refers to that machines can perform tasks that typically require human intelligence. In contemporary terms, we can consider any theory, methodology, or technique that facilitates the analysis, simulation, and investigation of human thought processes and behavior by machines, as AI. Intelligent systems encompass a broad range of technologies and fields such as cognitive robotics, natural language processing, sound and image recognition, expert systems, neural networks, machine learning, etc. (Sarker, 2022).

1.1. AIED Paradigms

The application of AI in the process of formal and informal learning is the subject of intensive scientific research. AI is considered a powerful tool for creating new paradigms in instructional design, technological advancement, and educational research that would otherwise be difficult to achieve through conventional methods. Ouyang and Jiao (2021) articulate three AIED paradigms:

- **AI – directed learning.** In this paradigm, AI is used to introduce cognitive learning tools, with learners in the role of recipients of AI services.
- **AI – supported learning.** In this paradigm, through the application of various cognitive and social constructivist theoretical foundations, AI supports learning. Students collaborate with AI to obtain desired knowledge, skills, and competencies.
- **AI – empowered learning.** This paradigm is based on collaboration, with artificial intelligence empowering learners to take initiative in their own learning, and collaboration between student, facilitator, mentor, information, and technology increasing the added value of learning.

There are two distinct approaches in AIED, consisting of developing AI-based tools for classrooms on the one hand and using AI to gain insight, assess and improve learning on the other. AIED includes the integration of different social, cultural, economic, and pedagogical approaches in the use of AI technologies such as intelligent

learning cyber-physical systems (Stoyanov, 2022), chatbots, learning robots, learning tracking and analysis tools, adaptive learning systems and automated assessment, etc. One of the most commonly used AI technologies to support teaching and learning activities is the utilization of Chatbot technology (Deng et al., 2023). By nature, a Chatbot is an intelligent agent that engages in meaningful conversations with users, thanks to a well-structured knowledge base. Creating a Chatbot is based on Natural Language Processing (NLP) technologies. The first Chatbot Eliza, was developed to act as a psychotherapist as early as 1966. As technology advanced, numerous Chatbots were created, including SmarterChild, Apple Siri, Amazon Alexa, IBM Watson, Microsoft Cortana, Google Assistant, and more.

1.2. Chatbots in the Classroom

In the past few months, some of the popular chatbots like ChatGPT and Microsoft 365 Copilot have quickly caught on in the classroom. We will look at some of their functionalities through the lens of school education. ChatGPT was created by OpenAI and launched in November 2022. ChatGPT is described as a powerful machine learning software that uses the Generative Pre-trained Transformer (GPT) algorithm to generate answers to text questions. A wide range of tasks can be performed by ChatGPT, including language translation, answering questions, creative writing and generating long or short content, explaining complex concepts or topics, generating, or debugging programming code, and more. ChatGPT's ability to understand natural language queries and generate responses has made it a popular tool for getting quick answers to a wide variety of questions in the classroom. For example, it can quickly summarize a long and difficult topic in a few sentences. It not only discovers what the problem is but also provides descriptive solutions to math and physics problems; can assist in the detection of programming errors; to comment and explain program fragments and modules.

Another AI chatbot that can be effectively used in school education is Microsoft 365 Copilot as it aims to improve collaboration between participants in the educational process and facilitate teamwork in the implementation of educational projects. It provides personalized, AI-driven advice and suggestions that can help teams accomplish their tasks more effectively by making full use of the full set of Microsoft 365 tools. On the other hand, Copilot is also implemented as a chatbot that can communicate with individual users or teams to help them troubleshoot problems and suggest solutions. It is embedded in Microsoft 365 applications such as Word, Excel, PowerPoint, Outlook, and Teams and offers collaboration to all participants in the learning process. To implement these features, Copilot provides personalized access to user profiles and manages personal calendars, emails, chats, documents, meetings, contacts, etc. In addition, it can also be embedded in programming environments such as Visual Studio Code and assist in the teaching of programming in various programming languages in middle school (Puryear & Sprint, 2022).

All this gives reason to the authors to make an assumption that AI can make a significant contribution to improving the learning and teaching process in the classroom.

1.3. Approaches to applying AI technologies in the classroom

Despite its potential to revolutionize schooling, achieving positive educational outcomes requires much more than the uncritical use of AI. It is necessary to conduct research and pedagogical experiments to ensure the necessary reliability, validity, and security of the educational process from a didactic point of view. The use of AIED technologies, learning content, and pedagogical approaches must be integrated and adapted to the particularities of the learning environment. Therefore, when designing learning activities supported by AI, teachers should consider six key elements to achieve the expected learning goals: learners, context, tasks, pedagogical approaches, interaction methods, and application of AI technologies (Zheng et al., 2023).

When we talk about the application of AI in school education, we usually refer to various aspects aimed at improving learning, teaching, and administrative processes. Some key areas where AI can be used in education include:

- **Personalized Learning:** AI-driven adaptive learning platforms can analyze students' learning patterns and preferences to tailor educational content and activities to their individual needs. This allows students to learn at their own pace, in a way that suits them best, fill knowledge gaps, and receive individualized learning tasks suitable for their specific status and level.
- **Intelligent Learning Systems:** AI-powered tutoring systems can simulate human interactions in learning, providing appropriate learning resources and offering immediate feedback and assistance to students. These systems can also interact with other participants in the learning process, such as teachers, parents, and administrators, by providing them with suitable services and resources.
- **Testing and Assessment:** AI can automate the assessment process for multiple-choice, true/false, and other normed response questions. This saves teachers' time and allows them to focus on evaluating free-response answers, as well as providing quality feedback.
- **Language Learning:** AI language learning platforms can help students practice speaking, listening, reading, and writing skills in different foreign languages. These platforms often include NLP algorithms for pronunciation and grammar error assessment and correction.
- **Virtual Reality (VR) and Augmented Reality (AR):** AI can be integrated into educational VR and AR applications, enabling students to explore historical sites, conduct virtual scientific experiments, or simulate real-world scenarios. Studies show that this improves understanding of difficult and unclear educational material in subjects like history, geography, biology, etc.
- **Supplementary Knowledge:** AI algorithms can recommend appropriate educational resources, books, and articles based on student's interests, learning progress, and past experiences. This helps students discover new topics and expand their knowledge beyond the curriculum.
- **Preventing Learning Difficulties:** AI can identify potential learning difficulties or challenges at an early stage, allowing teachers to provide the necessary support to students before problems escalate. This aspect of AI application addresses critical important social issues related to students at risk of dropping out.

- ***Special Education and Inclusion:*** AI can be used to develop assistive technologies that support students with special educational needs and disabilities, enabling them to have more effective and inclusive access to education.
- ***Student Support and Counselling:*** AI-powered chatbots or virtual assistants can interact with students and provide advice and guidance related to school issues and other personal emotional challenges, offering additional information, tips, and support.
- ***Administrative Efficiency:*** AI can streamline administrative tasks in schools, such as planning, resource allocation, student enrollment, and staff management. This improves overall operational efficiency and allows teachers to focus primarily on teaching and enhancing the quality of educational activities, freeing them from non-teaching administrative duties.
- ***Assisting Teachers' Work:*** AI can analyze vast amounts of educational data to identify trends, patterns, and insights that can inform teachers' decision-making, curriculum development, and school policy adjustments.
- ***Plagiarism Detection:*** AI-based plagiarism detection tools can assist teachers in identifying cases of plagiarism and cheating, promoting academic integrity among students.

Despite everything presented so far, it is important to note that while AI offers significant benefits to education, it should complement and enhance teacher teaching, rather than replace it entirely. Effective integration of AI into education requires careful consideration of multiple ethical issues and privacy considerations, as well as continuous monitoring, evaluation, and analysis to ensure optimal benefits for students and other participants in the educational process.

2. OUR EXPERIENCE

In the last few years, a team of scientists and pedagogical specialists from Plovdiv University "Paisii Hilendarski" in Bulgaria, together with teachers in secondary schools of the Plovdiv region, have developed different approaches for the application of AI in school education in almost all aspects discussed above. A prototype of an intelligent educational platform Virtual Educational Space (VES) was developed as a cyber-physical and social environment that provides adapted learning resources and services to students of various specialties in the Faculty of Mathematics and Informatics (Valkanov, 2016) (Rahnev, 2014). VES is realized as a multi-agent platform, with the personalization of learning realized through the interaction between the personal assistants of all users – students, teachers, and university administration. The VES space provides different types of services such as:

- training and examination tests, analysis of training results;
- standardized SCORM-based learning resources that take into account the individual basic knowledge of each learner and provide an appropriate individual learning path;
- administrative services such as a smart student book and teacher's notebook;
- services for joint work on projects, consultations, etc.;
- provision of services implemented as an integration of the cyber-physical worlds.

As an adaptation of VES for school education, a prototype cyber-physical space called BLISS was developed. This platform is multi-agent and enables personalized learning for self-directed students, as well as personalized access to learning resources and services for regular students. The system was successfully tested during the period of blended learning during the period of COVID'19 pandemic. By using block chain technologies in BLISS, an electronic diary related to the administrative process of issuing documents with factory numbering is modelled and is in the process of prototyping (Todorov et al., 2019). The system for checking and evaluating knowledge is connected to the electronic diary, which monitors the progress of students and, in the presence of educational problems, informs the parents and teachers of the student. In parallel with the development of BLISS, in which the ecosystem of personal assistants is a main component, the team also turned its attention to the integration of AI chatbots, which, on the one hand, can interact with personal assistants and other intelligent agents in the space, and on the other hand, help to solve various tasks in the present classroom training. Over the past two years, with the rapid development of LLM and chatbots, we have been experimentally using the capabilities of AI in the classroom in the following areas:

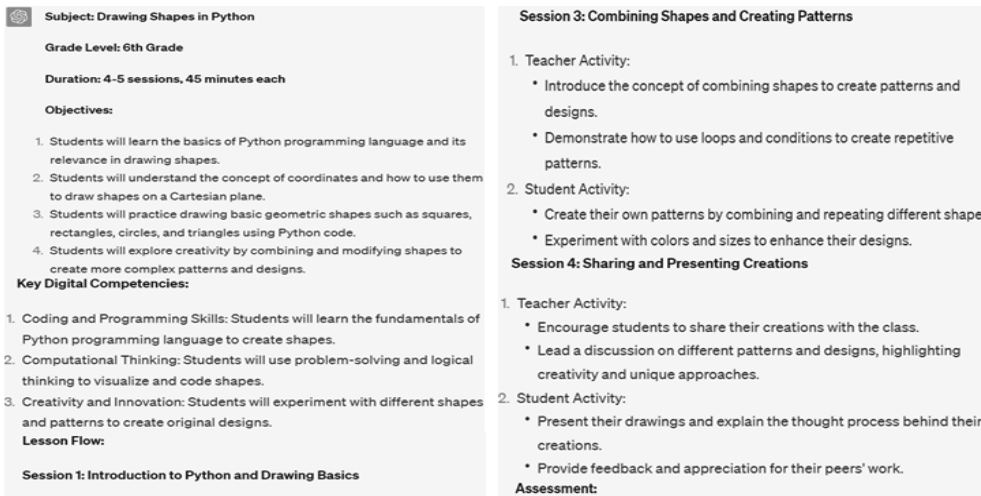
- for planning the learning topics and lessons by the teachers;
- for personalization of the learning process;

2.1. Planning the learning topics and lessons by the teachers

The transition from Education 3.0 to Education 4.0 marks the need to adapt educational systems and practices to dynamically changing technologies. This also determines the need for a change in the planning and preliminary preparation processes of teachers, who turn from expert teachers into mentors and facilitators, and the student from a passive participant in training into an active subject responsible for his own development. This process is a challenge for the teachers' college and requires a new approach to planning learning tasks and learning activities. AI chatbots can be used to a large extent in the planning and pre-training process of teachers. For example, when preparing a Learning and Creativity Plan for the compulsory 6th grade school subject "Computer Modelling and IT" lesson with the topic "Drawing in Python", the teacher can make a request to ChatGPT similar to "Create a Learning and Creativity Plan for 6th grade on: Drawing in Python. Create objectives, learning tasks, digital competences, teacher and students' activities and lesson process" and to receive the proposition in Figure 1.

As can be seen from Figure 1, the ChatGPT response includes all the desired parts: subjects, grade level, objectives, key digital competencies, lesson flow, teacher activities, student activities, learning tasks, assessment, and additional tips. The proposed plan is not perfect, but it can serve as a good basis for planning the teacher's work and save a lot of his/her time.

Creating a test to test students' knowledge on this topic can also be supported by the chatbot. At the teacher's request "Create a quiz with closed questions to test students' knowledge of this topic", ChatGPT offers the following test (Figure 2).



2.2. Personalization of the learning process

Personalization and differentiated approach are particularly important features of modern education. While in the individual work of the students they can interact with their personal assistant or chatbot, in the general or group work in the classroom the teacher looks for other approaches. In pedagogical practice, various forms of typification of students are successfully used, and during his preliminary preparation, the teacher must prepare appropriate learning tasks or training materials for each of these types of students, which are often called Personas. A Persona is a description of a group of students with common characteristics. This description is based on different technologies and determination of different cognitive and emotional types of students (Nielsen et al, 2013). Thus, students in each class may associate themselves with several typical Personas profiles. The differentiated approach and personalization of the learning process is realized in practice by creating appropriate learning content, learning tasks and predicting the behavior of the Persons. Often, Personas can also be seen as typical roles in group work or role playing.

Using ChatGPT let is create typical student Personas according to their cognitive and emotional characteristics. As a result of the request, 5 student Personas were created with their sample names, cognitive and emotional characteristics. Figure 3 shows the Persona Alex.

 Create me sample persona profiles of students, according to their cognitive and emotional characteristics

 **1. Persona Profile: Analytical Alex**

Cognitive Characteristics:

- Alex is a highly analytical student who excels in problem-solving and logical reasoning.
- He enjoys breaking down complex tasks into smaller components to understand them better.
- Alex is attentive to details and often approaches challenges in a systematic manner.
- He prefers learning through structured materials and appreciates clear instructions.

Emotional Characteristics:

- Alex is self-motivated and takes pride in his academic achievements.
- He can be critical of himself and strives for perfection in his work.
- Alex is introverted and may need some encouragement to participate actively in group discussions.
- He tends to remain calm under pressure and rarely lets emotions interfere with his studies.

Figure 3. Created sample student Persona

Source: Own work.

One of the most important features of modern education is the use of a differentiated approach, where individual students or groups of students go through the learning process in an individual or differentiated way. The created Personas with their char-

acteristics create a prerequisite for the implementation of this approach. We can ask ChatGPT for assistance in creating personalized learning content and learning tasks, according to the cognitive and emotional characteristics of Persona named Alex. Figure 4 shows part of the example tutorial customized for Alex.

Session 1: Introduction to Python Basics

Objective: Introduce Alex to Python programming fundamentals.

Teacher Activities:

Hello Alex! Today, we will begin our journey into the world of Python programming. Python is a powerful language used for various applications, including drawing shapes and creating graphics. Let's get started!

Show Alex a brief presentation on the importance of Python in various fields, including graphics and data visualization.

Explain key Python concepts, such as variables, data types, loops, and conditional statements.

Provide examples of Python code snippets and their respective outputs.

Student Activities:

Welcome to the world of Python, Alex! Please listen carefully as we explore the basics of this versatile programming language. Feel free to take notes, and don't hesitate to ask any questions you may have.

Figure 4. Personalized lesson

Source: Own work.

3. PROBLEMS AND CHALLENGES

Although the use of AI technologies has many advantages, it is essential to carefully examine and soberly assess their limitations, problems, and challenges. We know that popular chatbots can pass the Turing Test, leading users to believe they are communicating with humans rather than bots. This raises ethical concerns related to potential misuse and deception. One of the major concerns is the fact that ChatGPT and other chatbots can spread false and misleading information and enable plagiarism and unethical behavior during exams in schools and universities. In January 2023 the New York City officials blocked access to ChatGPT from the school's devices and networks in the city's 1851 public schools, which serve over 1 million students, due to potential misuse and concerns raised by educators. However, in May 2023 they decided to remove the ban and try to leverage the potential of generative AI to support students and teachers with the understanding the reality that the students are participating in and will work in a world where understanding generative AI is crucial (Rosenblatt, 2023). Privacy and the protection of users' personal information are another significant issue, with Italy being the first EU country to temporarily ban ChatGPT in March due to privacy concerns. ChatGPT returned in Italy on April 30

after the OpenAI addressed the concerns of the Italian Data Protection Authority – Garante. These concerns include the necessity of age restrictions, clarifying how data is processed, providing data management options, and allowing users to opt out of their data being used. Other countries, including Canada, Germany, Sweden, and France, opened or consider to open their own investigations into ChatGPT's practices, including how the training data for the model is collected and what information that model produces for users. This led to further advancement of the AI Act of the European Union (AI Act, 2023) which was first proposed in 2021 and does not fully meet the challenges of the lately emerged generative AI tools and chatbots. These and other ethical problems with the use of AI technologies have led leading experts in artificial intelligence, such as Elon Musk and Steve Wozniak, to sign an open letter warning that uncontrolled AI usage can pose significant risks to society and humanity.

Another key challenge relates to the development and programming of Chatbots. Computational linguistics and Natural Language Processing (NLP) systems present some of the most significant potential issues (Kasneci et al., 2023). The accuracy of a Chatbot in providing information depends on the quality of the input data it is trained on. If not properly regulated and restricted, a Chatbot, for example, trained in chemistry or physics, could provide additional information and instructions on creating an explosive device, posing a threat to human life.

To overcome these challenges, the following eleven ethical principles for artificial intelligence have been outlined: (1) Transparency, (2) Fairness and Honesty, (3) Harmlessness, (4) Accountability, (5) Privacy, (6) Beneficence, (7) Freedom and Autonomy, (8) Trust, (9) Dignity, (10) Sustainability, and (11) Solidarity. These constraints on chatbots must be strictly adhered to, especially when they are used for educational purposes. In general, they raise questions concerning academic integrity and the use of these chatbots for unregulated writing of exam answers. Of course, there are other ethical issues related to the use of chatbots in education, which can be summarized as follows:

- Credibility and accuracy of the information generated and provided.
- Potential biases in the data leading to discriminatory or misleading responses.
- Privacy concerns, as personal information of students and teachers may be stored and used.
- Issues related to the role and skills of teachers and their impact on the job market.
- Lack of interaction with human teachers, which may inevitably reduce the quality of educational and social experiences for students.
- Over-reliance and dependency on technology.
- Concerns regarding intellectual property rights.
- Transparency and accountability, as it may be challenging to identify how the chatbot makes decisions, processes, and analyzes information.

On the other hand, in school education, ensuring fairness and accessibility for all students is of particular importance. It is crucial to ensure that AI-based educational tools are designed with user confidentiality and data security in mind and that they do not exacerbate biases and inequalities (Yang, 2022). Given that versions of Chat-

GPT and Microsoft 365 Copilot can be integrated into Office applications, including Word, Excel, PowerPoint, and Outlook, by using machine learning to analyze data from various sources, including telemetry data and user feedback, it is not difficult to anticipate that the impact of ChatGPT in education will grow rapidly in the coming years. Therefore, additional research is needed to establish the potential benefits and challenges of these emerging technologies for school education.

CONCLUSION

There are several advantages of using AI in education, as well as certain challenges. AI can improve learning outcomes, productivity, and student engagement by opening new pathways for personalized education, feedback, collaboration and support. However, ethical and practical issues related to the application of AI in education cannot be ignored. Important problems that need to be addressed include the potential for biases in AI algorithms and the requirement for sufficient training and support for teachers.

Collaborative efforts involving teachers, researchers, and policymakers are necessary to ensure the ethical and responsible use of AI in education. We can build a more equitable and successful educational system that provides children with the individualized learning, feedback, and support they need by addressing the challenges posed by AI technologies and leveraging their advantages.

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AI IN HIGHER EDUCATION: UTOPIA OR REALITY?

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Abstract: *The advent of ChatGPT opened the doors of AI in an unprecedented way. However, while ChatGPT and similar AI technologies have the potential to greatly benefit higher education, there are certain considerations that might lead to viewing them as utopian. The authors explored how learners are using ChatGPT in two Portuguese universities. By analysing the results, it is intended to better understand the challenges presented to universities regarding its use, as well as the degree of satisfaction of the performance of this type of technology in their learning activities. Finally, this study shows that there is a way to go while there are issues to be aware of, such as the dependence on the use of general AI tools.*

Keywords: ChatGPT, Dependency, Higher Education, Portugal

INTRODUCTION

AI is forever changing how educators and learners access and share information. Its capacity to do more than we can imagine will advance at a rate more quickly than it can be understood. ChatGPT and other new AI tools will present new opportunities, namely due to the enthusiastic ability to understand and generate human-like text and free access to a valuable tool for interaction (Gupta, 2023). These new technologies have the potential to create inconceivable opportunities for educators and learners in higher education (Duggan & Knyazeva, 2020). However, envisioning a utopian future where AI solves all learners' problems should not be neglected with the fear of a dystopian reality where AI leads to dehumanized education and potential threats to learners themselves. For instance, utopia can be related to what students expect from AI in the face of promises and advertisements, namely ChatGPT 3.5 (OpenAI, 2023), which we can call personal utopias, and which can generate stress-related challenges when they are confronted with the results obtained, i.e. reality. By now, ChatGPT 3.5 has its limitations and is predicted to be the first in line for advanced AI systems, or it is only a commonly known preliminary substitute for AI.

According to Saleh (2023), there is an emergence for all academia to reflect, explore perspectives, examine implications on lecturing and learning, as well as share fears and hopes. This study focused on research made on how learners from two Portuguese universities are using ChatGPT in their academic activities. The analysis of the results of this research led us to better understand both the opportunities presented to higher education and the learners' opinions regarding the use of ChatGPT and other AI tools in their schoolwork. Finally, this study shows that there is a way to go and an expressed willingness to move towards incorporating all these new technologies into lecturing. One of the points raised has to do with the fact that attention must be paid to the dependence on the use of AI tools, which could lead to a decrease in the intelligence of the academic population.

1. INSTRUMENTS OF AI IN EDUCATION

1.1 Overview of AI in Education

We have been using embedded AI for a long time, even in unforeseen events such as search engines, optical character recognition, transcription, and translation or chatbots. In addition, attention-based models are developed to efficiently handle large inputs and outputs such as images, audio, and video (Vaswani et al., 2017). However, the AI entered the public domain with the launch of ChatGPT 3.5 in late 2022 (OpenAI, 2023). Despite the study on machine learning and AI being ongoing for decades, it is now becoming more accessible and democratized.

Approaches to AI instruments that have been used in Education undergo a variety of features and functionality that can benefit learners, lecturers, and the administration of educational institutions in various ways. Indeed, generative AI has been identified as a powerful tool to improve teaching and learning. For example, Chaudhry and Kazim (2022) explored case studies in subdomains of reducing lecturers' workload, contextualized learning for learners, revolutionizing assessments, and intelligent tutoring systems. The key features can be observed across a sample of major massive open online course (MOOC) platforms, AI-enabled learning management systems, Chatbots for Virtual Tutoring, AI translators, and personalized learning (Biliuk et al., 2023).

Universities today have great challenges that include improvement of the possibility of having personalized learning experiences based on learners' abilities and preferences, real time data analysis, exploration of new courses and ways to enhance research. Within this framework, and to denote the advance of AI in education, it is convenient to specify its intervention in intelligent tutorials and innovative courses, adaptive learning platforms, educational recommendations by virtual assistants, and automatic response evaluation.

On the other hand, applications are becoming conversational, proactive, and interactive (Gartner, 2023), requiring a redesign of user experience to foster a collaborative approach. In addition, AI can interact with its environment and learn from it. Recent advances in Explainable Reinforcement Learning have the potential to dramatically improve learner engagement levels (Frackiewicz, 2023). This is complemented by

the ability of AI to make connections across different data points, which is viewed by Duggan and Knyazeva (2020) as Augmented Intelligence.

1.2 The impact of ChatGPT in Education

AI integrates many technologies already used, such as machine learning, deep learning, predictive models, automatic speech recognition and natural language processing. Definitions and classifications for AI generally include a set of technologies that apply advanced analytics and logic-based techniques to create new information. Meanwhile, intelligence refers to a process that includes obtaining knowledge based on learning, applying knowledge, and updating knowledge depending on the experience gained after applying knowledge (Bhise et al., 2022). Generative AI, in particular, is exciting because of its wide-ranging applications, such as content creation (Gupta, 2023), but will move beyond responding to natural language queries and begin suggesting things that were not asked for (Gartner, 2023).

Anyway, a Generative AI tools landscape (There's An AI For That, 2023) shows a lot of examples to Text (Bard, Copy.ai, Copysmith, ChatGPT, Jasper, etc.), Audio (Amazon Polly, Voicebooking, etc.), or Code (Mostly.AI, OctoML, etc.). Moreover, learners use AI-based software like Grammarly for language processing (Hutson et al., 2022), DeepL with millions of translations every day, Happyscribe capable of transcribing any video or audio into text, or Copilot which is present in Microsoft 365 Word and is able to help writing, editing, or summarizing, and at the same time creating content.

Virtual assistants like ChatGPT 3.5 can provide support to a large number of learners simultaneously or could be used to grade essays or other written assignments, freeing up instructors to focus on more high-level tasks like providing feedback and support to learners (Cotton et al., 2023). Rethinking human machine interaction with natural language, ChatGPT 3.5 promises to enhance productivity when prompt textual inputs that provide some context on what is expected for the outcome. The different prompt categories and principles for effective prompt writing determine how to apply these concepts in a real-world setting (Nyakundi, 2023).

When prompted with the question “why ChatGPT may present challenges or limitations in higher education” (own work), ChatGPT 3.5 generated text indicating reasons like (OpenAI, 2023): ChatGPT’s language capabilities can help learners understand complex texts, and facilitate communication in different languages; ChatGPT operates based on patterns and statistical correlations in the data it was trained on, rather than true comprehension or contextual understanding; or ChatGPT’s knowledge is limited to what it has been trained on, which may not encompass the breadth and depth of subjects taught in higher education. Relying solely on ChatGPT for educational support could lead to misinformation or misunderstandings if not carefully monitored. Consequently, checking results before using them is a critical quality assurance task to ensure that correct assumptions and conclusions are obtained. ChatGPT 3.5 can inadvertently perpetuate biases, and this can be problematic in educational settings that aim to provide unbiased and inclusive learning experiences. Other limitations include ChatGPT training with limited knowledge of the world and events not included after 2021 (IDC, 2023). Finally, ChatGPT 3.5 does not possess emotional intelligence

or the ability to empathize with learners. According to Gillani et al. (2023), technical limitations entail important risks and ethical considerations which have significant bearings on the application of AI to the field of education. For instance, Bubeck et al. (2023) put special emphasis on discovering more specific limitations.

1.3 The distress of Higher Education institutions

The overall impact of AI on higher education depends on how institutions navigate these challenges and leverage AI's capabilities to enhance the learning experience. They can mitigate these potential issues through careful planning, clear communication, proper training, and thoughtful implementation strategies. It is important to note that the impact of AI depends on how it is integrated, the ethical considerations taken into account, and the adaptability of these institutions to new technologies (OpenAI, 2023). Nonetheless, it is critical to consider that there was no inherent reason for ChatGPT or similar AI systems to distress higher education institutions and were not developed to cause affliction.

First of all, affliction can emerge if cultural values are not supported, and institutional action is taken to change culturally responsive pedagogies and a collaborative approach to education with AI. The loss of educational values could happen if AI-generated content becomes the primary source of educational materials and might be a risk of losing the values and cultural context that human educators bring to the lecturing process. Also, the learner's dependency on AI systems could happen if learners become overly reliant on its use for learning and problem-solving, because it might hinder their development of critical thinking, creativity, and independent research skills. In addition, a few potential ways in which AI systems could inadvertently lead to distress or affliction: job insecurity among lecturers and administrative staff; learners might miss the personal touch, mentorship, guidance, and emotional support; learners could misinterpret or misunderstand certain concepts, leading to confusion and frustration (OpenAI, 2023). On the other hand, human interaction, mentorship, and the ability to engage in deep discussions are crucial aspects of the learning process that AI might struggle to replicate. Moreover, mismanagement of data security and privacy could lead to distress among stakeholders.

Higher education institutions were practically forced to review their AI strategy in the face of Open AI's decision to publicise ChatGPT 3.5 and grant free basic access, contrary to what had been the practice of other AI stakeholders. This is one reason why most academia agrees that the methods of lecturing and learning ought to be revisited (Saleh, 2023), keeping up with the changing times and accelerating technology needs (Kumar, 2021). Nevertheless, the distress of higher education institutions could be also related to costs, as investing in AI systems means costs that will only increase. It seems important for those investments to increase learners' learning experiences, as indexed by their self-rated satisfaction (Rodway & Schepman, 2023). Bender et al. (2021) provide recommendations including weighing the environmental and financial costs first, curating and carefully documenting datasets rather than ingesting everything on the web.

Finally, effective change management strategies, including clear communication, training programs, and involvement of key stakeholders, are crucial in creating

a positive culture around adopting ChatGPT. An organizational culture that promotes collaboration and cross-departmental teamwork can facilitate the integration of ChatGPT into the higher education ecosystem. Collaboration, although very old, is at the core of new AI pedagogy (Saleh, 2023).

1.4 The learner's push

Despite the little that is known about the distress of learners, or the variables positively or negatively associated with the daily use of ChatGPT 3.5, the learners push to speed up artificial intelligence adoption in higher education institutions. Therefore, ChatGPT can help learners to push their learning and critical thinking to focus on topics that can help them undertake their specific skills gaps. This is a kind of pull learning where Generative AI could push the skills and capabilities that learners need in autonomous learning. Also, learners need to continue to pull the skills and benefit from the collaboration agenda between academia and AI enterprises.

On the other hand, there is a risk that learners may use this technology to cheat on assessments (Gonsalves, 2023), and the acknowledgement of these limitations leads academia to actively seek alternative assessment methods to maintain academic integrity (Elkhatat, 2023), due to a potential threat to the integrity of online exams (Susnjak, 2022).

Given the importance of the above issues, in this study the authors took into account the objective of understanding the opinion of learners in the use of AI tools, such as ChatGPT, in higher education institutions in Portugal.

2. METHODOLOGY

Scientific research can be carried out using a variety of methodologies. The orientation of the research should take into account the objectives of the study, the information it intends to collect and the means to collect that information. The use of a survey in conducting research on performance and analytical frameworks is a widely used tool that allows investigating specific behaviours in institutions through examples in the answers obtained (Akyüz & Erkan, 2010). Evans and Mathur (2005) listed some types of surveys that are most widely used, such as online surveys, email surveys, physical surveys or surveys conducted by telephone. Furthermore, Ouyang, Zheng and Jiao (2022) claimed the implementation of more empirical research to test actual effects of AI applications, and Zhai et al. (2021) suggested it into three categories: technique, lecturers and learners, and social ethics. Following factors that make responding to the form convenient for both the respondent and the interviewer, this research conducted physical surveys between lecturers and learners. The advantage of this method is to make learners feel confident and comfortable in participating, and it is much easier to engage the classrooms for a long time. However, there are also some disadvantages such as representativeness of the sampling. The questions posed benefit from gathering mainly quantitative data, with answer scales used to measure attitudes and opinions, while qualitative data emerges in open answers, classroom briefings, and observations. Respectively, all data was classified and divided between numeric and categorical data.

2.1 Research questions

The methodological approach of this study was based on two main research questions: Is the use of AI tools during higher learning process influencing the learners' work? Are these AI tools improving lecturing?

2.2 Sample definition

Taking advantage of the end of the 2022–2023 academic year (May and June), to try to ensure a higher response rate (100%), this study carried out a physical survey on 220 learners of the second and third year of Information Technology courses from two private universities in the Lisbon region, whose ages range between 20 and 45 years – a wide range given that there are also after-school classes for working learners, with a male predominance in the group of respondents.

2.3 The survey

The survey aimed to understand the reality in Portuguese higher education regarding the use of ChatGPT in their academic activities. By analysing the results, it is intended to better understand the challenges presented to the universities regarding its use, as well as the degree of satisfaction of the performance of this type of technology in their study activities.

Due to the fact that this was a physical survey in the classrooms, 100% was the level of participation. The survey had eight questions, asking (1) if the learner used ChatGPT 3.5, (2) if so for which purpose (private or academic work), (3) if the results obtained were confronted with other sources and (4) if they were up to date, (5) if the use of ChatGPT 3.5 was useful for their academic work, (6) if sources were mentioned, and finally asking (7) if in their opinion this new technology will alter the traditional way of teaching and (8) how should teaching be changed to cope with these new tools.

Analysing the results of the data obtained (Figure 1), it appears that 85% of the respondents regularly use ChatGPT 3.5 to obtain information for professional and/or academic purposes, of which 54% also use it for personal matters. It was observed that 77% of the respondents usually check the results obtained with other sources of information, as they found differences in the information obtained and even 31% do not trust that information. Many respondents also stated that depending on the way the question is asked, the result may differ.

Although half of the respondents using ChatGPT claim that the results obtained were correct, the other fifty per cent said that they confronted the bot and that it did not always correct the results. On the other hand, they claim that using this tool makes it easier to get the answers they want. If they have a question about something, they can just ask the AI directly, there is no need to search through search engines that only return links whose sites must be searched and their information summarised, and it also allows them to complete data that the materials provided in the discipline do not include.

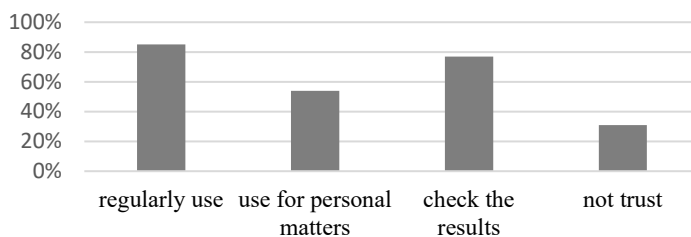


Figure 1. Learners' ChatGPT use

Source: Own work.

When asked about how teaching can change, with artificial intelligence being one of the parts of this change, several interpretations and opinions were transmitted. In general, it was stated that teaching should not block the use of these tools, but rather ally with them, taking to the classes other types of challenges and more complex paradigms allowing learners themselves to explore the tools and compare the results. It is also a general opinion that this type of tools will interfere with the role of the lecturer as it should be readjusted to this new reality, thus allowing learners guided by artificial intelligence, where the program will be defined by lecturers, to have individualised classes and adapted to their real needs, thus raising the quality of teaching where, given the increasing size of the classes, personalisation and individualisation are increasingly smaller.

3. DISCUSSION

3.1 The results

Although several opinions, especially from younger respondents, expressed the hope that through the use of AI, teaching would become more interactive and less “boring”, all the issues addressed in relation to the use of bots such as ChatGPT in teaching should be considered with the utmost care. The results obtained through this study convey that the reality of these new AI tools is still in their initial state, far from perfect. They should not be used for all kinds of problems and that it is important to maintain critical thinking in classrooms and in the field of teaching itself. Its use in the field of teaching should be relativised by the imprecision of the results in situations where one is working with technical and highly complex issues. On the other hand, it has the facility of being a more assertive “search engine”, getting straight to the point without digressing into adverts and advertising associations.

It is assumed that AI can become a great teaching resource especially for its ability to adjust to the needs of learners (emphasising the issue of learners with special needs), where the lecturer has more difficulties in adapting and that other teaching resources simply do not have the same capacity.

It can be concluded that there is still a long way to go in the evolution of this type of system, from its full acceptance to the recognition of its complexity and technicality. This study shows, however, that there is a way to go and an expressed willingness to move towards incorporating all these new technologies into teaching. One of the

points raised has to do with the fact that we must be aware of the dependence on the use of AI tools, which could lead to a decrease in the intelligence of the population, since its misuse could lead to the habit of not thinking, expecting AI to solve all problems autonomously. Therefore, its use in universities should be properly regulated (Aldhaen, 2022) and learners should be properly trained so that it is used responsibly.

3.2 Managing expectations, utopia and reality

As in all of higher education, a decision map on ChatGPT should put stakeholders willing to take full responsibility (legal, moral, etc.) for any inaccuracies (Sabzalieva & Valentini, 2023). The novelty in this study has shown that utopia is related to the majority of learners regularly using ChatGPT, but the reality is that the majority of these learners usually check the results obtained with other sources of information (77% as seen above). Because Generative AI are trained on massive datasets of text from the internet (Gupta, 2023), it is relevant for ChatGPT and related AI systems to curate training datasets through a thoughtful process of deciding what to put in (Bender et al., 2021). For instance, there is a responsibility gap caused by different sources, some technical, other organisational, legal, ethical, and societal (Santoni de Sio & Mecacci, 2021), and ChatGPT could be a bad idea for higher education (Narayanan & Kapoor, 2022). So, AI labs and independent experts should jointly develop and implement a set of shared safety protocols (Future of Life Institute, 2023). However, addressing security risks will require collaboration and cooperation with academia, applying knowledge to a given situation overcoming AI systems, because one important aspect of human intelligence is emotion (Bhise et al., 2022).

The seduction and populism of ChatGPT could be unevaluated of shared reality and reason, because learners are comfortable in adopting new technologies like ChatGPT and “Habit was found to be the best predictor of behavioural intention, followed by performance expectancy and hedonic motivation” (Strzelecki, 2023, p. 1).

Technological utopianism views technology’s impacts as extremely positive (Chaudhry & Kazim, 2022), but learners may not necessarily perceive the introduction of these technologies in a positive way (Rodway & Schepman, 2023). Use cases now need to be defined, creating paths to advancement, and necessary disruptions to teaching, learning and assessment, and administration (Davison, 2020). Until recently, the reality is, even in an unforeseen way AI is in use in several applications, such as with a chatbot, web search, or classification and translation systems (Hutson et al., 2022). The utopia is that some of these applications are not yet developed enough to be fundamental in higher education. For example, authors experienced unexpected quality problems in classroom real-time AI speech translation for Erasmus learners. There is a way for accuracy and care of transparency in AI services.

CONCLUSION

Higher education institutions can actively cultivate a culture that fosters innovation, collaboration, and adaptability, which can positively influence the adoption of ChatGPT and other AI systems. Nevertheless, nothing is more utopian than the idea that higher education institutions could face future liability for an unforeseen use of

AI, or in a dystopian envision that AI could become an all-encompassing force subjugating the learner. Learners appear to be autonomous and dependent on the use of ChatGPT and claim that using this tool makes it easier to get the answers they want. However, an overreliance on AI technology like ChatGPT may lead to a diminished emphasis on human interaction and engagement in higher education. The reality is that these new AI tools are yet in their initial state, far from perfect, as it should be readjusted, thus allowing learners guidance, where the program will be defined by lecturers, to have individualised classes and adapted to their real needs. Out of the darkness of disruption, ensuring a balance between the benefits that AI offers, the need to be properly regulated and learners properly trained, then it would be used responsibly. These limits need to be defined not only at a legislative level, but also at the personal level. Not technological obscurantism, but critical thinking perspectives and audit AI tools to avoid losing the human aspect that is crucial in education.

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AI INFLUENCING E-LEARNING TO OPTIMIZE SKILLS FOR BUSINESS PROCESSES

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Abstract: *Artificial Intelligence (AI) is changing the way things are done, and there is a lot of hidden potential waiting to be discovered. Modern ERP (Enterprise Resource Planning) systems have implemented AI-enabled wizards for better utilization and advanced data analysis. AI creates space for the creativity of IT users, and the interest is in process mapping, detailed analysis of selected business processes, and searching for hidden relationships in data with subsequent interpretation of the results. IT users must have the necessary skills to solve needed activities. It is important that education reflects the current situation, and AI is also influencing learning to support optimal students' skills with information technology. This article focuses on changes in education supporting critical thinking and the ability of group work to learn more about different intelligences (AI, business or customer intelligence) that data is ready for optimal decision-making and the implementation of business processes. Practical work with students took place in the summer semester of the academic year 2022/2023. It involved teaching in groups, implementation of questionnaires in the teaching to find out current knowledge and opinions on the topics discussed with a retrospective evaluation of the benefit achieved in the learning process.*

Keywords: Artificial intelligence; E-Learning; ERP systems; information technology

INTRODUCTION

Artificial intelligence (AI) affects many activities in business processes as well as in education. A close connection is necessary between education and business processes needs. The reasons lie in the need to ensure task optimization and decision-making with sufficient variability and quality. The scope of business processes includes core

processes, support processes, management processes, and business process technology. It is important to have optimal business processes (The Extensive Guide to Business Processes for 2024, 2023) for:

- Clear communication and customer support.
- Identification tasks with links to business objectives.
- Improving their efficiency through the implemented tasks.
- Use available resources responsibility.
- Standardization of implemented processes.

In a global and digitized society, information technology and data have an important role to play in leading to technological transformation (de Mattos et al., 2023). From an information technology perspective, artificial intelligence is just one of several intelligences such as business, customer (Subramaniam, 2019), computational (Somnuk et al., 2017) or competitive (Competitive Intelligence for Business Growth, 2019) and swarm intelligence (Shethna, 2023). Their strength lies in supporting prediction to gain insight into current trends and the future development of monitored metrics. Contact with customers (Evenson, 2017; Dib, 2016) is unique for every business (Roy et al., 2023). It is about loyalty and the ability to continue with offers, services, and purchases (Keenan, 2018; Softclouds, 2018; Miller, 2017). Businesses face a challenging position here because customers are educated. They share their opinions and experiences of services and goods on the Internet, especially on social networks (Dollwet, 2019).

If a businessman wants to have a business solution and implemented processes, optimal knowledge is needed there. Optimal knowledge requires education, specifically long-term education and e-learning (Kuzior et al., 2023). Like other activities, e-learning uses information technology to support education. Again, there is pressure to maintain quality, variability and keep up with current trends that students have:

- More practical experience.
- More communication skills for working in teams.
- Greater variability in problem solving.
- Greater willingness to learn about innovations.

For these purposes, the interpretation with the support of teaching materials and subsequent practical seminars introduces students to the current perspective on the discussed topic, and the practical seminars support their experiences. This article is based on practical experiences from lectures with students during the academic year 2022/2023 for the operating systems course. The research question concerns the usefulness of implemented innovation for both students and teachers. The method is based on a literature review and practical work with students, followed by feedback. Integrated innovation focuses on group work on given topics, such as information technology for start-ups and various intelligences to support business processes. A partial component of the innovation involves conducting surveys to gauge students' current opinions on selected issues, thus fostering their interest in information technology and business processes. For more detailed research, there is a general hypothesis that the educational activities have the necessary potential to support students' curiosity and skills, enabling the appropriate implementation of IT for business processes with flexibility and in line with existing trends.

1. ERP AND IT SUPPORT OF IMPLEMENTED PROCESSES

For a modern company, a high-quality ERP (Enterprise Resource Planning) system is a key element without which the company cannot be managed successfully. Business support requires the development of an ERP system covering essential business processes, from business to production and finance. There is also a crucial need for production solutions and customer contact support. It is not uncommon for orders to consist of thousands of items that must be manufactured and delivered on time. Errors and delays in delivery can result in financial losses, additional costs and a damaged reputation.

ERP systems are divided into about 250 different types of software solutions (Mandziuk, 2023). They are classified according to characteristics such as:

- Cloud systems.
- Custom or hybrid systems.
- Generic or industry-specific systems.
- Systems for small, midsize, or large companies.

The most popular ERP systems (Johnson, 2023) are Sage 100cloud, Acumatica, Oracle ERP Cloud, Epicor Kinetic, SAP S/4HANA, Skubana, Microsoft Dynamics 365, Sage Business Cloud, Oracle NetSuite, SAP Business One, Dolibarr, BrightPearl, DELMIAworks, Odoo, JobBOSS.

2. VARIABILITY IN INTELLIGENCES

ERP systems collect company data, and it is natural that various intelligences are integrated. Well-known is business intelligence (Sharda et al., 2022), which analyzes stored data and creates dashboards to present ways in which data may be easily understood, identifying available opportunities. The current trend is AI (Faggella, 2020; Sentence, 2019; Unemyr & Wass, 2018), which performs and automates tasks that require human intelligence. This information technology is an indispensable part of ERP systems for speeding up various business processes. The integration of various intelligences into ERP systems leads to the evolution and formation of intelligent ERP systems (What is Intelligent ERP?, 2023; Brain Metrix, 2018; Sunnersjö, 2016) using analytical functions, cloud, machine learning (Market Business News, 2022), mobile technologies for real-time analysis, optimal support of decision making, up-to-date overview of the customer experience (Watts, 2018; Williams, 2014).

Another advantage is support of customer relations. ERP systems enable more accurate service, personalized offers and precise communication with customers. It is also about customer loyalty and integrating customer intelligence. In many cases, ERP and CRM systems (Meyers, 2023; The Leading Contact Centre Magazine, 2018; Ropponen, 2017; Kaushik, 2016) are linked by application programming interfaces (APIs). This integration has a necessary effect on the ability to be an excellent ERP system providing data processing and ensuring data accuracy. Well-known benefits of customer intelligence (Kaur, 2023) include improved customer retention, customer satisfaction, detailed customer data collection and analysis, personalized marketing, and knowledge of customer trends and interests. The key is the adoption of imple-

mented technologies that provide improved business processes, leading to greater profits and customer retention. And again, the need for education is emphasized.

3. EDUCATION AND ARTIFICIAL INTELLIGENCE AND IT

Education plays a key role in the optimal use of information technology, offering a wide range of applications and proven methods. In many cases, both IT users and students have difficulties choosing a suitable application with an optimal operating system background and using the full advantages of this information technology. A crucial aspect lies in the methods of implementation that support adaptive learning (Smyrnova-Trybulska et al., 2022) with a profound impact on the European Education Area (Klatt, 2023). Information technologies have an unlimited number of methodologies, methods and tools ranging from the simple to the complex. Some recommendations are integrated into applications and operating systems, but limited knowledge about them causes difficulties.

The operating systems course, as its name suggests, focuses on the structures of operating systems, providing students with the necessary background for handling installed applications. During the academic year 2022/2023, innovations were implemented to support critical thinking, teamwork and the exploration of new capabilities in information technology. Group work was integrated into the seminars, and students were given the opportunity to select two topics for collaborative problem-solving. The first topic centered on the hardware and software requirements for a start-up, while the second explored artificial intelligence and other intelligences that IT users may use. In both cases, students work in groups according to their preferences, with tasks that involved assigning roles within the team, designing solution plans, specifying their IT needs and conducting final evaluations.

From the teacher's point of view, the chosen business for a start-up as the first topic of group work was interesting. Students preferred an e-shop, food imports such as chlebič.cz, invoice processing services or the optimization of B2B SafeWorking business processes. For inspiration, educational materials were prepared that show successful start-ups (Raska, 2022) that create a new companies with business concept and potential for further growth. There were also examples of supported business processes and methods for selection of optimal software (Kodouskova, 2021). Examples of software were linked across different categories (Capterra, 2023) to show variability for:

- Prices (open-source, free, licences, payment by IT user number, amount of processed data, storage space size).
- Characteristics by selected category of software (CRM systems, chatbots, data mining, simulation, accounting, customer services, and many others).
- Support for operating systems (Windows, UNIX/Linux, Mac, Android, iOS, or cloud and server solutions).

The answers to questions about assigned roles in student teams, the perceived difficulty of the tasks, the limitations they encountered, and the uniqueness of their cooperation, as perceived by the students, are shown in Table 1.

Table 1. Answers to questions in individual groups

Question 1 about assigned roles in student teams	
Groups of students	Answers
1	manager, coordinator, speaker, writer and resource finder
2	owner, IT specialist, marketer, and manager
3	individual members had a responsibility about searching, writing and objections
4	individual work because an student does not wish to cooperate in group
5	no roles, students work based on equal rights together on needed activities
Question 2 about the difficulties in solving from the students' point of view	
Groups of students	Answers
1	specification business for start-up
2	communication in team, and searching optimal information
3	optimal composition of needed modules of selected ERP system with support
4	verification that designed plan is correct
5	all was easy, no difficulties
Question 3 about the limits of their work	
Groups of students	Answers
1	knowledge to select optimal application for start-up
2	badget, time and lack knowledge for expertise, regulations
3	time and badget
4	knowledge, time and unknown concepts
5	congestion, solving queries
Question 4 about the uniqueness of cooperation according to the students	
Groups of students	Answers
1	to have ability to implement IT in enterprises
2	precision, speed and loyalty of team members
3	diligence and interest in customer service
4	joint work in a team
5	the best cooperation with smart people

Source: Own work.

The students' final assessment of their satisfaction with the teaching was positive. The rating scale used was "agree", "rather agree", "rather disagree", and "disagree". See Table 2 for details.

Table 2. Student satisfaction with teaching

Evaluation for operating systems course	
Evaluated criteria	Answers
the course was useful	rather agree
the conditions of graduation were clearly defined in the subject	rather agree
the subject was provided with quality teaching materials	agree
the lectures/tutorials were clear	rather agree
the seminars were useful for developing my knowledge and skills	agree

Source: Own work.

The operating systems course has been a longstanding component of the Bachelor’s program in Management Informatics. In 2023, it was included as part of the new accreditation process. A total of 58 students were enrolled in the course. The students’ ages were not available to the teacher, but they were primarily estimated to be around 20 years old. The survey was conducted from April 24, 2023 to August 31, 2023, with response rates varying from approximately 10% to 30%.

Innovations in education aim to support curiosity about information technology and the ability to search for optimal solutions. It is also an opportunity to explore one’s own communication and argumentation skills with colleagues (other students). Accessing information from the internet is relatively easy, but the difficulty is the ability to think critically and apply it in a manner that aligns with multiple intelligences in the classroom (Armstrong, 2017). Innovative methods in education encompass various approaches, (Tran, 2023) such as:

- Case study solutions.
- Defense of the project.
- Group work.
- Professional essay.
- Research.
- Role playing.

The expected skills in this operating systems course encompass analysis, application, evaluation, memorization and understanding. The course included group work where students worked on assigned topics and then presented the solutions they had developed. Assessment concerned group performance rather than individual contributions, with groups formed randomly. From the teacher’s point of view, highly valued skills included the ability to research, categorize and articulate information, justify the adopted solution and effectively express ideas in one’s own words.

Additionally, the ChatGPT (Svitlyk, 2023) played a role in generating interest. Students were intrigued by its potential for crafting optimal questions to obtain relevant answers on specific topics. Some students used this application and gained experience in asking questions related to choosing operating systems according to specified needs and preferences, identifying the most suitable operating system according to required functionalities, and inquiring about well-known applications. The results were expected and ranked based on criteria such as compatibility, cost, functionality, personal preferences, security, support and user interface.

CONCLUSION

This article focuses on the significance of education in the context of business processes, particularly in understanding the optimal IT support provided by ERP systems. There are many solutions and a good orientation is needed. Current trends are leading to the integration of intelligences, such as artificial intelligence and business intelligence, resulting in the development of intelligent ERP systems. From the point of view of education, the focus shifts towards fostering critical thinking and the ability to research, categorize and articulate, justify accepted solutions and express oneself effectively in one's own words. It necessitates working in groups and precise communication using different roles. Additionally, AI also has an impact on education in optimizing skills for business processes. There is enough information, but the challenge lies in effectively working with it. For this purpose, an innovation in the form of group work was implemented during the seminars of the selected course. This approach also aimed to explore different intelligences, allowing students to investigate the various ways they can be implemented in IT. Particular interest was shown in ChatGPT, which served as a valuable source of information. The achieved benefit is that students had a positive impression of this form of work and the majority evaluating it as "agree" or "rather agree".

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EXPERIENCE OF INVOLVING FUTURE IT PROFESSIONALS IN THE DEVELOPMENT OF LEARNING TOOLS AS AN ELEMENT OF DIGITAL TRANSFORMATION OF EDUCATION

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Abstract: *The development of digital educational resources is currently the primary task of IT specialists, which, in turn, is a component of the digital transformation of education in general. Since the digital transformation of education consists of the development of significantly new electronic resources for educational purposes, we have considered specific examples of the development of digital educational resources by students and analyzed their feasibility of development and use within the framework of the digital transformation of education. The article also shows how the involvement of students of IT majors in the development of such digital educational resources contributes to the improvement of their professional and linguistic competencies. At the same time, students reflect exactly their vision of learning a foreign language with the help of such tools, and all this contributes to the digital transformation of higher education.*

Keywords: digital transformation of education, IT specialists, e-learning tools

INTRODUCTION

Under the conditions of war, the digital transformation of education has acquired particular importance (Kovalchuk, 2023, Glazunova 2023; Ryabko, 2023). In particular, the pandemic caused by COVID-19 was an essential condition for the digital transformation of education (Sych, 2021; Ovcharuck, 2022). However, the challenges facing the educational process in Ukraine's higher education institutions today are entirely different than they were a year ago. The full-scale Russian invasion of Ukraine showed that the educational process is simply impossible without the digital transformation of the educational process. Thus, a significant role is played by developing new digital educational resources that can be used in the educational process of institutions of different levels (from kindergartens (Trubavina, 2021) to universities (Budinskii, 2021)).

Moreover, English has become an integral part of our life, recognized as an international language, and some of its words are also found in everyday life (Lemeshchenko-Lagoda, 2020). Furthermore, international scientific cooperation and the current development of digital technologies necessitate the creation of various digital educational resources, including educational resources for learning a foreign language and electronic multilingual explanatory dictionaries.

The demand for electronic multilingual explanatory dictionaries is due not only to the need to objectify research, optimize and rationalize the professional work of a specialist but also to the growing demand of an ordinary user for adapted objective, reliable information of a linguistic nature in the form of such dictionaries. Furthermore, creating simple and easy-to-configure dictionaries will provide access to an array of factual material, which will help optimize the work of specialists in various specialties. Moreover, the need to develop digital educational resources for learning a foreign language will help improve the linguistic competence of participants in the educational process. At the same time, the development of such resources will become an integral part of the digital transformation of the educational process.

Involving students of IT specialties in developing digital educational resources will help improve their professional and linguistic competencies. Moreover, students will reflect on their vision of learning a foreign language using such means. Therefore, it contributes to the digital transformation of higher education since the digital transformation of education hinges on the development of significantly new electronic resources for educational purposes.

1. THEORETICAL BACKGROUND

An increasing number of scientists are exploring various aspects of the digital transformation of society in general and education in particular. For example, Mitra and Banerjee (Mitra, 2023) tried to show that learning programs based on artificial intelligence for learning English are successful. Furthermore, the authors argue that AI-based strategies should help teachers interact with English teaching more fun. Takamatsu et al. (2023) proposed a new concept of digital transformation of education, also institutional research, and ICT based on Eduinformatics. The authors

clarify that Edinformatics is a field that combines computer science and education. Scientists cited the experience of a Japanese university based on Edinformatics. Cabrera et al. (2023) described the experience of applying the transformational model of school digital sustainability to develop the professional identity of a teacher, and experimentally confirmed the feasibility of such an application. Del Castillo Castro et al. (2023) conducted an experimental study on the application of a new digital transformation model for learning strategies in Education 4.0, successfully demonstrating its feasibility.

Msila (2022) explored the issue of digital transformation in African universities, highlighting strategies for effective digital transformation. The author interviewed university leaders, concluding that the digital transformation of higher education is not possible without collective decision-making and depends on employees' skills in the digital technologies field. Hoang et al. (Hoang, 2022) conducted an experimental study to determine the digital level of teachers in universities of education in Vietnam as a result of which they found that digital competency of teachers in middle-level teacher training schools in Vietnam. At the same time, they also found that competence depends on the level of awareness of digital opportunities, scientific degrees, and gender. D'Ambra et al. (2022) considered another aspect of digital transformation, namely the use of electronic textbooks in Australian higher schools, through the prism of accessibility theory. As a result, scientists concluded that when using digital textbooks, some parameters should be considered (accessibility, copying, portability, selection and viewing etc.).

Jain et al. (2022) conducted a pilot study at universities in India on the effectiveness of collaborative learning exchange during the COVID-19 pandemic using digital tools and technologies. Trujillo Valdiviezo et al. (2022) studied the problem of digital transformation in Latin America, leading to the conclusion that digital transformation occurred in the following areas: education, companies, and people. Hofstetter et al. (2022) explored the problem of digital transformation due to the creation of one's own or the use of a federal framework training program, with the latter having only a minor impact on the acquisition of digital competencies.

The article aims to describe the experience of involving future IT specialists in developing learning tools as an element of the digital transformation of education.

2. METHODOLOGY

This study used empirical methods such as discussion and micro-interviews (a type of survey), as well as a pedagogical experiment that was analyzed using Pearson's criterion. The micro survey included a series of questions to determine the significance of the process of developing digital resources for students themselves. The discussion was used to determine what students wanted to see the developed tools do in the future and whether they were convenient for them to use in the educational process as a finished product. A total of first-year students from the 2021–2022 academic year, enrolled in 121 specialties within the field of Software Engineering participated in the study.

The study's hypothesis was based on the fact that the creation of electronic educational resources by students for further use in the educational process will contribute to the development of their professional competencies.

3. RESULTS

In their professional training, future IT specialists annually carry out various course projects. At the end of the training, they perform qualifying work and participate in the implementation of collective projects within the scope of individual disciplines. In particular, during the training, students can develop digital educational resources while working on course projects, completing qualification papers, and other types of work.

Notably, during the 2021–2022 academic year, students specializing in IT fields at Zhytomyr Polytechnic (Ukraine) develop such digital educational resources, including those designed for learning foreign languages:

1. A web-oriented system of teaching a foreign language.
2. A web-based dynamic testing system using fuzzy logic to assess the level of knowledge.
3. An application designed for foreign language learning and analytical knowledge control.
4. An information and reference application assisting in the learning of English words.
5. A mobile application designed for foreign language learning.
6. A mobile application designed for teaching mathematics to elementary school students.
9. The development of the program “Construction of graphs of functions”.
11. The development of an explanatory multilingual dictionary.
12. The development of a simulator program “Computer equipment”.
13. An English language learning app.

It is important to note that the list above is not exhaustive. The authors chose only those examples that they considered relevant precisely in the framework of the digital transformation of education. In the following sections we will consider specific examples of students' development of digital educational resources and analyze the feasibility of developing and using these resources within the framework of digital transformation of education.

To illustrate, first-year students specializing in “121 Software Engineering”, as part of their coursework in “Object-oriented programming”, developed applications for foreign language learning.

Let's consider the possibilities of the “English Learning” application (see Figure 1). Upon launching the application, the user can see the main tab, which displays all available topics (categories) for study, navigation buttons, and a search bar for searching word sets by name. When you click on one of the topics, the application displays the words available in this topic and a search string for locating specific words. In addition, new buttons appear for interacting with words and topics (see Figure 2).

Within this interface, the user can learn words and their translation within the selected subject area.

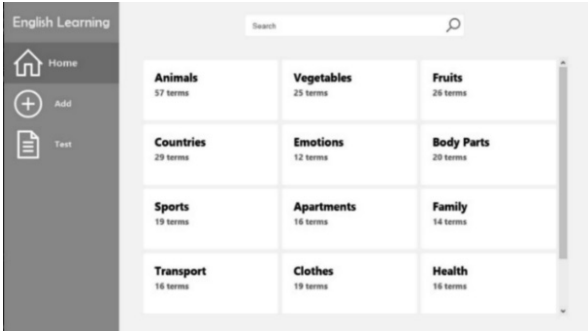


Figure 1. The main tab of the application “English Learning”
Source: Own work.

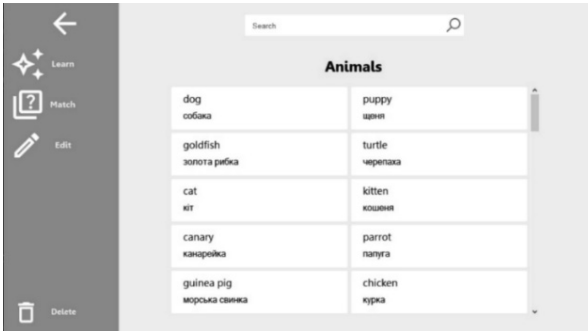


Figure 2. Display a set of words
Source: Own work.

When you click on the “Learn” button, the user’s attention is directed towards a test for learning words. In this case, one should choose the correct translation of the specified word from four available options. If the answer is correct, the next question is displayed. If not, a message with the correct answer is displayed first (see Figure 3). The “Match” button opens a game where the user needs to pair words in Ukrainian and their corresponding English translations. The game begins when the user presses the “Start” button. It’s important to note that this game is timed. In this activity, the user must select word pairs that match in both Ukrainian and English (see Figure 4). If the pair is chosen correctly, both words disappear from the screen. Upon completing the task of the game, the user will receive a feedback on the time taken to complete it.

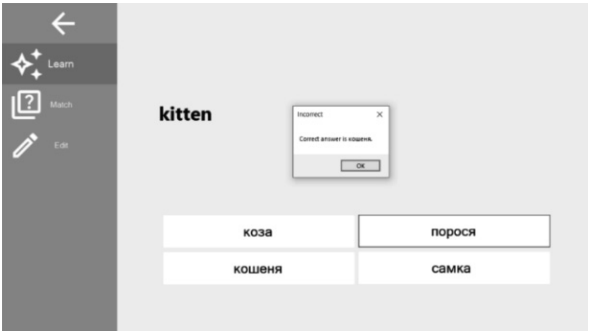


Figure 3. Notification displaying the correct answer when the selected word does not match its corresponding translation
Source: Own work.

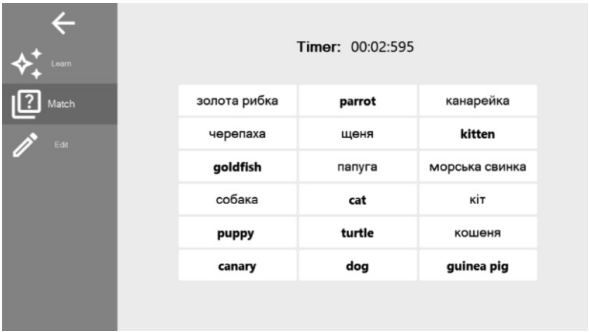


Figure 4. Display all words at the beginning of the game
Source: Own work.

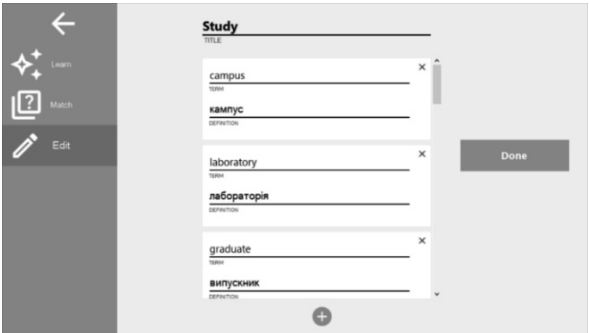


Figure 5. Word editing form
Source: Own work.

Using the “Edit” button, the user can edit and delete words and edit the set’s name, while pressing the “Done” button will save the changes to the database (see Figure 5). In addition, the user can delete a specific topic by entering it, clicking on the “Delete” button, and confirming the action (see Figure 6).

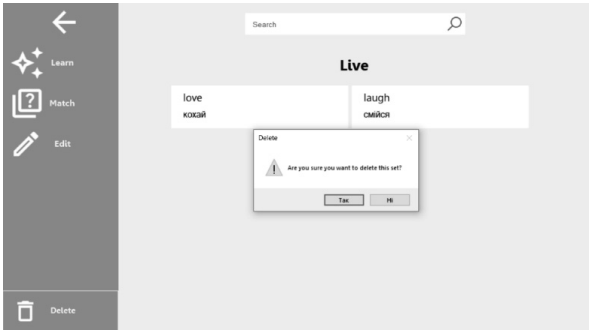


Figure 6. Proof of removal of the topic

Source: Own work.

Among the options not initially visible in the main window, two additional buttons are available: “Add” and “Test”. The first one opens a form for creating a new set of words, where you need to enter the desired name and a few words and click the “Done” button (see Figure 7). The second button, “Test”, allows users to take a test on the selected topic and with a certain number of questions in the test (see Figure 8). The test implies the user has already learned the words associated with the selected topic, and offers questions in one of three possible forms: choosing one correct answer out of four, entering the translation of the word, or matching two words with True / False responses. Upon completing the final question, users will receive a results window (see Figure 9) displaying their.



Figure 7. Form for creating a new topic

Source: Own work.



Figure 8. Selecting topics for testing and the number of questions
Source: Own work.



Figure 9. Display of test results
Source: Own work.

Exploring the functionalities of another application “Electronic multilingual terminological dictionary”, its main screen displays all available topics (sections), a search bar for searching a topic by title, a drop-down list for selecting the order in which topics are published, and a button for adding new topics (see Figure 10).

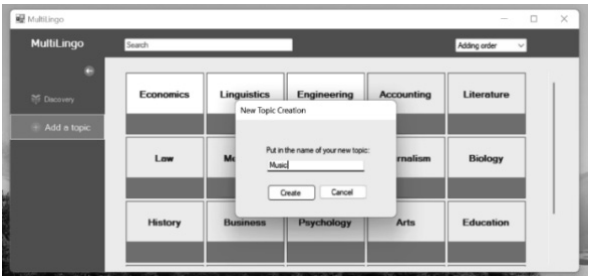


Figure 10. Creating a new topic
Source: Own work.

When selecting one of the topics, the terms related to the selected topic and a search bar for searching for a single word are displayed. There are also new buttons available for interacting with words and a top panel with a search bar and language selection option. Users can also add a new term, delete a topic, and return to the original window using the “Back” button (see Figure 11).

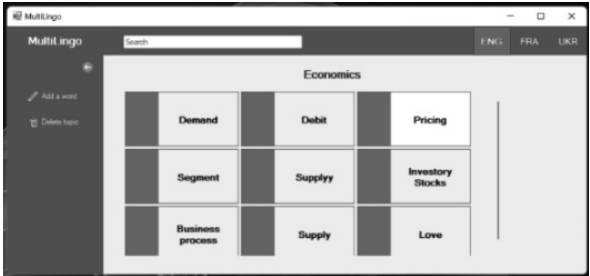


Figure 11. Viewing words on the topic in English

Source: Own work.

Clicking on a specific term enables users to access its definition. In this view, several buttons are present: one for editing the term, another for deleting it, and one for marking the term as a favorite (see Figure 12). The user can review all their selected terms in a separate window (see Figure 13).

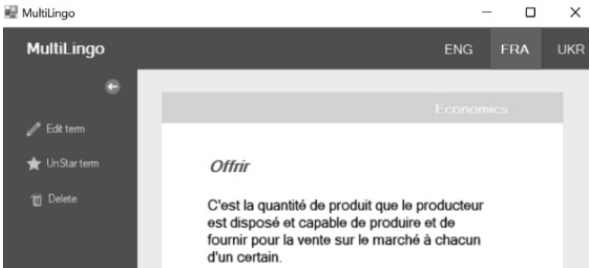


Figure 12. Viewing your favorite term in French

Source: Own work.

In the event a user selects a term for editing from the drop-down list, the “Create Term” button becomes inactive. If the user leaves one of the “New Term” or “New Definition” fields empty during editing, the corresponding field in the definition being edited will remain unchanged. However, if both fields are left empty, a prompt will appear, requesting the user to enter data to continue the operation (see Figure 14). Upon creating a new term, the drop-down list is updated to include the newly created term, which is automatically selected. Users have the option to complete the term in other languages. It’s worth noting that the dictionary is organized into three languages: French, English, and Ukrainian.



Figure 13. Viewing the favorite terms section

Source: Own work.

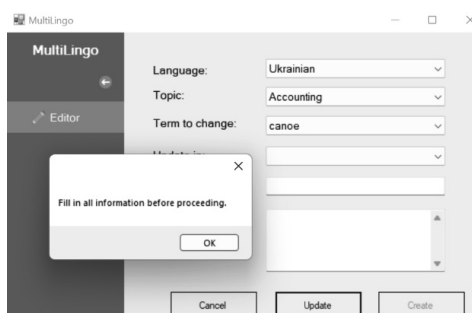


Figure 14. Notice the need to enter test information before continuing with editing

Source: Own work.

It should be noted that, in both cases, all data is stored in an external database, even though first-year students have not yet studied database concepts as part of their training. That is, the development of such projects contributes to the organization of their working time to get acquainted with new material, interest in new knowledge and skills, improve programming skills and databases, that is, the development of their professional competencies as IT specialists.

Also, the availability of ready-made digital educational resources allows for their use in the educational process to form the linguistic competence of not only future IT specialists but also, for example, applied linguists.

In particular, the first English Learning tool was used to teach English to future IT professionals to improve their language skills. The second tool “Electronic multi-lingual terminological dictionary” was used in teaching English to future applied linguists to improve their digital and linguistic competence. In both cases, the tools were offered to students for discussion as experts, indicating their preferences and comfort levels with using them.

Thus, students noted that in the first application they would like to see additional language options beyond just English, and in the second case, they would like to see more than three languages. It, of course, is not critical and can be improved in further modification of the proposed applications. Furthermore, since all data is stored in the database, there are no problems with adding fields or tables.

4. DISCUSSION

To assess the practicality of developing and using digital educational resources, micro-interviews were conducted with students. These interviews aimed to understand what benefits students derived from creating such resources and why they selected specific topics and functionalities.

As a result, it was found that the primary motivation behind developing such tools was the convenience they offered, particularly the ability for the user to create and categorize words into collections/topics. This organizational structure allowed users to concentrate on specific words and subjects. Furthermore, when developing such tools, one should pay attention to the fact that the words in the game are better remembered, which makes it possible to memorize better and practice already learned words. Moreover, when developing such applications, one should consider the possibility of choosing a topic for testing knowledge in the form of tests or other forms. As for the second application, within the framework of the research work “Creation of an electronic multilingual terminological dictionary”, this tool was immediately tested and compared with other prototypes (Vakaliuk, 2020).

To confirm or refute the hypothesis, a pedagogical experiment was conducted to measure the state of formation of professional competencies of future IT specialists in the control and experimental groups, which showed that there was an increase in the number of students in the EG compared to the number of students in the CG with a high and sufficient level. It is worth noting that students in the EG participated in the development of e-learning resources and their use in the educational process, while in the CG – only in their use. Considering this data, it was concluded that the development and use of digital learning tools had a significant positive impact on the increase in the percentage of students in the experimental group.

To substantiate the conclusions about the effectiveness of the forms of the pedagogical experiment, the data obtained were statistically processed using Pearson's χ^2 criterion, which resulted in the conclusion that the samples have statistically significant differences, i.e., the experimental methodological system is more pedagogically appropriate than the traditional one. Thus, the pedagogical experiment has confirmed that the development and use of digital educational resources are effective for the formation of professional competencies of future IT specialists.

CONCLUSION

The development of digital educational resources is currently a top priority for IT specialists, which, in turn, is a fundamental component of the digital transformation of education in general. The search, development, and use of digital educational resources are complex and require further study. Nevertheless, all these stages contribute to the development of professional and linguistic competencies of future IT specialists and their self-development, which is necessary for their future professional activities.

The prospects for further research endeavors should include comparing the developed tools by students of different courses for the correlation and dynamics of developing their professional competencies.

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STUDENTS' SCIENTIFIC WORK IN CONDITIONS OF E-LEARNING: REFLECTION OF UNIVERSITY STUDENTS

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Abstract: *Considering the challenges of the present, contemporary universities pay significant attention to providing an effective electronic environment. Such an environment creates all the necessary conditions for multifaceted students' activities, with a predominant emphasis on scientific activities. It is precisely this factor that defines the relevance of the researched issue. The objective of the scientific search was to facilitate the implementation of reflective practices by undergraduate students and graduates in order to determine the key indicators of their scientific work throughout their e-learning experience. The following research methods were used: analysis, synthesis, specification, systematization, and generalization of scientific data regarding the specifics of students' scientific work during e-learning; analysis of the reflection papers written by the university students titled: "My Scientific Work During University Years: What It Was Like"; mathematical calculations of the results. Therefore, scientific work conducted under conditions of e-learning revealed a range of indicators (15 items in total) in students' self-analysis, including 12 positive indicators and 3 negative ones. The specified indicators should be considered in the organization of various forms of scientific students' work in the university educational environment. The prospects for further research are seen in the clarification of the influence of online form of education on the students' independent work.*

Keywords: students' scientific work; the electronic environment of a modern university; E-learning, students' reflection; indicators of scientific students' work during online education

INTRODUCTION

Modern transformation processes taking place in the higher education system of Ukraine are aimed at ensuring the improvement of professional training for future specialists. Primarily, these processes are intended to make them competitive in the labour market not only within the country but also in the European Union countries, as stated in the “EDUCATION 4.0: Ukrainian sunrise” program (2022). The program “EDUCATION 4.0: Ukrainian Sunrise” (2022) outlines the need for the application of new learning technologies aimed at developing technological skills among university students. According to the program, the priority is the digital transformation of education and science, which involves the development of a digital educational infrastructure that provides the area of the free Internet, access to content without restrictions, the development of a digital space in educational institutions with the use of modern digital tools (cloud library, electronic textbooks, online educational process, etc.) (EDUCATION 4.0: Ukrainian sunrise, 2022).

Considering the challenges characteristic of today’s realities, the university education system in different countries has accumulated experience in organizing student’s education in both traditional and modern forms. These include e-learning (Al Rawashdeh et al., 2021; Nikou & Maslov, 2021; Wagiran et al., 2022; Wickramanayaker, Hewaarachchi, & Brown, 2021), also known online learning (Dumford & Miller, 2018; Hamdan & Amorri, 2022; Stoian et al., 2022; Yang & Cornelius, 2004). *Since the definitions of these terms are identical – acquiring education using information technology and the internet – they will be used interchangeably and synonymously in our research* (thus, we consider *e-learning* and *online learning* as equivalent notions in the paper).

The organization of the educational process in higher education is a multifaceted phenomenon as it encompasses various components such as academic work, research work, students’ internship, etc. Scientists Castro-Rodríguez (2022), Ferrero (2020) and Van Eeden, Eloff, & Dippenaar (2021) single out the scientific work of students as a priority, because it contributes to the development of students’ critical thinking, ability to produce creative ideas, and search for non-standard solutions. In fact, this is what distinguishes the personality of a modern competitive specialist.

Any changes, including in the form of education at universities, have corresponding consequences. Therefore, determining the influence of e-learning on students’ implementation of scientific work tasks has become a pressing problem. The experts in assessing the quality of getting educational services are the students themselves (Moroz et al., 2018), so it is important to consider their positions to improve the quality of higher education.

Based on the above-mentioned relevance of the topic and its scientific argumentation, the **purpose of the study** was to organize a reflection (as a method of self-analysis) among undergraduate students (specialty 012 Preschool Education) from two Ukrainian universities. This reflection aimed to determine the primary indicators (both positive and negative) carrying out scientific work during e-learning.

The following **main research questions** have been identified:

1. determination of the theoretical foundation of the essence of students' research work in the context of E-learning;
2. determination of approximate components of students' scientific work in the context of E-learning;
3. analysis and presentation of the results of the students' reflection on the features of their scientific work, which took place during online studying (during quarantine restrictions related to COVID-19 and martial law in Ukraine – from February 24, 2022).

Research Hypothesis: student research conducted under the conditions of university e-learning may achieve qualitative results. While not aiming to ascertain the effectiveness of using a range of all electronic means and resources it is important to diagnose the actual state from the perspective of students' self-analysis as consumers of educational services.

1. THEORETICAL BASIS OF THE ESSENCE OF STUDENTS' SCIENTIFIC WORK IN THE CONTEXT OF E-LEARNING

Modern Ukrainian scientists (Karimov et al., 2022; Moroz et al., 2018; Morze, Kuzminska, & Liakh, 2017) increasingly emphasize the necessity to improve the quality of future specialists' professional training within the university educational system, which requires the study and scientific reevaluation of various forms of student education organization, particularly in the online format. Given the ongoing transformation of higher education in Ukraine, aligning with European standards, there is a significant focus on enhancing students' scientific work (Lokhvytska, 2023) and understanding various aspects of the educational process.

In global scientific research and practice (Hamdan & Amorri, 2022; Liu, 2019; Nikou & Maslov, 2021; Stoian et al., 2022; Wagiran et al., 2022; Wickramanayaker, Hewaarachchi, & Brown, 2021), significant advancements of e-learning in universities have been extensively presented. The organization of E-learning has been strengthened due to the implementation of quarantine measures in many countries. It has been proven that online learning contributes to broadening awareness regarding the application of information and communication technologies. It also develops skills in solving non-standard problems and tasks, which, in turn, enhances professionally significant qualities among students to achieve their set goals (Aesaert & van Braak, 2018; Morze, Kuzminska, & Liakh, 2017; Yang & Cornelius, 2004).

Several research studies (Dumpit & Fernandez, 2017; Fernández-Márquez, Leiva-Olivencia, & López-Meneses, 2017; Karimov et al., 2022; Wagiran et al., 2022) have explored the impact of e-learning on the development of students' motivation and volitional efforts in acquiring relevant knowledge. These studies highlight the stimulation of intensive independent search and choice of information sources from different resources, the activation of cognitive activity in solving tasks related to the study of subjects using computer technology, and the acquisition of computer thinking skills. This can be interpreted as the development of a holistic set of personal qualities in students. Researchers Dumford & Miller (2018) noted that online

courses develop analytical thinking and a desire to learn more by discovering new Internet resources that present scientific material in an appropriate way. Additionally, according to Al Rawashdeh et al. (2021), e-learning increases the possibility of communication among all participants of the educational process, enhancing their mobility and efficiency in activities.

Castro-Rodríguez (2022) and Ferrero (2020) emphasise the importance of creating a research environment in universities, where students have the opportunity to experiment with their scientific ideas. This process not only contributes to their professional development but also promotes personal growth and development. They demonstrate independence, perseverance, creativity, and responsibility in their scientific inquiry. They engage in interactions with others, discussing their own research projects, which directly impacts their development as professionals (Nurpratiwi, Amaliyah, & Romli, 2022; Wickramanayaker, Hewaarachchi, & Brown, 2021). The implementation of research tasks that occur online facilitates the development of students' ability to navigate the information space, get relevant information, and operate it effectively. It stimulates their personal interests and needs, aligning with the demands of a modern high-tech society (Becher, 2022; Bellei & Munoz, 2021; Van Eeden, Eloff, & Dippenaar, 2021).

Thus, students' scientific work in the context of e-learning is characterized by enhanced attributes such as *informativeness*, *individuality*, and *activity*. These attributes will be considered as components for conducting empirical research. However, in the presented scientific studies there are no results regarding the characteristics of the strengths and weaknesses of e-learning from the students' point of view, which will be carried out on the basis of their self-analysis.

2. METHODS OF THE RESEARCH

A set of methods was used to conduct the presented research. In particular, to determine the theoretical foundations of the essence of students' scientific work in the conditions of e-learning and to clarify the peculiarities of organizing students' scientific work in the environment of a modern university, a theoretical review of thematic sources was conducted, including their analysis and synthesis, specification and systematization for the identified scientific provisions. While analysing the students' works: "My scientific work in the university years: what it was like" quantitative and qualitative analysis of the obtained results and their mathematical analysis were implemented. To summarize the primary research findings and draw conclusions, we applied the method of generalization.

During the empirical research, we employed the reflection method, which was presented to the respondents in the form of composing a reflection paper. The foundations for applying the reflection method were based on the scholarly ideas of Chang (2019), Liu (2019), and Nurpratiwi, Amaliyah, & Romli (2022). These researchers (Chang, 2019; Nurpratiwi, Amaliyah, & Romli, 2022) identified reflection as a valuable approach during online learning and team collaboration (as evidenced by our study, particularly when performing tasks related to scientific work within a group setting). Written reflection allows an individual to gain insights into their own activi-

ties, self-awareness, and draw relevant conclusions (Liu, 2019). Self-analysis through reflection is one of the most accessible and universal methods for individuals to conduct self-assessment, evaluate their own achievements, and recognize their own shortcomings (Chang 2019). Thus, reflection as a self-report promotes awareness of the problem and stimulates the search for ways to solve it, activating personal capabilities (Nurpratiwi, Amaliyah, & Romli, 2022).

In line with our scientific position, we believe that reflection, as a method for collecting research data, will be effective. Self-analysis conducted in this manner, without external pressure, but in a free form, offers respondents a wide range of opportunities to objectively assess the real state of education during e-learning. This enables them to identify both positive and negative indicators related to the implementation of students' scientific work tasks.

Based on the systematization and generalization of the scientific provisions presented in the Chapter "Theoretical foundations of the essence of the scientific work of students in the conditions of e-learning", students received a brief instruction on the description of self-analysis in the work "My scientific work during my university years: what it was like". This was done in order to direct their reflection towards highlighting how the informational-cognitive support was provided (*the informational component*) and whether it contributed to satisfying personal needs, interests, aspirations, and motivation for seeking scientific truth (*the personal component*), as well as whether it was possible to fully accomplish the assigned tasks of scientific work online (*the activity-based component*).

3. RESEARCH RESULTS: ANALYSIS OF THE STUDENTS' REFLECTION "MY SCIENTIFIC WORK DURING THE UNIVERSITY YEARS: WHAT IT WAS LIKE"

The research was conducted at the end of the 2022-2023 academic year (from April to – June 2023) in the graduating departments of two Ukrainian universities – Psychology and Pedagogy of Preschool Education at Hryhorii Skovoroda University in Pereiaslav and Preschool Education at Bohdan Khmelnytsky National University of Cherkasy. A total of 137 fourth-year graduate students (both full-time and part-time) obtaining a Bachelor's degree in the field of 012 Preschool Education participated in it. Since both higher educational institutions are state establishments, the organization of the educational process is identical.

The purpose of applying reflection in conducting an empirical study was to gain insights into students' understanding and definition of positive and negative aspects of online learning during their engagement in scientific work tasks. The scientific work of the students covered the following types: mastering the educational component "Basics of Scientific Research"; preparation of term papers, scientific projects; participation in scientific workshops, creative problem groups, various scientific events (seminars/webinars, conferences, round tables, symposia, etc.), student Olympiads, competitions of student scientific works of various levels, etc. Undergraduate students who graduated in the 2022-2023 academic year had different forms of educa-

tion (offline, online and mixed) during their studies at the university. They entered universities in September 2019, and in March 2020, due to the COVID-19 epidemic, quarantine restrictions were introduced, which led to the transition to online education. The situation became even more complicated with the beginning of the full-scale invasion of Russia on the territory of Ukraine from February 24, 2022, when the shelters had not yet been properly prepared and equipped. These factors led to the fact that students in these years of study gained as much experience as possible in getting education in the online format.

For the research, the method of reflection was used by the preparation of the students' reflection papers: "My scientific work during the university years: what was it like". At the beginning of the experiment, students were given the following instructions: *"Do a self-analysis of what your scientific work was like during your studies at the university. Indicate your own achievements and gaps regarding the informational, personal and activity-based components of the scientific work carried out. Outline the positive and negative aspects of the online format of obtaining an education in relation to the students' scientific work"*.

All respondents' reflections were prepared anonymously to conduct an objective analysis of the results.

Analysing the content of students' reflection papers allowed us to make the following generalizations: it revealed the key characteristics of the scientific work conducted during online learning – in terms of *information* – the ability to find and analyse scientific sources, the desire to be aware of modern scientific problems, the desire for scientific research through study of new scientific developments; regarding the *personal* – the ability to conduct scientific research, the desire to increase the level of one's own scientific activity and positioning oneself as a scientist at various events; in terms of *activity-based* – the ability to independently conduct scientific research on the psychological and pedagogical problems of teaching preschool children, the readiness of future specialists to apply the results of scientific research in practical pedagogical activities, the activation of one's own scientific potential through participation in various types of scientific activity.

The calculations presented, conducted during both quantitative and qualitative analysis of the students' works, are visually represented in Figure 1 and Figure 2. In particular, Table 1 presents a list of positive indicators of students' scientific work conducted in an online format.

As can be seen from the quantitative indicators presented in Figure 1, the largest number of respondents indicated that they received thorough professional training during the study, which took place in an online format, 86.86% (n=119). Example: *"I was able to constantly be in learning mode in order to gain enough knowledge in the electronic environment of the university. I think that I am ready to fulfil my professional duties to the full extent and will even be able to immediately choose a topic for my own scientific and experimental work at the workplace"*.

The scientific orientation of the educational process was noted by 78.83% (n=108) of students, whose papers include the following arguments: *"I feel that my knowledge gained during the training on how to organize scientific work gave me the basic level necessary for their practical implementation"*.

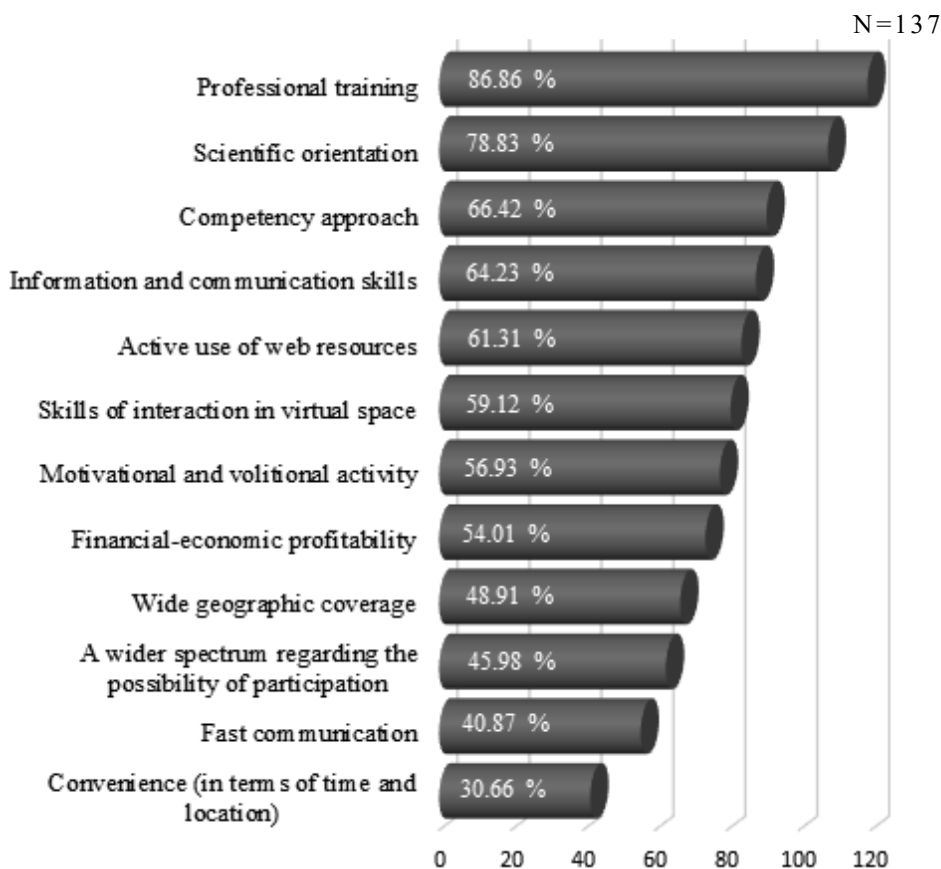


Figure 1. The list of positive indicators of students' scientific work conducted in online format (according to the results of the students' reflection)

Source: Own work.

66.42% (n=91) of the respondents pointed out that the e-learning provided a competency-based approach, who noted that they *“feel fully prepared for independent professional activity, because during the implementation of practical tasks of scientific work, they carried out analytical and synthetic research, with “explained the essence of a scientific problem, engaged in its evaluation and learned to find solutions”*.

As a positive thing, the students noted that information and communication skills are developed during e-learning. Such a respond was recorded by 64.23% (n=88) of respondents, who emphasized that *“they mastered the skills of using various gadgets, learned to quickly find information on various Internet sites, especially the resources of e-libraries were useful”*.

61.31% (n=84) of students indicated their activity in using web resources. In particular, they noted: *“Many times I had to use Google to search for the right scientific event – a webinar or a conference, so that it corresponds to my topic and it would be possible to present the results obtained during the research”*.

Scientific work of students in the conditions of e-learning contributed to the development of their interaction skills in the virtual space. 59.12% (n=81) of respondents mentioned this as positive indicator in their works. For example: *"I was a little scared at first, but later, thanks to the acquired knowledge, I started communicating in Internet groups that were dealing with the same scientific issue as me. We started to exchange ideas, shared opinions on how to organize such a thematic study in an appropriate way"*.

During online training, positive indicators were recorded regarding such an indicator as the motivational and volitional activity of students during the performance of scientific work tasks. In particular, it was 56.93% (n=78). The following expressions of reflection are present in the works of the respondents: *"It seems to me that when we studied online, we were just obliged to complete all the tasks on the "Fundamentals of Psychological and Pedagogical Research", because there were all the conditions for this, despite frequent air-raid signals. I would be ashamed not to complete the task, because there is more time to prepare on the distance, you just have to not be lazy"*.

In the process of analysing the students' reflection papers, the financial and economic benefit of online participation in scientific events was singled out as a claim. This was noted by 54.01% (n=74) of respondents. For example: *"Internet conferences are cheaper, we use them to test our scientific works and do not spend money on public transport and paying for accommodation and meals. Participation in scientific events held online is a budget option, where you can prove yourself as a novice scientist"*. Similar to the indicator mentioned above, there is also a mention of a wide geographical area, which was indicated by 48.91% (n=67) of students. In their reflection works, there are the following considerations: *"If I speak English well, I can take part in Internet conferences that interest me in their topic, which are held in any country, of course, except for the aggressor's country and those that support it. In the online format, I took part in the International Competition of Scientific Papers, and if it was held only in face-to-face format, I would not have been able to go to"*.

The indicator, which was pointed out by 45.98% (n=63) of students is unanimous – it is a wider spectrum regarding the possibility of participation in scientific work conducted online. In particular, the following considerations were expressed: *"I will improve my skills in delivering a scientific report precisely through participation in a remote form, because I am not as afraid as doing it live in the public. In order to improve my professional level, I plan to participate in seminars and conferences, which will be held online"*.

Another positive aspect mentioned in the students' reflection papers is the specified and operational connection in the scientific work organized during online education. This was noted by 40.87% of the respondents (n=56). Some students argued: *"We had electronic educational and methodical materials, multi-access to them was provided. Interactivity was constantly maintained, online communication took place thanks to social networks, when it was not possible to communicate in person, we kept in touch through Viber, Telegram"*.

Convenience (time and place of stay) was called the final positive indicator in the presented list, submitted from the largest number of choices. It was chosen by 30.66%

(n=42) of the analysed students' reflection papers. In particular, these students expressed the following opinions: *"Modern realities require us to be mobile, and conducting online scientific events provides such an opportunity. It is very convenient when you join a webinar or conference from any location. You don't need to spend extra time commuting, turn on the computer and you can take part in the discussion of the scientific problem you are investigating"*.

However, in addition to the positive aspects of scientific work, which took place in the conditions of e-learning, students also noted some negative aspects. Figure 2 presents a list of these negative indicators related to students' scientific work conducted in an online format based on the results of the students' reflection.

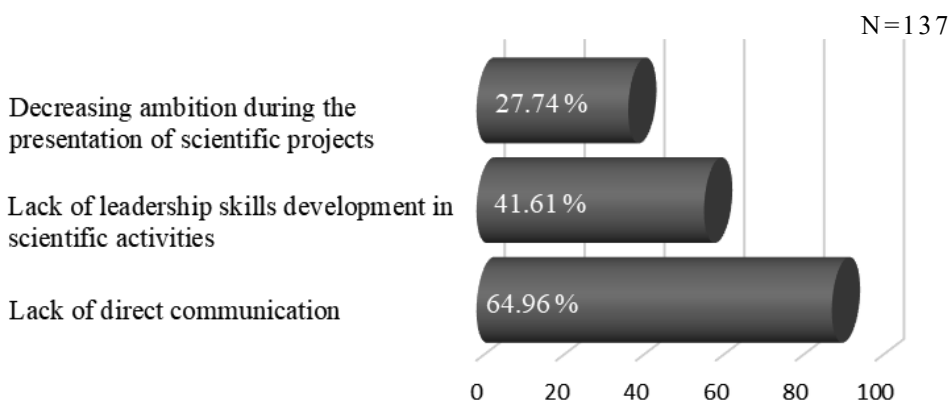


Figure 2. The list of negative indicators of students' scientific work conducted in online format (according to the results of the students' reflection)

Source: Own work.

Among the weak points, as shown in Figure 2, graduate students noted a decrease in ambition during the presentation of scientific projects, which was recorded in the works of 27.74% (n=38) of respondents. In their opinion, *"only a live discussion with elements of debate, which can fully take place in classroom conditions, and not in front of monitors, makes it possible to prove the legitimacy of the expressed scientific hypothesis. An online speech will not replace an offline speech, because it is not possible to achieve that degree of scientific conviction"*.

Among the negative aspects, 41.61% (n=57) of students also included the lack of leadership skills development in scientific activity when it is held online. Their argument was that *"the protection of scientific work on the Teams platform did not fully contribute to showing the advantages of the conducted research. It is difficult to reveal the specifics when you read dry comments in the chat, and there is no ability to demonstrate scientific proof of the facts"*.

The indicated negative indicators are closely related to another one, which is indicated by the majority of respondents, 64.96% (n=89), which is a lack of face-to-face communication. The students noted that *"online communication does not give the emotional colour that is present in real life. The interlocutor's reaction is sometimes*

even incomprehensible. In direct communication, the basis for establishing contacts in further joint scientific activity is created, but this does not happen online”.

Thus, having systematized the obtained results of the conducted empirical research, we can claim that in relation to scientific work, learning in an online format had a number of advantages, which were pointed out by students, although certain negative aspects of this process were also noted. Namely:

- The *informational component* positively included the development of students' scientific orientation (78.83%, n=108), development of information and communication skills (64.23%, n=88), stimulation of activity in the use of web resources (61.31%, n=84), activation of interaction skills in the virtual space (59.12%, n=81) and the ability to establish operational communication (40.87%, n=56). No signs of weak points regarding the informational component of students' scientific work in online learning conditions were found.
- As for the positive aspects of the *personal component*, the respondents noted the development of professional readiness (86.86%, n=119) and the formation of motivational and volitional activity (56.93%, n=78). However, some weak points were also recorded: according to the students, during e-learning, to some extent there is a decrease in ambition during the presentation of scientific projects (27.74%, n=38), there is no opportunity to develop leadership skills in scientific activity (41.61%, n=57) and, unfortunately, the participants of scientific events are limited in face-to-face communication (64.96%, n=89).
- With regard to the *activity-based component*, according to the research data, exclusively positive characteristics were established: the implementation of the competence approach in the process of obtaining an education (66.42%, n=91), significant financial and economic benefits of participation in scientific activities (54.01%, n=74), wide geographic coverage of topics of scientific interest (48.91%, n=67), a wider range of possible participation in scientific events (45.98%, n=63), as well as the convenience of joining scientific events both in terms of time and place of stay (30.66%, n=42).

Considering the above, we have identified a significant number of positive indicators, compared to the negative ones, expressed by students regarding their scientific work in online learning. This suggests that students' education in this format is quite effective, and therefore, both offline and online educational processes contribute to the high-quality professional training of specialists in the specialty 012 Preschool education.

Since they were obtained in the reflection papers “My scientific work during university years: what it was like” the results of students' reflection on positive and negative indicators of online learning during their conducting of scientific work tasks are a presentation of only a limited sample of respondents from two universities of Ukraine, the data cannot be generalized. However, the application of such a method made it possible to diagnose the real state of students' scientific work in the conditions of e-learning, as outlined by the **hypothesis confirmed in the process of conducting an empirical study.**

DISCUSSION AND CONCLUSION

Considering modern challenges, significant changes are taking place in the system of university education, aimed at strengthening the quality of future specialists' professional training in the labour market. An important component in the educational process is students' scientific work (Castro-Rodríguez, 2022; Ferrero, 2020; Lokhvytska, 2023; Van Eeden et al., 2021), which has undergone certain transformations in the conditions of e-learning. That is why, the aspect of its effectiveness in the real organization of the educational process in the e-learning environment of the university was the subject of discussion.

The goal of the study, which was fully achieved, was to find out the opinions of undergraduate students on the first educational level (bachelor) about the positive and negative aspects they faced while conducting scientific work during online education. The research problems were addressed as follows:

- (1) On the basis of the conducted theoretical review of the raised problem, it was found out that in its essence the students' scientific work in the conditions of e-learning has a number of specific features, which consist in the modernization and dynamic improvement of their scientific and research activities through the use of modern information and communication technologies and new organizational forms.
- (2) It has been established that in student research conducted in e-learning, it is advisable to distinguish informational, personal, and activity-based components.
- (3) Based on their reflections in the works titled 'My Scientific Work During the University Years: What It Was Like', undergraduate students shared their experiences of conducting scientific work, which primarily occurred online due to quarantine restrictions related to COVID-19 and martial law in Ukraine, starting from February 24, 2022. The respondents identified several positive indicators related to the informational and activity-based components. However, they also mentioned some negative aspects in the personal component. These identified indicators should be considered when organizing various forms of scientific work for university students. Given that students' scientific work emphasizes independence, **further scientific research** will focus on assessing the impact of e-learning on students' ability to carry out independent work.

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DIGITAL TOOLS OF BUSINESS COMMUNICATION IN EDUCATIONAL ORGANIZATIONS OF EUROPE

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Abstract: *The article presents a comparative analysis of the digital competence of representatives of educational and scientific organizations in Europe, in particular Austria, regarding their ability to use digital tools in business communication. The study encompasses the results of experimental training conducted between 2022 and 2023, which includes a series of theoretical and empirical data: questionnaires and data from a pilot experiment, an educational component, and the results of a formative experiment. The study explores the adaptability of adults to the use of digital tools for business communication within a defined timeframe. Furthermore, it examines the changing dynamics of digital tool usage, particularly Facebook, Messenger, Instagram, YouTube, and ChatGPT, identifying the most popular and user-friendly business communication digital tools for educators.*

In the course of experimental training, it was established that the level of digital competence in utilizing modern digital tools for business communication significantly improved. This improvement was statistically confirmed using the Wilcoxon signed-rank-test. The data obtained validate the efficacy of the chosen methodology for instructing adults in the use of digital tools for business communication.

Moreover, the study revealed that, following the training, representatives of European educational organizations began to actively and effectively use digital tools for business communication in various speech genres, such as short messages, business letters, group chats, newsletters, business audio essays, business video content, and business emoticons. The research also identified specific scenarios of professional

business interaction among participants from educational organizations that involved the use of modern digital tools.

Keywords: modern digital tools, digital competence, business communication, genres of business communication

INTRODUCTION

Today, society is moving from a society of knowledge to a society of competent citizens. In this context, possessing computer literacy is a necessary condition for effectively using digital technologies in business communication.

The European Union has taken active steps towards implementing its own developed system of forming digital competence among its residents of citizens. The European Digital Competence System, also known as Dig Comp, is a tool for increasing the level of digital competence of EU residents.

The modern business system of various spheres of production and services must take into account all these processes of change and transformation of the world. In this regard, educational institutions of all levels, international corporations, public associations and associations, we must rebuild communication processes as much as possible so that they meet the standards of life in the digital world, provide opportunities for such digital competences, knowledge and skills, so that the modern adult a person could be useful to the world and could live comfortably and qualitatively in a transforming world.

What skills can help a modern business person adapt to the world of digital technologies and globalization processes? We believe that it can be business communication skills and the ability to use digital tools (Kahoot, Mentimeter, ChatGPT, Flipgrid etc.). In our opinion, comprehensive digital competence in business communication should be possessed by all participants of business processes in various spheres of life and production, including students in various training programs.

In the field of science, there are many statements and views emphasizing the importance of improving the digital skills and abilities of pupils, students and adult members of society. Scientists worldwide are united in their conviction that digital tools are effective aids for modern individuals (S. Carretero, J. Garcia-Zubia, S. Skvortsova, N. Xenofontos, O. Budnyk, T. Blyznyuk; Mano, & Mesch, 2010; Mark, Volda, & Cardello, 2012; Salanova, Llorens, & Cifre, 2013; Mark, Iqbal, Czerwinski, & Johns, 2014; Salanova, Llorens, & Ventura, 2014; Morze, Smyrnowa-Trybulska, & Kuzminska, 2018). Digital tools studies in business are dedicated to the work (Saran, 2011).

We are convinced that modern individuals with digital competences are able to make valuable contributions to the global economy as a whole.

In our research, we focus on people working in the field of education, who are part of a public association on, and have a wide age range (from 27 to 78 years old). They use the linguistic and stylistic arsenal of business communication tools in their daily work.

At this stage, it is necessary to integrate science and educational practices as much as possible to enable modern individuals to master the technologies of working with digital tools for high-quality and effective professional activity. Modern educators and researchers must possess versatile professional competences in business communication, which are based on the principles of fundamentality, systematicity, consistency, scientificity, perspective, connection with life. Researchers must possess the qualities that will allow them to perform both individual and collective tasks, they must be ready for self-education in the digital world. At the heart of our methodology is the improvement of researchers' abilities and skills use digital tools of business communication. This competence approach is determined not only by the results of higher education, but also by lifelong learning ("Recommendations of the Council on key competences for lifelong learning", 2018). It ensures clarity and comparability of learning outcomes, acquired competences, and qualifications, creating a solid basis for European and global integration.

Objectives of the study:

1. Analyze scientific monographs, publications related to the research problem.
2. Determine the range of competences in business communication and their criteria.
3. Specify modern digital tools that are effective for improving the quality of business communication.
4. Develop the technology for the experiment: the ascertaining and formative stage.
5. Present the results of experimental training based on the developed course "Modern digital tools in business communication" in the proposed article.

The research hypothesis is based on the assumption that the development of competence in using modern digital tools in the process of creating various genres of business communication is a) creating the conditions of global society for accessibility to new digital resources; b) training according to the developed course; c) respondents' personal interest in their own development and improvement of their own efficiency in the labor market.

Working with the online course "Modern digital tools in business communication" provides researchers with qualitative and permanent skills.

In the first part of this article, we presented the cross-cutting skills that researchers acquire in the process of learning to use digital tools.

In the second part, we analyzed the results of studies conducted from September 2022 to May 2023, demonstrating the use of technology for working with the online course "Modern Digital Tools in Business Communication." We have presented a set of measures and elements of analysis of surveys conducted with representatives of the international association who have completed this distance learning module in the online course of the Center of Ukrainian Researchers in Austria. The purpose of this study is to present the technology of developing skills and working with digital tools in the process of business communication.

1. ANALYSIS OF THE LATEST PUBLICATIONS ON THE PROBLEMS OF APPLYING ARTIFICIAL INTELLIGENCE IN BUSINESS COMMUNICATION

The problem of the development and functioning of artificial intelligence has recently gained serious importance. Scientists and progressive global humanity are trying to analyze the effects and consequences of the interaction of the human-artificial intelligence pair in many dimensions and facets. Artificial intelligence can be seen as a tool that serves to benefit humans and helps create innovative products. On the other hand, artificial intelligence can displace many professions from the job market. With the help of artificial intelligence, it is possible to automate any intellectual work on topics: thoughts, meanings, texts; two-dimensional images and photographs; editing and generation from scratch of video; creating and editing music of any genre; management of employees; investment and finance management.

The problem of business communication and the use of digital tools to improve its quality have been the focus of modern researchers. We are interested in the article by Silhanova, R. "German Business Letter from the perspective of language development" (Silhanova, 2016), in which the scientist examines the development, function, forms, standards, and aspects of the German business letter writing. Using the example of authentic texts, the article shows modern linguistic trends towards simplifying business communication in the modern world. Another work that piques our interest is the scientific research by Pikhart, M. "Electronic Managerial Communication: New Trends of Intercultural Business Communication (Pikhart, 2018). We have also analyzed the article by researchers Cerna, M. and Svobodova, L. "Internet and Social networks as a support for communication in the business environment – pilot study" (Cerna, & Svobodova, 2017). This paper provides a comparison of collected data regarding the utilization of various means of communication by small and medium size enterprises with their clients and the utilization of social networks for both private and corporation purposes. The results presented in the article "Artificial Intelligence in Business Communication: the Changing Landscape of Research and Teaching" (Getchell, Carradini, Cardon, Fleischmann, Ma, Aritz, & Stapp, 2022) are of significant importance in our research on digital tools in business communication. In this article the authors describe the current capabilities, challenges, and concepts related to the adoption and use of artificial intelligence (AI) technologies in business communication. The study (Iaia, Nespoli, Vicentini, Pironti, and Genovino, 2023) is the first to relate the perspectives of business communication, AI and knowledge management (KM), establishing a virtuous circle between KM and AI. At the centre of the proposed model are people, processes and technologies, based on which KM represents the ideal perspective to define the implementation of AI. This primarily involves augmented intelligence, as AI cannot entirely replace humans in business communication processes, notably due to the absence of emotional intelligence.

The active engagement of scientists in researching the effective application of digital technologies in business communication indicates the relevance of the chosen topic of scientific research.

2. DIGITAL SKILLS OF A BUSINESS COMMUNICATION RESEARCHER AS A CROSS-CUTTING COMPETENCE AND A KEY TO SUCCESS ON THE LABOR MARKET

The design and implementation of the educational program is based on the competency model of a specialist (across various training programs).

Today, it is generally accepted that competences are divided into two groups: subject competences and key competences. Key competences, also known as general competences, transferable skills, soft competences, transversal competences, are universal, not tied to a specific subject area. They must be balanced with special competences in the development of educational programs and their formation must be planned. It should be noted that academics differ about terms, but we adhere to the term “transversal competences” proposed by UNESCO proposed for general use in 2015. Transversal competences facilitate “learning transfer”, allowing individuals to apply their acquired knowledge, skills and metacognitive abilities to real-life situations.

The online course developed for enhancing digital competence in business communication is aimed at fostering transversal competences to use modern technologies. The presence of transversal, namely digital competence in business communication enables individuals to feel comfortable in a constantly changing world, in an endless flow of information and transformation of textual content.

When considering a group of transversal skills in the process of teaching researchers in using digital tools for business communication in the online course “Modern Digital Tools in Business Communication”, it is necessary to clearly define the core objectives. In this context, we are interested in several key aspects:

The development of competence in using digital tools for business communication includes four main directions:

1. focusing on understanding the main functional principles, concepts, and logic of using digital tools, developing one’s own skills in using digital tools in the context of business communication;
2. training in responsible high-quality use of digital tools;
3. learning to use digital tools in business communication to effectively manage information
4. gaining practical experience in using digital tools for interaction and work in social networks in the context of business communication.

3. DISTANCE EDUCATION AS AN EFFECTIVE METHOD FOR DEVELOPING INTERMEDIATE SKILLS OF STUDENTS

The center of Ukrainian researchers in Austria was established in 2022, uniting 145 researchers not only from Ukraine, but also from Austria, Poland, Romania, and Belgium. The age range of the Center’s community spans from 27 years old to 78 years old, and all its members are researchers who have diverse educational background, but have different training programs based on higher education in both Ukraine and Europe. The Center’s activity encompass active scientific, educational and social engagement and involves the proficient use of digital tools for business communication.

The traditional approach to organizing the training of association members and using the center's classrooms and only these classrooms to master transversal skills of working with digital instruments is neither the sole nor the most effective option. In fact, working on these skills requires a lot of time, individual and team work, personalization, equipment. Consequently, a different structure is required: combining e-learning with distance learning. In addition, members of the association are geographically dispersed, residing in different countries, and gathering them for in-person training poses financial and organizational issues. With the implementation of distance learning, facilitated by the online course "Modern digital tools in business communication", three restrictions on the audience are eliminated: time, content and degree of personalization. All these elements are closely interconnected. More time allows for more intricate tasks and richer, more complex content. Extended time fosters autonomy, enabling individuals to engage with tasks independently and experiment with different ways to find information and use it constructively and effectively. Distance learning significantly improves the quality of the product, as students, including future philologists are not burdened by time constraints. They can explore topics at their own pace and feel less restricted by time while conducting research. Moreover, extended time allows students to tackle more difficult problems, rendering the learning process more engaging. The use of distance learning within the framework of the online course "Modern Digital Tools in Business Communication" encourages individuals to maximize their use of digital technologies. However, it is crucial to consider collaborative work when discussing autonomy. In distance learning, effective time management is vital, as the time allocated for working with specific digital tools and business communication texts and completing tasks, is limited. Deadlines require specific outcomes, such as creating a business cold email for communication with the CEO of a global corporation or international organization.

4. EXPERIENCE IN DEVELOPING THE DIGITAL TOOL SKILLS OF CENTER RESEARCHERS FOR BUSINESS COMMUNICATION THROUGH AN EXPERIMENTAL ONLINE COURSE

In 2022, the Center of Ukrainian Researchers was officially registered, and as of May 2023, it has already welcomed 145 participants. Consequently, it became necessary to create a specialized program for the development of both professional transversal competences of business communication researchers, namely the skills related to digital tools. The internal and external communication of the Center heavily relies on new information technologies and various types of digital applications. The initial stage of the endeavor involved assessing the existing digital competences of the Center's representatives, defining the level of these competences, and establishing curriculum criteria. One of the key success criteria for achieving the assigned tasks is the degree of independence and autonomy of the work. We took this criterion into account during the development of the experimental online course. Therefore, researchers who are members of the International Association of Austria are expected to develop the ability to independently use digital tools in business communication.

However, they must also exhibit a critical awareness of when and how to use these tools in different communicative interactions with external and internal partners. This was the primary goal of training the students in the online course “Modern digital tools in business communication”.

The online course training was included in the curriculum for the first year of the Center’s researchers and was divided into 5 activity groups.

As mentioned earlier, an independent module was developed specifically for the first-year students at the Center. The content was presented in the form of 5 blocks: 1) The art of writing a cold email; 2) Writing a memorandum; 3) Writing proposals; 4) Developing strategic issues for negotiations; 5) Writing a project report. Each block, in turn, comprised tasks of different levels of difficulty.

A total of 43 researchers from the International Center in Austria took part in the experimental training. It was not mandatory for all organization members to participate; instead, we offered the researchers the opportunity to voluntarily engage in the online course. At the beginning of the program in September 2022 we identified one group consisting of 43 researchers. The experiment was conducted at the Center of Ukrainian Researchers in Austria. Researchers were provided approximately 20–25 days to complete each group of tasks. The content was of a progressive level of difficulty, but did not align with the curriculum they typically received in their primary workplaces within educational institutions (universities or other professional associations): the module was entirely self-contained. The period of observed activity, for which we present some results and comments here, extended from September 2022 to May 2023. During this period, we performed diagnostic assessments to monitor the progress of the researchers who participated in the experiment. These assessments were conducted at different stages, both at the beginning and at the end of the online course, for the participants. The main skills we focused on included:

1. skills in using digital tools such as Kahoot, Mentimeter, Flipgrid, ChatGPT, Telegram, and YouTube;
2. architecture of oral and written text (communicative skills according to the principle of simple language);
3. interpersonal communication skills (partnership), organizational skills (time management, resource management);
4. skills in working with information.

5. EXPERIMENT RESULTS

5.1. Evaluation of the method of using digital skills developed by the organizers during the training module for the online course “Modern digital tools in business communication”

Table 1 below presents our assessment of skill needs for the first year of the Centre’s Researcher Digital Skills Program. We assigned tasks to researchers aimed at developing their digital tool skills in business communication; the business communication text was a focal point as the primary output, created and distributed in society and in professional environments by means of digital tools. To assess these skills, we

used the Rensis Likert method (summary evaluation method). It consists in rating the skill mastery level of each participant on a four-point scale ranging from 1 “never” to 4 “very often”. We calculated the average value based on these assessments, allowing us to determine the priority skill areas for each participant. One of the crucial aspects of business communication is the ability to write texts effectively. Therefore, the methodology of the course was focused on enhancing written communication skills. During the training, we assigned researchers tasks that included creating Instagram, Telegram, and Facebook pages as well as creating business texts, for example, developing and presenting a plan for a new project, creating a Viber chat group for exchanging messages in a business manner, creating a system of questions for strategic communication within the framework of management negotiations using ChatGPT. Researchers emphasize (Lund, Wang, Mannuru, Nie, Shimray, Wang, 2023) that ChatGPT and related technologies have the potential to significantly impact academia and scholarly research and publishing. However, it is important to carefully consider the ethical implications of these technologies, particularly in regard to their use by academics and researchers. While ChatGPT and GPT-3 represent major advancements in artificial intelligence, machine learning, and natural language processing, it is necessary to ensure that they are used ethically and responsibly for scholarly research and publishing. Many questions about the ethics of using GPT in academia and its impact on research productivity remain unanswered.

The online course also included a variety of interactive business communication tasks. We used Kahoot for interactive activities. This tool offers has great advantages – it is engaging, social, user-friendly and interesting. The KAHOOT, a digital tool created in 2013, enables quick creation of interactive content: quizzes, polls, and discussions. The process of creating a new business text takes only a few minutes. Another tool that facilitates business communication is MENTIMETER. It facilitates interaction with all participants in business communication. We used this tool to create presentations for business communication as it allows for conducting business surveys, receiving feedback on any issue, and presenting results to the target audience promptly. MENTIMETER is highly effective during business communication activities, including negotiations, and presentations at meetings, gatherings, with the help of MENTIMETER, online voting on various business issues can take place. We also focused on improving the oral business communication skills of researchers, and one of the tasks was to make a video on business communication, particularly for presenting projects using the digital platform Flipgrid. Flipgrid is widely used by business professionals worldwide, and it enhances the development of oral genres of business communication. Its applications range from exchanging business messages, feedback on new projects, presenting project plans, presenting the essence of memoranda, proposals, announcing agendas, and sharing corporate performance results, etc. These tasks collectively contributed to the development of digital literacy in business communication. We assigned tasks that involved setting up and managing YouTube channels, Instagram pages, developing synonyms with a positive aura for communication in business sectors, including agriculture, energy, beauty, and travel. Additionally, we proposed creating a strategic map for unanswered and closed questions to use in negotiations with representatives of the Global International Corporation

for presenting new projects and securing funding (the project must first be presented and presented via email). The information and figures provided in Table 1 are quite subjective, but they reflect the importance assigned to each skill. As seen in Table 1, our training process emphasized the quality of the written text in business communication. Many tasks were aimed at transforming, adding, condensing, editing, analyzing complex business cases. At the beginning of the work, in the first four months of distance learning, we paid less attention to time management, because the activities proposed initially required less time to complete. In the first few months, researchers at the Center created and registered their own Facebook pages, Instagram pages and YouTube channels. The texts for the internal and external Center activities improved in quality. Additionally, there were tasks that required a creative approach from researchers, as they involved working with various types of content, including images, texts, Internet links to sites, videos. When creating video content, participants considered the following factors (Lind, 2019): 1. Audience and purpose (the fundamental goal of each video is to convince a likely viewer of the video to support the individual persuasive business proposal); 2. Content requirements (external content must be correctly cited, include credible sources to support the proposal, comply with copyright regulations.); 3. Aesthetic requirements; 4. Technical requirements. To stimulate critical thinking, we designed tasks with deliberately incorrect algorithms to mislead researchers. For example, in the task of creating a presentation using MENTIMETER and submitting information to the group as part of a project proposal, we included provocations intended to violate the action algorithm during group creation or disrupt the structure of the business communication text. Not all participants identified meaningful errors, but everyone was able to recognize issues in the violation of the chat group creation algorithm. This helped us identify knowledge and skills and to improve the blocks of tasks in the process of experimental work.

Table 1.Work on developing writing business communication skills in the first step (3months) of study of researchers (scale from 1 “never” to 4 “very often”) – an example for a single individual

Business writing	Professional skills in business communication				
	Organizational (time management)	Critical thinking	Linguistic skills	Information skills	Text architecture
The art of writing a cold email	2	4	4	4	4
Writing a memorandum	2	4	3	4	3
Writing proposals	2	3	3	3	4
Development of strategic issues for negotiations	2	4	2	4	3
Writing a project report	3	3	4	3	4
Average	2.2	3.6	3.2	3.6	3.6

Source: Own work.

During the second step, students provided more complex written answers, leading to increased requirements for text architecture. Work on critical judgment was considered completed mainly during the first year, although provocative tasks were occasionally used. We paid more attention to time management, as task complexity increased. This allowed us to explore the implications of time management in terms of distance learning, whether tasks were completed as assigned, and whether the majority of students faced problems with meeting deadlines. Also in the process of implementing the distance learning technology for the proposed independent module, specific task groups related to experimental texts proved effective in developing interactive skills and information management skills (Table 2).

Table 2. Presentation of the results showing the improvement in respondents’ ability to use digital tools in working with genres of written business communication (Scale from 1 “never” to 4 “very often”) – an example for a single individual

Digital tools	Genres of written business communication				
	The art of writing a cold email	Writing a memorandum	Writing proposals	Development of strategic issues for negotiations	Writing a project report
Mentimeter	4	2	4	4	4
Kahoot	4	3	4	4	4
YouTube	4	2	4	4	4
ChatGpt	4	2	4	4	3
Flipgrid	4	4	3	4	4
Average	4	2.6	3.8	4	3.8

Source: Own work.

5.2. Evaluation by researchers of the method for developing transversal skills of working with digital tools during business communication and in the process of the online course “Digital tools”

At the end of each activity stage, the researchers received a questionnaire that included a question on a Rensis Likert scale to assess their perception of the robot’s level of skill with digital tools. Tables 3 and 4 below show the results for the period covered (study period at the Center from September 2022 to May 2023). This is based on certain opinions of the researchers and these results are partly subjective. Therefore, since the factor of subjectivity is taken into account, it is correct to speak not about results, but about assumptions. During the first stage (Table 3), we observed that the online course “Modern digital tools in business communication” had a positive impact on the researchers’ understanding of business communication, text structure, vocabulary, in particular, synonyms and metaphors. Some researchers felt that they made progress while working on the suggested tasks. First of all, the skills

in writing a cold email in English improved, and they became better at organizing the structure of a cold email and using a broader lexical range. However, fewer students perceived significant improvement in their ability to write memoranda. An interesting aspect was the experience of researchers working with the ChatGPT digital tool, which served as their assistant. The process of working with artificial intelligence involves developing specific skills, such as formulating precise questions, identifying key semantic elements.

Table 3 also reflects the researchers’ perspectives on two other aspects: writing proposals and developing strategic issues for negotiations, both of which were aimed at enhancing business communication skills. Researchers were also asked about which course tasks interested them the most, which ones they found difficult, and which tasks they considered redundant. The majority of students evaluated the program of this study very positively. The most interesting, in their opinion, were tasks for developing skills with such digital tools in the process of business communication, such as emailing with international corporations and working with the artificial intelligence of the ChatGPT.

Table 3. Perceived importance of the online course “Modern digital tools in business communication” in the development digital skills in business communication among researches: 1 step of study (from 1 to 4) n = 43

Skills	1	2	3	4
The art of writing a cold email	9	16	10	8
Writing a memorandum	13	12	14	4
Writing proposals	9	18	9	7
Development of strategic issues for negotiations	7	11	12	13
Writing a project report	9	16	11	7

Source: Own work.

Table 4. Perceived importance of the online course “Modern digital tools in business communication” in the development digital skills in business communication among researches: 2 step of study (from 1 to 4) n = 43

Skills	1	2	3	4
The art of writing a cold email	3	4	17	19
Writing a memorandum	9	13	14	7
Writing proposals	4	11	12	16
Development of strategic issues for negotiations	1	6	12	24
Writing a project report	5	11	16	11

Source: Own work.

In order to prove the effectiveness and importance of the online course “Modern digital tools in business communication” for the development of digital skills in business communication among researchers, the non-parametric Wilcoxon signed-rank test

was used. This criterion was chosen, taking into account the fact that one group of researchers was involved in the experiment. The Wilcoxon signed-rank test was used to assess the probability of a shift in the values of the characteristic – the degree of development of digital skills in business communication, which was measured in two different conditions “before” and “after” the involvement of the Center’s researchers in the online course “Modern digital tools in business communication”. We formulated and tested the following hypotheses at the $\alpha=0.05$ level.

Null hypothesis (H0): the overall degree of development of digital skills in business communication among researchers of the Center at the end of the online course (“after” group) does not exceed the overall degree of development of digital skills in business communication among researchers based on the results of the first diagnostic section of the experiment (“before” group).

Alternative hypothesis (H1): the overall level of development of digital skills in business communication among the researchers of the Center at the end of the online course (“after” group) exceeds the overall level of development of digital skills in business communication among researchers based on the results of the first diagnostic section of the experiment (“before” group).

The effectiveness of the proposed online course was statistically proven according to each digital skill. Calculations were performed using the IBM SPSS Statistics software package. The results are shown in Table 5.

Table 5. Calculation results Wilcoxon signed-rank test «before – after»

Skills	Z	Asymp. Sig. (2-sided)
The art of writing a cold email	-4.443 ^b	0.000
Writing a memorandum	-1.332 ^b	0.183
Writing proposals	-3.735 ^b	0.000
Development of strategic issues for negotiations	-4.365 ^b	0.000
Writing a project report	-2.678 ^b	0.007

Source: Own work.

According to the results of calculations in Table 5, the null hypothesis was rejected and an alternative hypothesis was accepted in cases of development of such digital skills as: The art of writing a cold email, Writing proposals, Development of strategic issues for negotiations and Writing a project report. In these cases, the p-value is less than the established $\alpha=0.05$. The null hypothesis was not rejected in the case of the development of the digital skill Writing a memorandum ($p>0.05$). The conclusion was formulated: the comparative analysis of the results of the first and second stages of the experiment proves the positive dynamics in the development of digital skills (The art of writing a cold email, Writing proposals, Development of strategic issues for negotiations, Writing a project report) in business communication among the researchers of the Center at the end learning the online course “Modern digital tools in business communication”. It has been statistically proven that there have been no significant changes in the development of the digital skill of Writing a memorandum.

For the Wilcoxon signed-rank test, we calculated the effect size using the r index (Table 6).

Table 6. Calculation results r -effect

Skills	Z	r -effect
The art of writing a cold email	-4.443 ^b	-0.825
Writing a memorandum	-1.332 ^b	-0.239
Writing proposals	-3.735 ^b	-0.682
Development of strategic issues for negotiations	-4.365 ^b	-0.873
Writing a project report	-2.678 ^b	-0.547

Source: Own work.

According to the data given in Table 6, significant and above-average effects can be observed in the development of skills related to “The art of writing a cold email,” “Development of strategic issues for negotiations,” “Writing proposals”, and “Writing a project report”.

The dynamics of changes in the development of digital skills in business communication of the Center’s researchers during the online training course “Modern digital tools in business communication” are monitored.

Figure 1 demonstrates the dynamics of changes in the development of digital skills of the Center’s researchers in business communication at the 1st and 2nd stages of training.

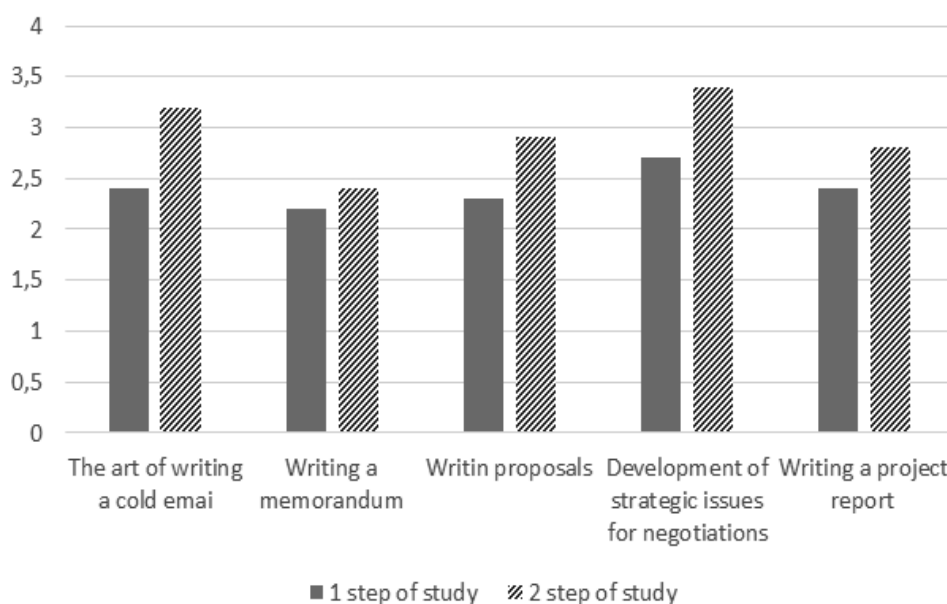


Figure 1. Dynamics of changes in the development of digital skills of the Center’s researchers at the 1st and 2nd stages of training

Source: Own work.

During the second stage of training (February-May 2023), the researchers experienced greater progress in the formation of skills for working with digital tools in the context of business communication. Particularly notable was the improvement in their ability to interact with artificial intelligence. The second stage of training following the proposed methodology and the results of the researchers’ questionnaire, confirms the correctness of the chosen methods and methods of training, as well as the organization of training.

Table 7. Importance of the online course “Modern digital tools in business communication” in the development digital skills in business communication among researches: 2 step of study (from 1 to 4) n = 43

Tools	1	2	3	4
Mentimeter	2	4	7	30
Kahoot	3	7	11	22
YouTube	4	6	8	25
ChatGPT	2	3	17	21
FLIPGRID	4	5	18	16

Source: Own work.

As previously mentioned, 43 students participated in the experiment during both the first and second stages of training at the Center. The results of the study show that researchers’ digital competence in applying digital technologies to business communication increased by an average of 14% after completing the experimental program. The results of the study show that the digital competence of researchers in using digital technologies for business communication increased significantly following the completion of the experimental program, as statistically proven using the Wilcoxon signed-rank-test. This provides us with confidence in the correct content of the course, its usefulness and effectiveness.

CONCLUSION

These results lead us to believe that the online course “Modern digital tools in business communication” was useful and really helped the researchers to develop the digital skills for working with digital tools in the context of business communication. The digital skills acquired by the researchers will not only be utilized for conducting high-quality business communication in both oral and written forms, but also for other areas of professional activity, if circumstances arise for the transformation of the professional sphere. We believe that digital skills will boost the researchers’ confidence in the dynamic world of digital technologies, increasing their marketability and overall success. We believe that the proposed training method at the Center of Ukrainian Researchers is correct and effective. It is confirmed by the experimental data based on performance results obtained from the two stages.

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LEVERAGING ARTIFICIAL INTELLIGENCE FOR PLAYFUL AND INCLUSIVE EDUCATION: DEVELOPING SEMI-AUTOMATIC AND ADAPTIVE EDUCATIONAL PATHS

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Abstract: *This review article investigates the revolutionary potential of utilizing artificial intelligence (AI) to nurture playful and inclusive education through the construction of semi-automatic and adaptive educational paths. It investigates the advantages of playful learning and individualized education, emphasizing their role in increasing engagement and accommodating varied learning styles. The incorporation of AI in education is poised to transform curriculum design, content generation, and evaluation, relieving educators of administrative duties. Furthermore, adaptive learning enabled by AI algorithms promises tailored educational journeys that modify dynamically to individual progress and preferences. However, ethical concerns about algorithmic prejudice and data privacy necessitate monitoring. The future promises intriguing potential, such as the integration of immersive technology and interdisciplinary collaboration to develop a responsible AI-powered educational landscape that responds to the different needs of students.*

Keywords: Artificial Intelligence (AI) in Education, Playful Learning, Inclusive Education, Semi-Automatic Educational Paths, Adaptive Learning

INTRODUCTION

Artificial Intelligence (AI) has emerged as a revolutionary force in the ever-changing world of education, challenging established paradigms and creating novel learning environments. AI has achieved significant advances in a variety of fields, from healthcare to economics, and education is no exception.

The limitations of traditional one-size-fits-all approaches have become increasingly apparent as educational institutions attempt to fulfil the different requirements and preferences of a global student body. AI enables educators in detecting student strengths and shortcomings, allowing for early intervention to help difficult students. The incorporation of artificial intelligence (AI) in education has brought benefits

and problems, altering instructional approaches, individualized learning, and making decisions based on data (Luengo-Oroz et al., 2021). Artificial intelligence (AI) is the science and engineering of building smart machines that can solve a variety of problems by utilizing machine learning, neural networks, and natural language processing (Mondal, 2020). Using intelligent agent systems, Chatbot, and recommendation systems, AI in education can assist teachers in predicting learner status and achievement, providing resources for learning, and automating tests to improve students' learning experiences (Mousavinasab et al., 2021; Su et al., 2022; Zheng et al., 2021).

This study is significant because it investigates the ground-breaking possibilities of using Artificial Intelligence (AI) for playful and inclusive education via semi-automatic and adaptive educational paths. This article intends to illustrate how AI-driven techniques can adapt to varied learning needs, boost engagement, and create adapted educational experiences by analysing the convergence of AI, playful learning, and inclusive education. The goal of this article is to provide insights into the benefits, problems, and empirical evidence around AI's role in creating the future of education, with the goal of promoting additional research, innovation, and informed practices in this expanding subject.

The study examines the following Research Questions:

1. How does the integration of artificial intelligence (AI) technologies impact the effectiveness of playful learning strategies in educational settings?
2. To what extent can AI-driven adaptive educational paths address the diverse learning needs of students in inclusive education environments?
3. What are the ethical considerations and challenges associated with implementing AI in education, particularly when aiming to achieve inclusivity and playfulness?
4. What are the key success factors and best practices derived from real-world implementations of AI in playful and inclusive education, and how can these be leveraged for future developments?

1. METHODOLOGY

The methodology for this review paper will be a comprehensive and systematic literature review. It will entail searching academic databases for peer-reviewed articles, books, reports, and relevant conference proceedings, such as PubMed, Google Scholar, and education-specific archives. Inclusion criteria will be developed to ensure that studies directly connected to AI in playful and inclusive education are chosen. To discover major themes, patterns, and empirical evidence, data will be extracted and analysed. A qualitative content analysis technique will also be utilized to evaluate the ethical concerns and issues related with AI in education. The methodology will strive to provide a comprehensive review of the subject.

2. THE ROLE OF ARTIFICIAL INTELLIGENCE IN EDUCATION

In an educational environment, AI refers to the use of advanced computer techniques that enable machines to replicate human-like intellect, such as problem solving, thinking, and learning. It entails the creation of algorithms and systems capable of analyzing data, adapting to user interactions, and making educated judgments in order to improve learning and teaching experiences (Pedro et al., 2019).

AI has been widely used in education since the development of computing and information processing tools. AI in education creates new opportunities, challenges, and challenges for instructional strategies (Ouyang & Jiao, 2021). The goal of AI in education is to significantly improve teaching techniques through real-world trials and the development of modular standard prototypes in statistical reasoning, data visualization, and learning analytics (Alam, 2021).

Numerous algorithmic applications in education are already powered by AI. Intelligent tutoring systems that provide intelligent help; individualized learning systems that promote student learning; and automated systems that aid teachers in measuring what pupils know are just a few examples. They also have an impact on the learning ecosystem through a variety of social networks, blogs, gaming platforms, and mobile applications that integrate smoothly into the learning processes (Holmes & Porayska-Pomsta, 2022). In recent years, scholars have developed the concept of „AI literacy” to underline the significance of include AI in 21st-century digital literacy skills for everyone, including children (Ng et al., 2021). In order for everyone (including young children) to understand and apply AI as a tool to live, learn, and work in our digital environment, it has become vital that AI literacy be taught in grades K–12 (Ng et al., 2021; Steinbauer et al., 2021).

The meta-analysis investigates the influence of AI on learning outcomes and perception. The findings indicate a link between AI use and learning achievement. Moreover, AI integration improves learners’ perceptions of the learning experience overall (Zheng et al., 2021). In order to enable further integration of intelligent technology into education and more teacher professional development initiatives linked to AI and AIED, the Chinese government developed an education modernization strategy in 2019 (Chiu, 2021; Xia et al., 2022).

2.1. Transformation of Traditional Education through AI Integration

AI has transformed traditional educational practices by offering revolutionary solutions that improve engagement, personalisation, and efficiency.

1.1.1. *Personalized Learning Paths*

Personalized Learning Paths make use of AI to customize each learner’s educational experiences. AI-driven systems tailor material and activities to each user’s preferences and performance, maximizing engagement and comprehension. Research from Vygotsky (1978), which emphasizes the advantages of personalised learning, supports this strategy. Personalized learning strives to adapt students’ learning experiences to their own needs, skills, talents, and interests (Shemshack & Spector,

2020). Increased motivation, engagement, and comprehension can result from using personalized learning as a successful strategy (Falcão et al., 2018). The study by Ingkavara et al. (2022) reveals how personalized learning promotes self-regulated online learning, increasing learner autonomy and engagement and aligning with AI's capacity to tailor education to individual needs. The Dogan et al. (2023) cite the top research areas for using artificial intelligence to enhance online learning and distance learning processes as educational information mining, learning analytics, personalized, adaptive learning, algorithmic online educational spaces, ethics, and human intervention, as well as online learning through detection, identification, recognition, and prediction. Students might receive individualized career guidance from AI based on their interests, abilities, and ambitions. This might help students in making better job decisions in the future (Bozkurt & Sharma, 2023).

These studies show that using AI to create personalized educational routes has shown amazing promise in terms of increasing student engagement and comprehension. However, as we move toward an inclusive and effective AI-driven educational future, ethical issues and the need for continued research remain critical.

2.1.2. Semi-Automatic Educational Paths

Semi-automatic educational pathways improve learning experiences by fusing conventional teaching strategies with technology-driven resources. These pathways can be customized to meet unique needs by utilizing AI and adaptive learning platforms, thus promoting individualized education. The Khan Academy, for instance, uses semi-automation by providing interactive video courses and activities that adjust difficulty based on user performance (Bendou, 2021).

To further deliver top-notch information to a global audience, Massive Open Online Courses (MOOCs) like Coursera use semi-automation. According on user preferences and prior knowledge, AI systems can suggest courses (Saadatdoost et al., 2023). Platforms like Udemy use semi-automation to offer a variety of courses in vocational training, enabling students to pick and choose the courses they want to take and learn at their own pace (Udemy, 2021).

AI support is used in semi-automatic educational pathways for curriculum design, content development, and assessment. They simplify administrative tasks so that teachers can concentrate on teaching. This strategy tries to increase educational effectiveness while keeping a personal touch in the teaching and learning process.

The study by (Vesin et al., 2022) emphasizes how semi-adaptive evaluation tools, such as Elo-rating, can improve student learning in programming classes. Continually altering the questions' level of difficulty and suggesting pertinent topics based on student performance.

Semi-automatic learning pathways democratize information and increase learning flexibility and inclusivity. Technology supports human educators' efforts, making education more flexible and learner-centered while maintaining the importance of human educators.

2.1.3. Adaptive Assessment

Adaptive teaching, a data-driven approach utilizing computer algorithms, offers personalized instruction to engage individual students and improve their learning (Fontaine et al., 2019). Learning effectiveness may be improved by adaptive learning (Kellman & Krasne, 2018). Recent systematic reviews and meta-analyses have shown that adaptive learning environment seem to be successful at enhancing students’ and professionals’ skill sets. It has been demonstrated that AI-powered adaptive learning systems can tailor language instruction to the needs of individual students, enabling personalized learning experiences (Rusmiyanto et al., 2023).

The study by Chen et al. (2023) shows how adaptive learning system improves individualized learning experiences by directing learners through material that is in line with their areas of strength and weakness. The study by Wang et al. (2023) discovered that the adaptive learning system produced favourable results in terms of learning efficacy. When compared to students receiving teacher-led instruction, those using the adaptive learning system demonstrated greater comprehension and memory of the subject matter. The study by Xie et al. (2019) highlights the beneficial effects of these methodologies on students’ learning outcomes and engagement while identifying various technical tools and methodology utilized to conduct adaptive learning. The study by Peng et al. (2019) emphasizes how adaptive learning can improve motivation, engagement, and overall learning results. The strategy attempts to promote a more productive and inclusive educational environment by giving learners content and experiences that are in line with their individual qualities.

Finally, adaptive educational pathways provide effective and tailored learning opportunities. They increase engagement and skill learning by customizing the pace and content to each learner’s needs. By encouraging lifelong learning and guaranteeing that students flourish in dynamic, knowledge-driven environments, adopting these innovative approaches can revolutionize education.

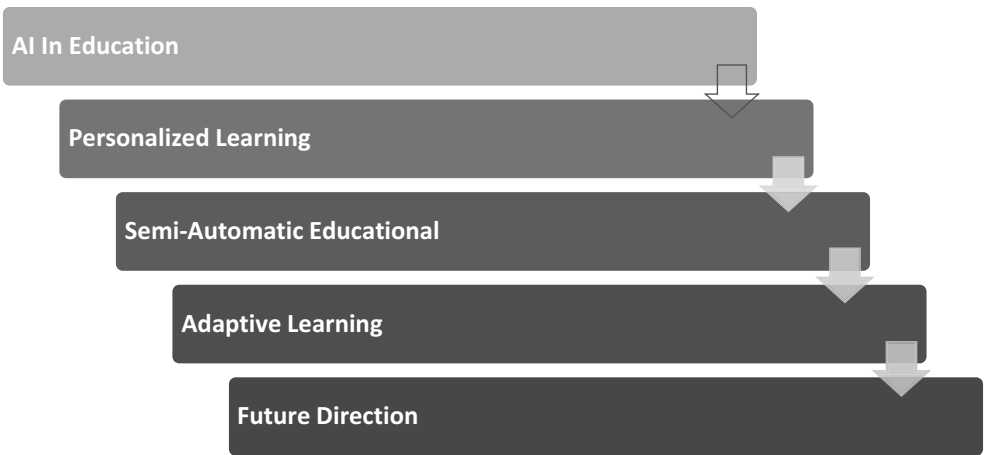


Figure 1. Workflows related to AI in Education

Sources: Own work.

2.2. Playful Learning and its Pedagogical Benefits

Playful learning is a learning strategy that includes elements of play and exploration into the learning process to improve engagement, motivation, and knowledge acquisition. Play has traditionally been regarded as essential to human development and development (Whitton, 2018). Play-based learning is learning that occurs during play, also known as learning by play or fun learning (Danniels & Pyle, 2022; Parker et al., 2022). Exclusionary pedagogy” is a term used to describe teaching methods or practices that intentionally or unintentionally exclude specific groups or persons from the educational process (Raji et al., 2021).

Despite a huge body of research emphasizing the benefits and relevance of play in the field of care and education for young children, our understanding of playful learning among adults, particularly in teacher education programs, has been severely limited (McArdle et al., 2019). It is not enough to understand the theoretical underpinnings of play to successfully implement play pedagogy in early childhood settings. Pre-service teachers should have sufficient opportunities in beginning teacher education programs to learn about play, investigate the play-based curriculum, experience playful learning, and practice play pedagogy in order to encourage play among young learners (Canaslan-Akyar & Sevimli-Celik, 2022).

A powerful educational strategy that multiplies its pedagogical advantages is provided by playful learning when integrated with the capabilities of artificial intelligence (AI). Aslan et al. (2022) investigate collaborative and immersive play-based learning experiences for children. The researchers are looking into the usefulness of a system called “Kid Space,” which is intended to assist learning through playful and interactive activities in a multi-modal and immersive environment. Ng et al. (2022) investigate the use of digital narrative writing as an instructional strategy for developing AI literacy in primary school children. Ng et al. (2022) explore the use of digital narrative writing as an instructional strategy for developing AI literacy in primary school children. Gibert and Schneider (2022) concentrate on the creation and application of a platform targeted at enticing young people into STEM fields (Science, Technology, Engineering, and Mathematics). The platform uses robots and artificial intelligence (AI) in a creative way to encourage interest in and education about these fields.

AI integration with playful learning has the potential to completely reshape education as we know it, making it more learner-centered, efficient, and pleasurable.

2.3. Inclusive Education and the Role of AI

Regardless of a learner’s talents, background, or differences, inclusive education refers to a pedagogical method that tries to meet their different needs (Jungjohann & Gebhardt, 2023). A “procedure that helps beat barriers” to students’ enrolment, engagement, and academic performance is “inclusive education” for all young people, especially those who have historically been overlooked and those who have disabilities (UNESCO, 2017).

AI has huge potential to improve inclusive education by tailoring learning opportunities for different student populations. The study by Krasniqi et al. (2022) looks at

how assistive technology affects the independent living and inclusive education of people with Down syndrome. In the context of inclusive higher education for students with specific learning impairments, the study by Yenduri et al. (2023) examines the shift from assistive to metaverse technology. The study conducted by Han and Lee (2022) discovered that integrating a FAQ chatbot improved the learning experience for a wide spectrum of learners by offering immediate and individualized responses to their questions.

Finally, the symbiotic integration of AI into inclusive education has the potential to be transformative. AI's individualized adaptations, assistive technology, and cross-cultural bridges help different pupils learn better. The importance of ethical vigilance cannot be overstated. As artificial intelligence advances, appropriate implementation offers a more equitable and accessible educational landscape.

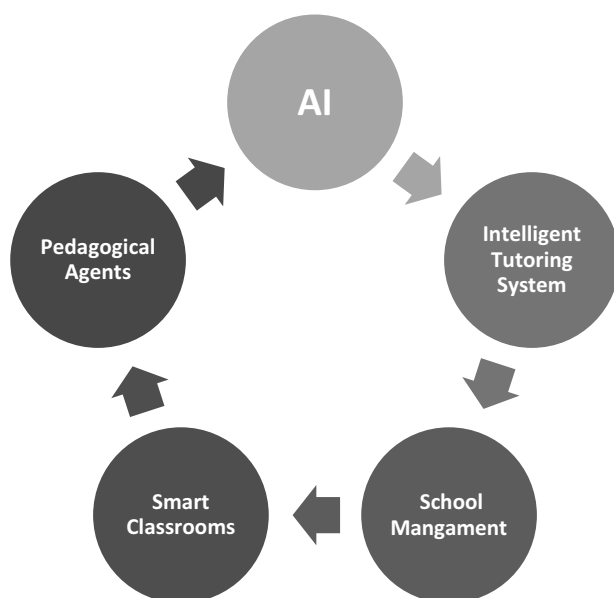


Figure 2.Application of AI in Education

Sources: Own work.

2.4. Technological Implementation and Challenges

Through virtual platforms, technology in education improves engagement and flexibility. However, there are challenges related to universal access, data privacy, and bias mitigation. Tools for artificial intelligence (AI) are continually being made available to the general population. Even if technology has the potential to transform education, there are still a lot of difficulties for academics and practitioners who work with related systems or activities (Kay & Kummerfeld, 2019). This presents a variety of potential and problems for education, primarily for teachers and students, as with all new technical developments (Foltynek et al., 2023). AIED is an “extremely technology-dependent and multidisciplinary field” by definition (Hwang et al., 2020).

The technologies built on artificial intelligence can be quite useful when utilized by experts, and they can also help students when used appropriately. However, if students choose this possibility, it may be able to substantially reduce effort by using artificial intelligence to provide better job results (Cotton et al., 2023).

In AI-driven education, address issues regarding data gathering and storage. The study Kamalov et al. (2023) talk about the difficulties with data security and privacy in healthcare settings and offer solutions to these problems. Using generative AI in education raises important questions about data privacy and security. The application of AI in education creates a lot of information about students, including their academic success, preferred methods of learning, and personal details. Making sure the data is kept and handled ethically and properly is vital (Su & Yang, 2023).

Across fields, including medicine, human resources management, and sports performance analysis, there are on-going discussions in the literature about the ethics of data exploitation in decision-making and interventions. (Araújo et al., 2021; Farris et al., 2021; Jalal et al., 2021; Reddy et al., 2020; Tambe et al., 2019). More emphasis has been called for on enforcing ethical standards for AI systems in order to better match them with social values, according to educators, students, parents, AI developers, and lawmakers (Berendt et al., 2020; Hagendorff, 2020; Nigam et al., 2021).

Ensuring equity and justice in AI-generated educational content is a complex task that necessitates a diverse strategy inspired by the dual goals of utilizing the benefits of AI while preventing the spread of bias and inequity (Kenwright, 2023).

Another issue is that, as students become increasingly dependent on automated tools to complete their work, the usage of generative AI may result in deterioration in their writing and critical thinking abilities (Warschauer et al., 2023). According to some researchers, this might have a detrimental effect on educational quality and eventually affect students’ learning outcomes (Chan, 2023; Chan & Lee, 2023; Zhai, 2022). In the light of above literature adoption of new technologies is a complex and revolutionary process. It necessitates thorough planning, flexible tactics, and a strong understanding of potential difficulties. Assuring that innovation leads the path for increased efficiency and advancement requires proactive problem-solving and a collaborative approach.

Table 1. AI in Education – Impacts and Challenges

Aspect	Impact	Challenge
Personalization	Improved engagement and comprehension	Data privacy and ethical considerations
Semi-Automation	Efficient teaching, adaptive learning paths	Over-reliance on AI, potential decline in critical thinking abilities
Adaptive Assessment	Individualized learning experiences	Equity in AI-generated content, balancing automation with human interaction

Source: own work.

2.5. Future Directions and Possibilities

Artificial intelligence (AI) integration in education offers opportunities for the future and ensures inclusive and engaging learning environments. One approach is to use immersive technology, such as augmented reality (AR) and virtual reality (VR). These technological advancements can offer dynamic and engaging experiences that let students participate more fully with the educational material (Mystakidis, 2019). Advanced adaptive algorithms could also take AI-powered customisation to new heights. These algorithms would combine real-time data from wearables and sensors in addition to taking into account different learning preferences and styles. According to Tapalova and Zhiyenbayeva (2022), this might result in highly individualized learning paths that adjust in real-time to a student's cognitive and emotional states. Deploying ethical AI will continue to be important in these advances. It will be crucial to strike a balance between automation and human contact while also guaranteeing justice and openness in algorithmic decision-making (Shulner-Tal et al., 2023). As AI develops, interdisciplinary cooperation among AI scientists, educators, psychologists, and designers will be essential to developing cutting-edge, interesting, and inclusive AI-powered learning environments. The potential for AI in education to transform both teaching and learning makes this field of study intriguing to explore.

2.6. Conclusion

Finally, the convergence of artificial intelligence (AI) with education offers a transformative opportunity for building entertaining and inclusive learning environments. AI technologies are making personalized educational pathways that adapt to individual learning styles and needs increasingly achievable. The combination of playful learning and individualized instruction has enormous potential to improve engagement, comprehension, and retention across a wide range of learners. However, as we embark on this exciting journey, ethical issues must be prioritized to ensure fairness, openness, and the protection of students' data and privacy. Collaboration among educators, engineers, and policymakers is critical for effectively harnessing AI's capabilities and creating a healthy balance between automation and human engagement. Cultivating a responsible AI integration ecosystem can pave the way for an inclusive and intellectually exciting educational landscape that empowers learners for future generations of learners.

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PREFACE. ENHANCING STUDENT FLEXIBILITY AND ENGAGEMENT IN ONLINE HIGHER EDUCATION: THE IMPACT OF INSTRUCTOR-CREATED VIDEO MATERIAL

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Over the past few years, there has been a significant growth in online higher education, resulting in an unprecedented degree of flexibility and accessibility for a diverse range of students.

However, the challenge lies in creating an interactive and personalized educational experience that caters to the needs of modern students, particularly those belonging to younger age groups.

This article examines the benefits of educators creating their own video content to enhance the degree of personalization and interaction they have with their students inside the online higher education setting.

Educators possess the capability to provide timely learning experiences that cultivate stronger relationships and effectively resonate with learners who have been raised in a digital milieu through the utilization of video technology.

This article examines the potential advantages associated with the creation of video material by educators. The advantages encompass enhanced engagement between students and teachers, heightened understanding and memory retention, as well as the development of critical thinking skills.

Furthermore, the article examines the potential challenges associated with personalized, video-based education and proposes feasible strategies to address these issues. This ensures that instructors may effectively harness the complete benefits of this educational approach.

The fast advancement of technology and the internet has transformed both the methods of delivering education and the platforms via which it may be accessed.

Many individuals seeking a more adaptable and convenient educational experience often opt for online higher education as a viable alternative.

However, the lack of personalization in traditional online courses sometimes fails to match the expectations of contemporary students, who are accustomed to highly interactive and customized digital and physical experiences.

The utilization of instructional videos created by educators presents a feasible solution to address this disparity and establish an educational setting that is characterized by personalized and captivating learning experiences for students.

In traditional educational settings, instructors possess the capacity to adapt their teaching methodologies based on the real-time feedback provided by students through their comments and inquiries.

The challenge associated with delivering online education lies in the necessity to mimic the level of responsiveness typically found in traditional educational settings. Educators are empowered by video lessons created by themselves, since they enable them to customize their training to cater to the specific needs of their students, while simultaneously providing up-to-date and relevant material.

Educators can enhance the linkage between theoretical ideas and practical applications by incorporating illustrative examples, stories, and real-world experiences into their instructional approach.

This instructional approach facilitates students' comprehension of the subject matter and sustains their engagement.

The utilization of video content facilitates teachers in showcasing their personality, passion, and expertise, thereby fostering the cultivation of a more robust teacher-student rapport.

Students find it more convenient to establish connections with teachers who exhibit authenticity and enthusiasm for their respective academic disciplines. The establishment of a personal connection fosters the development of a feeling of affiliation and communal identity inside the online educational setting, ultimately resulting in increased motivation and a more pleasurable learning encounter.

It refers to the practice of acquiring knowledge and skills precisely when they are needed, rather than through traditional, preemptive methods.

Students are able to conveniently access the educational materials at their own convenience due to the availability of video content created by their instructors.

This medium caters to a diverse range of learning preferences and schedules. The adaptability of online education aligns with the requirements of contemporary lifestyles and accommodates the many preferences of students opting for remote learning.

Learners possess the capability to actively interact with the educational material at their preferred time and location, hence yielding advantages to them, regardless of whether they are revisiting challenging subjects or exploring supplementary resources.

The younger cohorts have been raised in a digital environment characterized by uninterrupted connectivity and the ubiquity of many media platforms.

It is conceivable that conventional text-based resources may not effectively engage these learners to the same extent as dynamic and visually captivating video information. Educators can effectively capture and sustain the interest of individuals who are proficient in using digital technology by utilizing the potential of video content. This approach leads to improved retention of information and a more immersive learning encounter.

The cognitive benefits and advantages of analytical and critical thinking are significant.

The utilization of many sensory modalities during the consumption of video content enhances the cognitive processing and understanding of complex concepts. Enhancing the acquisition and retention of knowledge can be facilitated by the utilization of visual, hence catering to diverse learning preferences.

Educational videos curated by educators, incorporating animated visuals, graphical representations, and real-life illustrations, have the potential to facilitate a more profound comprehension of the subject matter among students.

The facilitation of critical thinking can be effectively achieved through the utilization of instructional video materials, wherein educators can present students with various scenarios that necessitate analytical thinking and decision-making processes.

Learners are motivated to employ their acquired knowledge in practical contexts by utilizing interactive elements such as quizzes, polls, and conversations, so enhancing their problem-solving aptitude.

This sort of dynamic engagement facilitates the enhancement of a learning process that is characterized by greater significance and profound change.

The process of generating video content may provide a formidable challenge for educators who lack familiarity with the field of video production. Nevertheless, the provision of suitable tools and resources, together with chances for professional growth, can enable educators to cultivate the necessary skills and produce engaging films with confidence.

The creation of high-quality videos necessitates a significant investment of time and work. Educators have the potential to mitigate the effects of this challenge by the use of more efficient protocols for content development, utilizing existing resources and own skills, and engaging in collaborative efforts with instructional designers or multimedia specialists.

It is imperative for educators to consider accessibility components such as closed captions, transcripts, and audio descriptions to ensure equitable access to knowledge for all students.

These enhancements not only provide assistance to students facing challenges, but they also contribute to the overall improvement of subject understanding and clarity. In the dynamic landscape of online higher education, the utilization of instructor-generated video content holds significant potential in enhancing personalization and fostering student engagement.

Educators possess the capability to create a learning experience that is timely and relevant for younger generations, fostering the development of critical thinking skills, by leveraging the unique attributes of video.

While it is true that difficulties may arise, they can be overcome via the implementation of strategic planning and ongoing professional growth.

Instructors who actively engage in the production of video content can foster a dynamic and engaged online learning environment. This educational setting provides students with the necessary resources to thrive in the era of digital technology.



USING BLOOM'S TAXONOMY TO ASSESS INFORMATION HYGIENE SKILLS

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Abstract: *The article raises the problem of assessing young people's information hygiene skills. The authors emphasize that despite the massive introduction of special courses on information hygiene, and the popularization of open educational resources on media literacy, Ukrainian society remains sensitive to informational influences, which is confirmed by hybrid military aggression. The authors consider a change in approaches to the evaluation of the results as one of the possible solutions to the situation. The article substantiates the appropriateness of using Bloom's taxonomy to assess the formation of youth information hygiene skills. The authors use theoretical (analysis of practices in the application of Bloom's taxonomy in the educational process, modelling of the evaluation process) and empirical (observation, expert evaluations, pedagogical experiment) research methods. A pedagogical experiment is described, the idea of which is to compare two methods of assessing the formation of information hygiene skills: an online test for checking the level of media literacy and a comprehensive test of information hygiene skills based on Bloom's taxonomy. The research model involved a double assessment of the formation of information hygiene skills in both ways. The first check took place after half of the course, and the second – at the end of the course. The evaluation results were*

compared. Based on the comparison of the results, the authors concluded that using Bloom's taxonomy for assessment provided advantages, as it allowed for the analysis of failure and ways to correct gaps in learning outcomes, while online tests gave higher skill assessments.

Keywords: information hygiene; Bloom's taxonomy; assessment; media literacy; information and communication competence; digital culture; professional training

INTRODUCTION

In the conditions of the globalization of the information space and the exacerbation of information wars, the professional activity of teachers deserves special attention, which should be directed not only to the subject education of young people but also to the implementation of educational and formative influences on them. One of these influences is the development of information hygiene skills among young people. Today, information hygiene is perceived as a field that addresses the impact of information on the overall well-being of society and its individual citizens. A frivolous attitude to information content enables informational influence on a person and his condition. Consuming informational content of dubious quality can lead to the neglect of potential information threats. The spread of false data and biased interpretations of facts results in a higher number of individuals falling victim to manipulation. Irresponsible handling of personal data on the Internet can be used for criminal purposes. The identified risks often depend on established behavioural reactions and communication habits of members of society. Countermeasures against risks are possible provided that relevant knowledge and skills are formed: an understanding of the work of the media, the ability to critically evaluate the content of the content, the ability to be responsible for its consumption, distribution, and production, the ability to adequately respond to it, etc. The formation of such skills currently depends on education. And if the processes involved in developing information hygiene skills among young people have already garnered the attention of Ukrainian scientists, then the outcomes of this development deserve special attention.

1. ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

The problem of assessing the development of information hygiene skills cannot be considered new, as it is closely related to the safe use of information and digital technologies in general and the problems of media, information, and digital literacy formation in particular. The analysis of scientific results shows that scientists use different methods to determine the level of ability to safely use information technologies and tools.

Thus, in a study (Torres-Hernández & Gallego-Arrufat, 2022), which focuses on a review-analysis of articles devoted to the formation of digital competence in the field of security, all the results presented in the publications from 2013 to 2022 are based on the interview method. For example, the authors of the study (Bissonnette et al., 2021) used an interview method to find out how students use cognitive skills to

analyse scientific and pseudo-scientific information in news from the Internet. The results of the interviews showed that there is a significant gap between the use of critical thinking skills in understanding the text, quantitative evaluations, correct argumentation, and impartiality. In particular, students had difficulties justifying their own position and comparing value arguments. The publication (Černý, 2021) presents the analysis, systematization, and generalization of the subjective testimonies of high school students regarding information literacy, which is a confirmation of the use of the survey method. The work (Austin et al., 2016) examines the effectiveness of teaching media literacy through questionnaires. The results of processing questionnaires show that critical perception of media sources is an important basis for the development of critical thinking regarding media messages.

Successfully completing online tests or online surveys often makes the respondent complacent and does not prompt them to address the issue of developing the required skills. Therefore, it is important for course developers and teachers to use such practices for evaluating learning outcomes, which would meet the expectations of society and focus not only on students' awareness of problems and the presence of ideas about informational influences but also include testing practical skills in countering informational aggression. Among these approaches, we consider the practice of applying Bloom's taxonomy to be the most focused on building a clear system of educational goals and learning outcomes. Bloom's Taxonomy, also known as "Bloom's Taxonomy of Cognitive Objectives", is a model for classifying educational objectives according to levels of cognitive complexity (Bloom, 1956). Developed in 1956, it has been widely used for a long time as a tool for planning learning objectives, developing tasks, and evaluating learning achievements.

A significant number of Ukrainian scientific results relate to the practical application of Bloom's taxonomy. In scientific works, the problem of the consistency of educational goals and the design of learning forms according to the levels of Bloom's taxonomy (Sokolyuk, 2017) and the use of the methodology for evaluating educational achievements based on the competence approach is solved (Boliubash, 2017). Scientific studies provide evidence supporting the appropriateness of using taxonomy to determine educational outcomes. Therefore, it is reasonable to assume that assessing educational achievements in the development of information hygiene skills using Bloom's taxonomy will provide the most objective results.

The research question: Is it appropriate to use Bloom's taxonomy to assess the development of young people's information hygiene skills?

2. METHODOLOGY OF RESEARCH

The research employed both theoretical methods (such as the analysis of practices in the application of Bloom's taxonomy in the educational process, modelling of the evaluation process) and empirical methods (including observation, expert evaluations and a pedagogical experiment) to support the suitability of using Bloom's taxonomy for assessing the development of information hygiene skills.

The research was conducted in the 2022–2023 academic year at A.S. Makarenko Sumy State Pedagogical University with the involvement of leading experts from

Donbas State Pedagogical University. Assessment of students' information hygiene skills (specialty 014 Secondary education of A.S. Makarenko Sumy State Pedagogical University) took place based on the results of the elective course "Information Hygiene". The main ideas, content, and features of teaching the course are presented in works (Rudenko et al., 2022; Rudenko et al., 2023). The tasks (results) of the course study are defined as follows: to give an idea of the peculiarities of media work; form the ability to identify hate speech and counteract it; develop the ability to verify photos, videos, and text messages; develop the ability to identify stereotypes and discriminatory messages; develop ethical communication skills; develop digital security skills; develop the ability to resist manipulation, propaganda, and other destructive influences. The total number of experiment participants is 39 students and 7 lecturers.

The research idea is based on the comparison of two methods of assessing information hygiene skills. The first method involves a media literacy test available on the Vseosvita resource (<https://vseosvita.ua/test/mediahramotnist-650418.html>). The selection was based on the generalized opinion of experts who had experience of teaching similar courses for less than five years and relevant scientific publications on media education issues. The first 10 resources offered by the Google search engine were taken by searching for "Media Literacy Tests". The criteria for choosing a test for experts were: the number and variety of questions; the possibility of testing not only knowledge but also skills; the possibility of testing the ability to verify data; compliance with the author's course. According to unanimous expert consensus, the Vseosvita resource provided a test that, met all the specified criteria. The test contained single- and multiple-choice questions, as well as those that required additional skills and actions on the Internet (skills for verification, search, etc.). The second method is a comprehensive test of information hygiene skills, which was developed by the authors on the basis of Bloom's taxonomy. The comprehensive test for information hygiene skills required students to earn a specific number of points by correctly completing various types of tasks. Experts approved the point distribution, which was then used to determine the levels of formation of information hygiene skills development. The research model included a double assessment of the development of information hygiene skills using both methods. The initial assessment occurred halfway through the course, while the second assessment was conducted – at the end of the course.

3. RESULTS OF RESEARCH

We will employ Bloom's taxonomy to assess the development levels of formation of students' information hygiene skills. In order to assess the outcomes of the course, we have established four levels of information hygiene skills development: low – understanding of the essence of media work and their impact on society; medium – the presence of skills in the conscious use of media; sufficient – free interaction in the media environment, ability to analyse media content; high – effective use and interaction in the media, skills in creating, protecting, resisting the destructive effects of the media. In order to correctly determine the level of acquired knowledge and

skills using Bloom's taxonomy, it is appropriate to formulate control questions for a comprehensive section of educational achievements – tests for testing theoretical knowledge and practical tasks for testing the skills developed. The Questions developed for all levels of Bloom's taxonomy are presented in Table 1.

Table 1. Control questions according to the levels of Bloom's taxonomy

The levels of Bloom's taxonomy	Key question words to construct a question	Examples of control questions
Information reproduction	What does it mean? Where? When? How many? Give examples.	What is a fake?
Understanding information	How do you explain? How do you understand? What's the difference?	How do you understand the term "information war"?
Information application	In what cases is it used? How to use it?	How to check the weather with Data Viewer?
Analysis	What are the main features (qualities, elements)? What does it consist of? What are the reasons? What are the consequences? What is the mechanism? What are the functions? What is the difference?	Give reasons for confirming or denying the authenticity of the media message.
Information assessment	Make an assessment, formulate conclusions, and justify the statement. What is evidenced by the presence of such elements as...?	How are "jeans" and the manipulation of consciousness related to each other?
Content creation	Present information in an unusual way (creatively)	Create a "Promoting healthy eating" meme.

Source: Own work.

These questions facilitate the evaluation of both theoretical and practical outcomes in full accordance with the educational material with a gradual transition from lower (to a greater extent, reproductive and theoretical) to higher (to a greater extent, practical and analytical-creative) levels of the taxonomy, as well as the four levels of formation of information hygiene skills defined by us. To quantify the educational outcomes, we assigned points based on Bloom's taxonomy, which were agreed with the experts (Table 2).

According to this table, the following quantitative characteristics of the levels of formation of information hygiene skills were obtained: 0–7.5 points – low level, 7.5–15 points – average level, 15–22.5 points – sufficient level, and 22.5–30 points – high level. The chosen assessment method aimed to minimize subjectivity in evaluation. It included a combination of multiple-choice questions and practical tasks, which facilitated the characterization of each taxonomy level and the overall mastery of information hygiene skills.

Table 2. Evaluation table of educational achievements on the exam
(according to Bloom’s taxonomy)

Bloom’s taxonomy level	Number of points	Number of questions	Points for one question
Reconstitution	5	5	1.0
Understanding	5	2	2.5
Application	5	2	2.5
Analysis	5	1	5.0
Assessment	5	1	5.0
Content creation	5	1	5.0
Total	30	12	

Source: Own work.

Rudenko, Yu., Drushlyak, M., Naboka, O., Proshkin, V., & Semenikhina, O. (2022). Special course on information hygiene as a tool for developing youth’s ability to resist informational influences. In E. Smyrnova-Trybulska (ed.). *E-learning in the Transformation of Education in Digital Society*. „E-learning” Series. Vol. 14. Katowice–Cieszyn: STUDIO NOA for University of Silesia (pp. 268–287). ISSN 2451-3644 (print edition), ISSN 2451-3652 (digital edition), ISBN 978-83-66055-31-5. <https://doi.org/10.34916/el.2022.14.20>.

The Vseosvita resource test (online tests) included 24 questions of various types, including it also contained tasks for the practical detection of fakes. The questions included single and multiple-choice answers. Figure 1 shows the results of the initial assessment of educational achievements through both methods: the complex control based on Bloom’s taxonomy (blue line) and the online tests (orange line). Based on the outcomes of comprehensive control (blue line), only 9 out of 39 students (23%) students out of 39 have achieved a “sufficient” and “high” levels, demonstrating their capacity to analyze and evaluate information in accordance with the cognitive complexity levels of Bloom’s educational tasks. The orange line, representing the results of the online survey, shows that only 6 out of 39 students (15%) in the group attained an academic achievement exceeding 50%. The visual results are presented in figure 1.

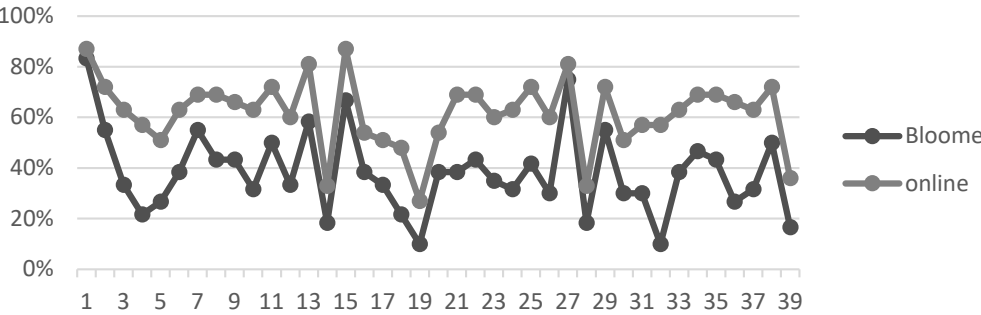


Figure 1. The results of the first cut of educational achievements

Source: Own work.

The results of the second cut of educational achievements are presented in Figure 2. According to the outcomes of comprehensive control (blue line), 24 out of 39 students (61%) reached “sufficient” and “high” levels, which signifies their ability not only to reproduce and apply but also to analyse and evaluate information, in line with the cognitive complexity levels of Bloom's educational tasks. The orange line (online test results) shows that the entire group has achieved educational outcomes exceeding 50%, implying their proficiency in managing media content and their ability to analyse and evaluate it.

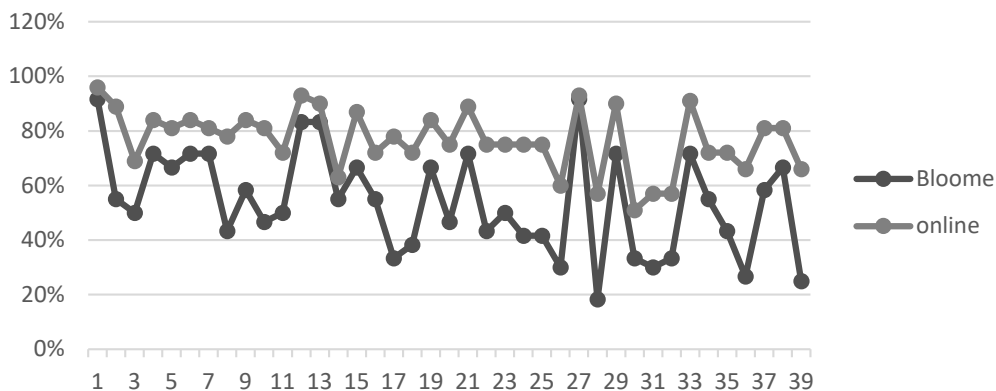


Figure 2. The results of the first cut of educational achievements

Source: Own work.

The two surveys showed not only a different level in the assessment of information security skills. A comparison of the results showed that:

- the correlation of data on the first and second slices is confirmed (correlation coefficient 0.85864 and 0.85328, respectively), which allows us to compare them;
- the online survey (yellow columns of the tables) in most cases gives a higher assessment of skills, which demonstrates both the first and second slices of educational achievements. At the same time, the average rating of the group according to the online survey is such that it is possible to talk about an average sufficient result (62% > 50% and 77% > 50%), and, therefore, sufficient formation of the information hygiene skills of young people. According to the results of the online survey at the end of the course, all students scored more than 50% of the correct results. At the same time, the averages for evaluation according to Bloom (blue columns of the tables) show that, in percentage terms, the average score does not give grounds to say that the students' information hygiene skills were successfully formed before the end of the course (38% < 50%) and only in 54% (> 50%) of students after the end of the course;
- comparison of the results of the assessment according to Bloom before and after studying the course shows that it significantly affects the development of skills of “understanding information,” “applying information,” and “creating content” (the results would differ more than twice) and moderately affect the

development of other skills (about + 20%). This demonstrates the complexity of the questions of levels 4 and 5 of Bloom's taxonomy for students (students' analytical and evaluation skills develop poorly). Therefore, it is correct to conclude that insufficient focus of the course on the development of analytical and evaluation skills and the need to focus on such tasks that will develop them;

- the analysis of the results according to Bloom makes it possible to identify gaps that can be eliminated during the next teaching of the course: according to the results of Table 5, it is clear that the students in the middle of studying the course solve the tasks of reproduction and application of knowledge better than with regard to the perception of information, its comparison and analysis. That is, at that moment, the students had not yet fully formed the lowest levels of taxonomy - reproduction, understanding, application, and therefore training tasks of this type require either an improvement, an increase in their number, or an increase in the time to solve them;
- assessment of educational achievements based on Bloom's taxonomy has a number of advantages. First of all, the development of control measures requires their comparison with the goals and objectives of the course and therefore is precisely focused on checking the desired result. Secondly, the result forms based on Bloom's taxonomy allow you to systematically and systematically track problems with the assimilation of the material and correct them in a timely manner. Thirdly, a transparent evaluation system allows reflection of educational results not only for the teacher but also for students.

4. DISCUSSION

At the beginning of the military aggression, it turned out that the majority of Ukrainian society and especially the youth does not have sufficient skills to resist informational influences. Open educational resources of the world (Yurchenko et al., 2021), as well as in Ukraine (like VumOnline (<https://vumonline.ua/>), grant projects (such as Filter: National Project on Media Literacy (<https://filter.mkp.gov.ua/>), as well as spot implementation of special courses on media literacy into educational programs for training specialists turned out to be insufficient, as a large number of reposts of fake information, emotional vulnerability through e-communication in chats, transfer of personal data to dubious accounts, etc. are observed in social networks. Thus, the contradiction between society's expectations regarding the formation of a sufficient level of skills for safe interaction on the Internet and the existing skills of this type among members of society is actualized. Special emphasis is placed on young people, who are today the most active in social networks. The ability to behave safely on the internet is established in school and develops in institutions of professional or higher education. At the same time, it is checked, as practice shows, in most cases through surveys and tests, which does not guarantee the formation of practical skills to a greater extent.

The problem of the formation of information hygiene skills is raised at the global level in the context of the formation of media literacy of the population. In 2016, UNESCO formulated five laws of media information literacy (MIL). The third law

appeals to the ability to resist informational influences: «Information, knowledge, and messages are not always value neutral, or always independent of biases. Any conceptualization, use, and application of MIL should make this truth transparent and understandable to all citizens.». The fifth law emphasizes that the ability to resist information threats is formed over a long period of time through the acquisition of a person's own dynamic experience ("Media and information literacy is not acquired at once. It is a lived and dynamic experience and process. It is complete when it includes knowledge, skills, and attitudes when it covers access, evaluation/assessment, use, production and communication of information, media and technology content") (Joyce, 2017). This proves that the problem of forming the ability of Ukrainian youth to resist informational influences in the realities of military aggression is extremely urgent, and its solution requires the acquisition of appropriate experience over time, which is naturally carried out in the conditions of educational institutions of various levels (Drushlyak et al., 2022; Ostroha et al., 2021).

Profound social changes are currently underway, with the development of cyber culture necessitating the analysis and cultivation of skills to adapt and thrive within it. Therefore, the authors emphasize that society today needs critical thinking from everyone in its own information interaction. Another review (Silber-Varod et al., 2019) confirms that information literacy and critical thinking are the most in-demand skills of the 21st century. These skills are basic for information hygiene, and therefore should not only be formed but also constantly developed.

In (Aguaded et al., 2022), attention is focused on the fact that the development of IT has had an unexpected impact on people's lives, changing the values of society. The ability to use IT not only in the profession, but also in everyday life has become the norm for society and led to the demand for appropriate training (media education), and the problem of determining the level of its formation in the last 10 years is relevant. Another review study assessed the digital competencies of teachers (García-Ruiz et al., 2023). The authors analyse a sample of 66 Web of Science and Scopus publications published between 2017 and 2022. They prove that it is a common practice for researchers to develop their own tool for assessing digital competencies – questionnaires, and self-assessments. However, the authors recommend supplementing author surveys with other tools that can objectively assess the actual level of competence. The authors' conclusion correlates with our assessments of the subjectivity of most methods for assessing the formation of information hygiene skills. The study (Semenog et al., 2020) advocates for assessing media education skills through specially developed tasks. This study has an objective measure of information security skills, but at the same time, it offers a more sophisticated way to assess such skills.

The study resulted in the identification of additional problems that hinder the effective implementation of Bloom's taxonomy in the educational process. Among these challenges are: low awareness among teachers about this method and its advantages; the significant time required to develop tasks and assessment criteria; and a lack of awareness of the importance of aligning course objectives with programmatic outcomes.

CONCLUSION

In the conditions of a hybrid war, there is a risk under the influence of information becoming a target for manipulation, not recognizing information attacks, and becoming a tool in the hands of the enemy, spreading dubious content. Leveling of such risks is possible through the formation of information hygiene skills of every member of society: idea of the peculiarities of media work; ability to identify hate speech and counteract it; ability to verify photos, videos, and text messages; ability to identify stereotypes and discriminatory messages; ethical communication skills; digital security skills; ability to resist manipulation, propaganda, and other destructive influences.

Considering UNESCO's recommendations and the findings of humanitarian research, one potential solution to address the formation information hygiene skills is the development of a variety of training courses within the framework of formal and informal education, which can also be widely disseminated on digital educational platforms. The success of such courses is often measured through formal methods (such as attendance records, tests or surveys), which may not always provide a comprehensive assessment of acquired knowledge or effectively guard against future negative informational influences. Therefore, the assessment of information hygiene skills is a problem in the field of education that can be solved using Bloom's taxonomy.

Bloom's taxonomy allows to formulate tasks according to the levels of cognitive complexity of educational goals (reproduction, understanding, application, analysis, evaluation, creation). The developed control tasks, as the conducted experiment showed, allow not only to determine the level of formation of information hygiene skills. Tasks aligned with Bloom's taxonomy, in contrast to other assessment methods, allow for the identification of gaps in educational outcomes across different levels of cognitive complexity. Consequently, they are more accurate and appropriate than surveys, interviews, or tests.

The results of the pedagogical experiment provide a basis for recommending the development and evaluation of skills for resisting informational influences: development and implementation of courses on the formation of information hygiene skills will be more effective in the case of using Bloom's taxonomy; for the introduction of complex control of the formation of information hygiene skills according to the levels of Bloom's taxonomy, it is important to reproduce the intermediate results for their further reflection; teachers of information hygiene courses should be careful to use the relevant tests available on the Internet for control since in most cases they do not always adequately evaluate the students' information hygiene skills.

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TEACHER STUDENTS' PERCEPTIONS OF THE ADVANTAGES AND DISADVANTAGES OF ONLINE AND FACE-TO-FACE LEARNING AS A BASIS FOR DESIGNING HYBRID LEARNING

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Abstract: *By 2020, only a small percentage of learners experienced online learning. During the Covid-19 period, all learners and teachers, at all levels experimented with online learning. In our research, we decided to focus on the area of hybrid learning, which has been somewhat neglected so far. We believe that good quality hybrid learning should take advantage of the benefits of both online and face-to-face learning, so we decided to conduct research specifically on the advantages and disadvantages of online and face-to-face learning, from the perspective of a new generation of educators who have experienced online learning from the perspective of students but may also be thinking about it as future teachers. The research was carried out at the Faculty of Education of the University of Ostrava using a questionnaire survey. In this article we want to present the results of the research (e.g. the need for social contact, commuting problems during face-to-face learning, and the flexibility of online learning), and possible innovations that online learning has brought to face-to-face learning and that can be used in the creation of hybrid learning (e.g. recording lectures, completing assignments online, working in shared storage, or connect to learning from home via online video call).*

Keywords: online learning; face-to-face learning; hybrid learning; pandemic of Covid-19; advantages and disadvantages; digital technologies

INTRODUCTION

Much research has already focused on the comparison between online and face-to-face learning. However, we decided to take this area further and use the research results to create a basis for creating good hybrid learning. This is where the originality of our research lies, as we are focusing on the area of hybrid learning because of its topicality triggered by the Covid-19 pandemic, but also because it has been a relatively neglected topic so far. We are addressing hybrid learning as part of a larger research project, the first part of which will be presented in this paper.

For this part of the research, we set four basic research questions:

1. *What do student teachers consider to be the advantages of online learning?*
2. *What do student teachers consider to be the disadvantages of online learning?*
3. *What do student teachers consider to be the advantages of face-to-face learning?*
4. *What do student teachers consider to be the disadvantages of face-to-face learning?*

These are descriptive research questions, hence we could not establish any hypotheses.

1. FORMS OF LEARNING

In today's modern learning environment, we encounter various forms of learning, the two most well-known of which are face-to-face and online. In recent years, however, hybrid learning has also become an increasingly well-known concept. We can also encounter the terms blended learning, distance learning, e-learning or m-learning. There is no need to introduce face-to-face learning at length. It is a traditional way of teaching where all the students and the teacher are present in the classroom, or laboratory or gym. However, even this form of learning is now increasingly permeated by the use of digital technologies, learning apps and other digital learning resources thanks to active teachers (Budiman et al., 2018).

Online learning, on the other hand, takes place only in an online virtual space using digital technologies and various digital learning resources. It is a synchronous form of learning, where all participants, i.e. students and teacher, are present in a virtual classroom in real time, where they work in a similar way as in a face-to-face classroom. At the time of the Covid-19 pandemic, online learning was also associated with the term distance learning. However, here it is important to distinguish distance learning into synchronous and asynchronous learning, as asynchronous learning takes place in the form of e-learning, i.e. without a live connection with other participants (Gherhes et al., 2021, King et al., 2022, Anderson et al., 2020). The term m-learning can then be encountered when the learning takes place using mobile devices (Klimova, 2015).

Each of these forms of learning has its advantages and disadvantages. Some students may be better able to concentrate in a traditional classroom environment, while others will appreciate the flexibility and convenience of online learning. But hybrid learning may be the ideal solution for those who want to combine face-to-face

interaction with online learning from the comfort of home. As research by Rath et al. (2019) confirms, it is always crucial that online, or hybrid, learning is properly organized and takes advantage of all the benefits available to it.

1.1. Comparison of online and face-to-face learning

Since the beginning of the 21st century, many studies have been conducted on online learning, comparing the learning outcomes and motivation of online and face-to-face learners, e.g., Mollenkopf et al. (2017), King et al. (2022), and others. In our research, we set out to find out whether these data are still valid, or whether they have changed in any way over the years.

For example, it is worth mentioning research that focused on comparing two parallel classes. The results of this research show that there was only a small insignificant difference between the learning outcomes of online and face-to-face students, with slightly better results for face-to-face students. Thus, online learning can be just as good as face-to-face learning and it depends on the needs of the students as to which form suits them better (Mollenkopf et al., 2017).

Face-to-face learning provides immediate interaction between teacher and students, allowing for quick feedback and a personal approach. Students can also better focus on the teacher's explanation. Face-to-face learning also provides a structured learning environment, which helps some students stay disciplined and study regularly. On the other hand, online learning offers flexibility and the ability to learn from anywhere with an internet connection. Students have control over their learning pace and can organize their study time according to their needs (Gherhes et al., 2021, King et al., 2022, Anderson et al., 2020).

However, both forms of learning also have limitations. With online learning in primary schools, we may encounter problems such as truancy, lack of motivation, increased absenteeism, classroom indiscipline, or unfamiliarity with technology (Stoloff et al., 2022).

Overall, neither form of learning is generally better than the other. The choice between online and face-to-face learning depends on the preferences and needs of individual students, the nature of the course, and the learning objectives. Some institutions are opting for a hybrid model that combines elements of both forms to provide learners with a choice that brings greater convenience and flexibility to learners, thereby increasing both learning interest and learning outcomes.

1.2. Hybrid learning

Hybrid learning combines elements of face-to-face and online learning. This combination allows us to take advantage of both forms of learning. According to research abroad (Gamage et al., 2022), the hybrid model is often preferred because of its flexibility and the possibility of an individual approach to each student. Gamage et al. (2022) even report that both students and teachers are in favor of a gradual transition to hybrid learning.

Hybrid learning should not be confused with the term blended learning as it has its own specificities. Hybrid learning is when the teaching takes place in a face-to-face setting, i.e. on the premises of the school where some of the students and the teacher

are present. At the same time, however, there is also an online video call during the lesson, through which other students can join in the live teaching from home. So, in simple terms, we can say that it is a combination of face-to-face and online learning into one unit, where both of these forms of learning take place simultaneously. However, it is always necessary to plan this form of learning properly and to organize the activities of students present in the classroom and connected online. In contrast, the term blended learning refers to the use of both face-to-face and online learning, but with the difference that the two forms of learning alternate and therefore do not take place simultaneously, as is the case with hybrid learning (Beatty, 2019).

Hybrid learning is a combination of online and face-to-face learning. Therefore, if we want quality hybrid learning to lead to better learning outcomes and learner motivation, we need to take advantages of online and face-to-face learning, while avoiding their disadvantages.

2. METHODS

We decided to design our research as quantitative research and therefore we chose a questionnaire survey to collect data. This offers easy and quick distribution of questions and data collection (Chráska, 2016, Gavora, 2008). In this first phase of our research, we focused only on the students at the University of Ostrava, but in the future, we will extend our research to other universities that include the Faculty of Education.

The development of the survey questions took place during November and December 2022. The subsequent distribution of the questionnaire and data collection took place from December 2022 to February 2023. During the next three months, we systematized, analyzed, and then interpreted the collected data.

2.1. Research file

In the first phase of our research, the research file were students of the Faculty of Education of the University of Ostrava. In order to generalize the results of the questionnaire survey, we used random sampling.

Specifically, our questionnaire was distributed among 409 students, i.e. future teachers. Thus, the obtained sample includes students across different disciplines, from humanities to natural sciences, as well as all levels of education, i.e. from the primary schools to secondary schools.

Of the total number of questionnaires sent out, we received responses from 88 respondents, with a return rate of 21.5%. Of these, 66 were female and 22 were male. These respondents were in their first and second years of study at the time of the research, i.e. the last academic year 2022/2023, both in Bachelor's degree programs and in Master's or Continuing Master's programs.

2.2. Questionnaire survey

We decided to use Google Forms as a specific tool for creating questionnaires. The created questionnaire consists of a total of 15 questions. In the introduction of the questionnaire, respondents were introduced to the research topic, instructions for

completing the questionnaire and important concepts. The first part of the questionnaire contains 5 functional questions, i.e. focused on the respondents’ data. The second part consists of 10 substantive questions. Of these, 5 questions sought experiences with online learning during the Covid-19 pandemic, and the other 5 questions focused on the advantages and disadvantages of online and face-to-face learning. We used both closed and open-ended questions in the questionnaire we developed. Of the closed-ended questions, we used two dichotomous questions and eight polytomous questions, specifically two enumerative and six multiple choice questions, three of which were scaled items that used a scale of 1 to 5 (Chráska, 2016). For the open-ended questions, respondents were given the option to provide their own answers. We opted for the open-ended questions at this stage of the research because we did not want to influence the results obtained by guiding answers, whereby respondents’ answers could be biased, however slightly. Our intention was to let the students think for a while about the advantages and disadvantages of online and face-to-face learning, so that they could think about what they themselves consider to be the most important and relevant.

3. RESULTS

We set out four research questions at the outset, so we will now present the results of each of these items separately. Based on the first five questions, we obtained an overview of the composition of the sample of respondents in terms of age and program of study, see Table 1, gender above, fields of study (multiple choice), see Table 2, and current year.

Table 1. Sample composition of respondents

Study program/ years	17–20	21–24	26–35	43–50	Total
Bachelor	51	9	0	2	62
Master’s	13	1	5	1	20
Continuing Master’s	0	5	0	1	6
Total	64	15	5	4	88

Source: Own work.

The majority of respondents were aged 17 to 20 years old in a Bachelor’s degree program with a focus on mathematics, computer science, languages, citizenship or primary education. The majority of respondents (81) were in their first year, with the remaining 7 respondents in their second year, regardless of degree program. The next 5 questions focused on experiences with online learning during the Covid-19 pandemic. The first of these questions explored experiences with online learning pre-pandemic. Here the answers of the respondents varied quite a bit. On a scale of 1 to 5, with 1 being excellent experience, most respondents (28) indicated option 5, that is, they had no experience with online learning and did not know how to use it. However, in terms of the number of respondents (23), option 2, that is, that their experience with online learning was quite good, came second. A further eighteen

respondents ticked option 3, eleven respondents ticked option 4 and the remaining eight ticked option 1.

Table 2. Combinations of fields of study of students of the Faculty of Education

Field of study/Level of school education	Primary education	Secondary education
Primary education	20	0
Physical education	0	5
Foreign languages	0	13
Czech language	0	9
Mathematics	0	22
Informatics	0	19
Education for citizenship	0	13
Art education	0	6
Specialized subjects	0	2

Source: Own work.

For the question focusing on the experience of online learning after the Covid-19 pandemic, respondents were already more in agreement. Most respondents rated their ability to work in online learning as good to excellent, again on a scale of 1 to 5, with 1 being an excellent experience. Forty-one respondents now indicated option 2 and twenty-six respondents indicated option 1. Sixteen respondents indicated option 3 and four respondents indicated option 4, with only one respondent indicating option 5.

Forty-two respondents identified poor internet connectivity as the biggest problem during online learning, with one respondent indicating that it was only sometimes. Ignorance and inexperience in organizing online learning was also a huge problem, with thirty-three respondents indicating this option. Similarly, inconsistency in the platforms chosen for online learning was a concern, which was indicated by thirty-two respondents. Not knowing how to work with specific applications was also a significant problem, indicated by twenty-two respondents, and not knowing how to work in an online environment, indicated by twenty respondents. Fourteen respondents perceived the support from teachers as insufficient, eleven respondents perceived it as insufficient from the school administration, and only three respondents perceived it as insufficient from parents. In twelve cases, respondents felt that there was a lack of digital learning resources, and nine respondents did not have enough technical equipment. Some respondents provided their own responses to this question. Here, three respondents agreed that the timetable was not respected during the online learning sessions, so that the lessons interfered with their free time or ran into the evening. Another three respondents perceived teacher inexperience with online teaching as a problem and two respondents had a problem with motivation during online learning. There was also a problem with the lack of information, which could be classified under the aforementioned “problem with the organization of online learning”. However, there was also a case where the respondent had no problem during the online learning.

We also wanted to know whether the school provided any training related to on-line learning to its students before, during, or after the Covid-19 pandemic, and to what extent the school explained everything needed for online learning. While the majority of respondents (58) indicated that no training was provided, only thirty respondents indicated that training was provided. However, in most cases the school explained everything they needed to know. On a scale of 1 to 5, where 5 means that the school did not explain anything to them, twelve respondents indicated option 1 and twenty-one respondents indicated option 2. In thirty-one cases where respondents marked option 3, the school provided them with at least some information. Fifteen respondents who marked option 4 and twelve respondents who indicated that the school did not provide them with any information on online learning considered themselves to be poorly informed.

3.1. Advantages of online learning

Although this section of the questionnaire was open-ended, a significant proportion of respondents agreed, see Table 3 for detailed results. Respondents perceived the biggest advantage of working from the comfort of their own home, where they can have enough time and peace of mind to work, a convenient environment, or can get up later. Flexibility is also a positive aspect of online learning. Specifically, this can be time flexibility, where learners can adjust their study schedule to suit themselves or choose their own pace of completing assignments. For some respondents, the advantage is that they can find everything in one place, can use several different resources, and can access information via the Internet. There is also the ability to return to lectures for self-study and a more individual approach to learning according to the learning style of the learner, or greater responsibility for studying. For four respondents, online learning provided greater motivation to learn and less stress. The last four respondents then stated that they themselves did not see any benefits of online learning.

Table 3. Advantages and disadvantages of online learning

Advantages of online learning		Disadvantages of online learning	
Work from the comfort of home	30	Lack of personal contact	37
No need to commute	29	Procrastination, loss of discipline	13
Flexibility	18	Problem keeping attention	18
Saving time	15	Problem with cheating on tests	4
Increase technical skills	8	Not suitable for practical subjects	3
Connect from anywhere	6	Technical issues	12
Possibility to connect the sick	5	More self-study, homework	5
Financial savings	4	Possibility of information loss	4
More resources in one place	4	Long time at computers	5
Option of self-study	4	Insufficiently explained materials	3
More motivation	4	Lack of motivation	4
		Lack of technological skills of teachers	5
Total		127	113

Source: Own work.

3.2. Disadvantages of online learning

Again, see Table 3 for detailed results of the disadvantages of online learning. Here, a large proportion of respondents agreed on the lack of personal contact with other classmates and teachers. Poor internet connectivity or other technical problems (e.g. a broken microphone or camera, a slow or outdated computer that cannot run the necessary applications) can also be a problem, hence another issue, namely the possibility of losing information during online transmission. The final problem, agreed upon by a larger number of respondents, is the difficulty in maintaining attention during online instruction, or only in some subjects, and the inability to concentrate or the possibility of being distracted. There was also a problem with cheating on tests and the associated reduction in time to complete the test. Three respondents agreed on the lack of explanation of the material and problems with understanding it, as well as the inability to use online learning in practice-oriented courses. Other disadvantages mentioned by the respondents include slow feedback on problem solving, inconsistency of platforms or generally poorly organised teaching and the resulting confusion, as well as little space for learners to express themselves, unequal learning conditions, less time to go through the required amount of material, or difficulty in explaining more complex material. However, there were also two cases where respondents found no disadvantages.

3.3. Advantages of face-to-face learning

In the case of the advantages of face-to-face teaching, many respondents were based on the already mentioned disadvantages of online teaching, see Table 4.

Table 4. Advantages and disadvantages of face-to-face learning

Advantages of face-to-face learning		Disadvantages of face-to-face learning	
Personal contact	47	Commute	40
Better focus	21	Fixed schedule	13
Instant feedback	14	Environment	8
Better explanation of the material	10	Not individualized	5
Regular regime	8	Sick pupils cannot attend	3
Possibility of demonstrations	5	Missing shared storage	3
Environment	2	Bad concentration	2
More motivation	2	Low motivation	4
More awareness	3		
Paper tests	2		
No internet required	4		
Total	118		78

Source: Own work.

Therefore, face-to-face contact with classmates and teachers was very common. Furthermore, the possibility of better concentration and attention retention, fewer stimuli for distraction and more engagement in the learning process. The speed of making arrangements, the possibility of immediate feedback or the ability to ask

for help is also a significant advantage. Better explanation of the material and better understanding of the material can also be an advantage. For some respondents, a regular routine, a fixed schedule and less self-study are important. The advantage of face-to-face teaching is also the opportunity to use demonstrations and aids, which is particularly important in vocational subjects. Two respondents prefer paper-based tests and the impossibility of making copies.

3.4. Disadvantages of face-to-face learning

Lastly, respondents reflected on the disadvantages of face-to-face teaching, and here too they based their opinions on the advantages of online teaching, see Table 4. For many respondents, commuting and the resulting time or financial demands are a problem. Nine respondents found no disadvantages to face-to-face teaching. A disadvantage can also be an unsuitable environment, where learners cannot relax and do not have the comfort and peace of mind to learn as in a home environment, they are stressed and find it more mentally challenging. Respondents also encountered the problem of low motivation due to traditional frontal teaching or boring lectures. Sick pupils miss classes and then have to catch up, and if they go to school they can infect other pupils. Some respondents lacked an online repository to keep track of assignments and access study materials.

3.5. Innovation of face-to-face learning with elements of online learning

The majority of learners would like to use elements of online learning in their face-to-face learning. Only two respondents said they would not want these elements in face-to-face learning. The majority of respondents (57) indicated the possibility of using digital learning resources, providing study materials and lecture recordings so that they could return to the material later. Online assignments were also very popular, with fifty-five respondents indicating this. Next was the use of shared storage, selected by forty-nine respondents. The ability to join an online class from home would be welcomed by forty-seven respondents. Thirty-four respondents need space for self-study, while only seventeen respondents need online collaboration.

4. DISCUSSION

It is clear that for many students, the key lies in the interaction with other students or teachers. This is confirmed, for example, by the results of the research of Bickle et al. (2019) that the ability to learn does not only depend on the methods and content of teaching, but also on social interaction and interpersonal relationships.

Our research results also confirm other researches in that the key to quality online or hybrid learning lies with teachers. And also, that many factors influence learning outcomes, such as learning style, ability, personal goal, teaching methods and technology (Lin et al., 2017). We found that problems in online learning were often caused by its poor organization (as Rath et al., 2019), whether it was a lack of experience on the part of the teacher or the learners, a problem of lack of learner awareness or insufficiently explained material, inconsistency of the chosen platforms, but also a loss of discipline or a problem of attention retention, which can also be experienced

by students in face-to-face classes if it is not properly organized. These results are confirmed e.g. by Bickle et al. (2019), Gamage et al. (2022).

CONCLUSION

As we stated at the outset, the main objective was to arrive through the research questions at ways to appropriately organize hybrid learning. The main idea was to build hybrid learning on the advantages of online and face-to-face learning, so that it would be an ideal choice for future learning. At the same time, however, it is important to avoid the disadvantages of online and face-to-face learning.

Hybrid learning offers the potential to remove the disadvantages of online and face-to-face learning. The fact that each student can choose whether to attend in person or online is the main reason why it should receive more attention in the future. It is a choice that individualizes learning and allows students to use their own learning style. Whether they are sick, or students who have a commuting problem, they can join an online class and yet the class can also be taught in person with all the benefits it offers for those who, on the other hand, prefer this form of learning. In secondary school, this choice would have to be accompanied by certain rules to prevent truancy. One possible weakness of our research is the smaller range of respondents to the questionnaire survey, but as we have already mentioned, this is only the first phase of our research for now, and we will therefore eliminate this shortcoming later by expanding the range of respondents to other universities with faculty of education. It is also clear that the area of hybrid learning still offers a lot of space for further research, so we want to continue to focus on this area, to gradually explore and complete the broader picture of this issue. However, our primary goal is to identify methods for effectively organizing hybrid learning, ensuring it becomes the optimal form of instruction for both students and teachers.

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USING MOODLE FOR INQUIRY-BASED LEARNING IN MATHEMATICS

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Abstract: *The scientific article aims to explore the possibilities of using the Moodle platform to implement a research-oriented approach to teaching mathematics based on students' questions and active engagement – Inquiry based learning in mathematics (IBLM). The article analyses the results of a survey of students, which was conducted in order to identify the difficulties faced by students during distance learning of mathematics. Problems encountered by students in learning mathematics online are identified, along with ways to overcome them. The opportunities provided by the Moodle platform to support active and research-oriented mathematics learning are highlighted, in particular, the creation of a favourable learning environment where students can explore mathematical concepts, formulate questions and solve problems at different levels of Inquiry based learning. The article provides examples of mathematics tasks developed on the Moodle platform aimed at teaching distance at different levels of inquiry, including structured, guided and open. Special emphasis is placed on the development of an individual approach to teaching mathematics that takes into account the level of students in Inquiry-Based Learning IBL. Thus, the article contributes to the understanding of the possibilities of using the Moodle platform for the implementation of IBL in the study of mathematics.*

Keywords: Moodle; distance learning of mathematics; Inquiry based learning in mathematics (IBLM)

INTRODUCTION

The leading methodology of modern education is active, research-oriented learning, which is designed to form key competences necessary for the culture of democracy (Competences for democratic culture). One of the effective strategies for achieving

this goal is Inquiry based learning (IBL). This strategy develops students' critical thinking and creative potential, engaging them in active work on their own research and problem solving.

In today's digital world, where information communication technologies are at the center of attention, educational platforms are becoming indispensable tools for implementing the IBL approach. One of such platforms that is gaining more and more popularity in teaching mathematics is Moodle. Moodle is an open learning management system that helps create a stimulating learning environment where students become active participants in the process of learning and research, which is what Inquiry-based learning consists in.

In this article, we will examine the use of Moodle to implement an IBL approach to mathematics education. We will explore how Moodle can become a powerful tool for stimulating students' independence and activity in the process of learning mathematics. We will also consider examples of specific Moodle tools and functionality that contribute to the implementation of the IBL approach.

1. ANALYSIS OF CURRENT RESEARCH

The importance of IBL in mathematics learning as a pedagogical technique that encourages students to explore, hypothesize, discover, prove, collaborate and communicate is revealed in (Capaldi, 2015; Dorier, & Maass, 2020). Calleja, J. distinguished four features of IBL in the mathematics class: mathematical tasks, collaborative learning, purposeful questioning, student agency and responsibility, led teacher's role and conditions for IBL (Calleja, 2016). The effectiveness of using IBL in the process of learning mathematics has been proven in many studies, for example (Karamustafaoğlu, & Pektaş, 2023; Nunaki et al., 2019; Pedersen, & Haavold, 2023). The use of digital technologies in teaching mathematics is the subject of modern scientific research, for example Clark-Wilson, Robutti, & Thomas (2020), Hillmayr et al. (2020), Astafieva et al. (2019). Researchers pay special attention to the development of an educational environment for teaching mathematics on the Moodle platform (Darmayanti, Baiduri, & Inganah, 2022). Aspects of using digital mobile technologies to support IBL are described in (Becker et al., 2020). However, the use of Moodle for the implementation of the IBL strategy in mathematics education has not been sufficiently investigated. This opens up prospects for further scientific research. The analysis of scientific sources allowed us to formulate the research question: *What are the possibilities of using Moodle to implement the IBL approach in teaching mathematics?*

2. MATERIALS AND METHODS

Theoretical – analysis, systematization and generalization of scientific and methodical literature to clarify the essence of IBL, its levels, and the possibility of adapting IBLM for the formation and development of mathematical thinking of schoolchildren, definition of the conceptual and categorical research apparatus; generalization of progressive ideas and existing shortcomings in modern secondary education to

justify ways of use Moodle for inquiry based learning in mathematics; empirical: a pedagogical experiment to determine the effectiveness of using inquiry-based learning in the process of teaching mathematics, as well as a survey to find out the difficulties that arise when learning mathematics in an online format and the effectiveness of use Moodle for Inquiry-Based Learning in Mathematics. The research was carried out within the scope of the scientific topic “Mathematical methods and digital technologies in education, science, technology” (state registration number: 0121U111924) of the Department of Mathematics and Physics of Borys Grinchenko Kyiv University.

3. MAIN RESULTS

3.1. Survey

A survey of 37 students majoring in “Mathematics” of Borys Grinchenko Kyiv University (BGKU) from 2019 to 2022 and 10 students of the online school “New Generation” in 2022, regarding the difficulties that arise when studying mathematics in an online format showed that these difficulties are practically the same and can be summarized as follows:

A. Lack of direct interaction with the teacher, which:

- deprives the student of the opportunity to immediately receive immediate answers to questions or additional explanations when learning new mathematical concepts or solving problems. This often leads to a decrease in motivation or even a loss of it when students encounter challenges without knowing how to overcome them.
- prevents deprives the teacher of promptly diagnosing the cause of the mistake made by the student and conducting work on correcting knowledge in a timely manner, which, as a result, negatively affects the student’s conceptual understanding of mathematical concepts, facts, methods, significantly increases the time for their assimilation and forms a stereotype about the complexity and incomprehensibility of mathematics.

B. Lack of teamwork. Even when teamwork is organized online (synchronously or asynchronously), it is ineffective, since the teacher does not correct the course of the discussion, and if the discussion is “stuck”, then most often no one can “unblock” it, steer it towards generating new, productive ideas. The task remains unsolved, faith in one’s own strength is lost.

C. Lack of self-discipline and the ability to independently organize and rationally allocate time (“... in the classroom I focus on work, I don’t get distracted, but I can’t do this during distance learning”).

D. Technical problems: It is not uncommon to experience problems with technical facilities such as computers, software, or power and Internet connections, which is particularly common during and as a result of Russian missile strikes. This results in interruptions in learning, stress and inconvenience in completing tasks.

There are reasons to assume that not only the successful choice of a distance education platform, appropriate digital tools, but also the Inquiry based learning (IBL)

strategy can significantly minimize the difficulties of online mathematics learning, as it involves students in research, active search and construction of knowledge, stimulating interest and motivation. IBL provides communication and interaction between the teacher-student and students among themselves, which reduces the feeling of isolation in the online environment, and various online platforms are an ideal place for discussions, joint problem solving, and teamwork. In addition, IBL encourages flexible individual learning, aiding in better time management and mitigating self-discipline issues.

3.2. Pedagogical strategy of Inquiry-Based Learning (IBL) and its implementation in the training of future mathematics teachers

The IBL approach, initiated in the 60s of the last century by Joseph Schwab, is actively developed (at all levels of education) and researched. This is evidenced by numerous publications, for example (Goodchild, Fuglestad, and Jaworski, 2013; Laursen, & Rasmussen, 2019; Manoli et al., 2015) and the implementation of a number of international projects. In one of these projects, namely, Erasmus + KA2 “Partnership for Learning and Teaching in University Mathematics” (PLATINUM), teachers of the Department of Mathematics and Physics of the Borys Grinchenko Kyiv University participated. The project developed methods and tools of IBL in mathematics higher education at the theoretical and practical levels. The results of the project are accumulated in a collective monograph (Gómez Chacón, Hochmuth, Jaworski, Rebenda, Ruge, & Thomas, 2021).

Inquiry based learning in mathematics (IBLM) is based on a paradigm in which students are encouraged to work in the same style as professional mathematicians: observe, experiment, notice properties and regularities, ask questions and look for mathematical, scientific ways to answer them, express hypotheses, make generalizations, interpret and critically evaluate solutions, communicate effectively in the process of searching, presenting, discussing ways and results. Within such a paradigm, the teacher is a partner (tutor, facilitator) of joint activities with schoolchildren. IBL requires a fundamentally different model of organizing the educational process, when the teacher organizes pedagogical support for the student's self-learning, effectively directs the trajectory of his search and research activity, which leads to the acquisition of new (for the student) knowledge. An inherent feature of IBL is the student's active participation and responsibility for acquiring (constructing) knowledge. With a series of purposeful inquiry-questions, the teacher (or student) directs progress towards the formulation of the hypothesis, supporting and encouraging discussion, reflection, and mutual assistance.

According to (Zion and Mendelovici, 2012), three levels of IBL organization of students on the way to new knowledge are distinguished: structured, guided and open Inquiry. We characterize the activity of the teacher and students in the implementation of IBML at each of these levels as follows.

Level I. Structured Inquiry

The teacher formulates a research question (problem, problem statement), briefly describes the procedure (solution idea), and students, implementing the proposed procedure or idea, come to the answer (get the result). The stages of the solution, intermediate conclusions or results, explain and argue.

Level II. Guided Inquiry

The teacher only formulates a research question or problem. Students independently analyse a known or new problem, formulate hypotheses regarding the idea of a solution or result, choose a method, procedure, tools to find an answer to the question, present and justify their choices and the result obtained, formulate certain conclusions (whether the solution is unique, whether it is sensitive to minor changes in parameters, whether it has interesting partial cases; whether the chosen method is rational, what are its “pros” and “cons”, what are other possible solutions).

Level III. Open Inquiry

Students independently formulate a research question or problem, look for a research method or solution, develop and implement the appropriate procedure, choose the necessary tools and present their results and conclusions. The teacher, depending on the situation, acts as a consultant, partner, team member, tutor, facilitator or opponent. Depending on the level of readiness of the students and their previous experience in search and research activities, the teacher implements one or another level of Inquiry. It is obvious that one should start with the first and second levels, gradually moving to the third level, at which the research work of students most completely repeats the work of scientists, except for the example of solving simpler (for a scientist, but not for a student) problems.

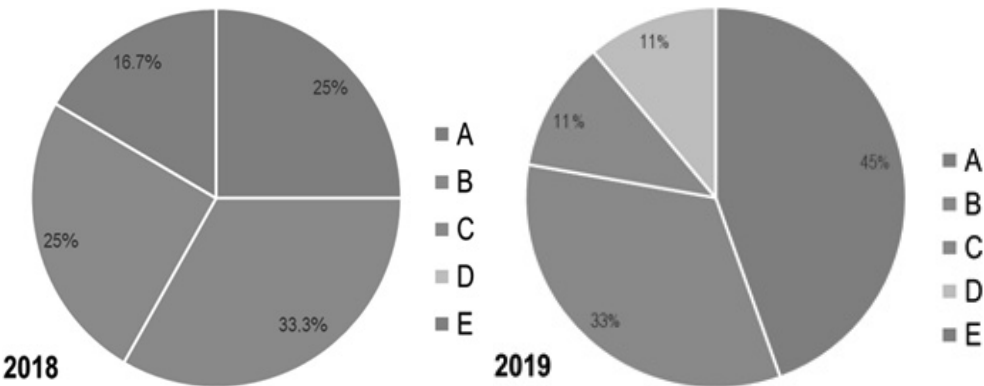


Figure 1. Results of exams on mathematical analysis of first-year students in 2018 (12 students) and 2019 (9 students) years of admission, respectively (A, B, C, D, E – ECTS grades)

Source: Own work.

IBLM pedagogical strategy tools (existing and developed by participants of the PLATINUM (Partnership for Learning and Teaching in University Mathematics) Project) were tested at Borys Grinchenko Kyiv University when teaching mathematical analysis in the “Mathematics” specialty (teacher Mariia Astafieva) and confirmed their effectiveness in forming conceptual mathematical knowledge and mathematical competence in general in students – future school teachers of mathematics (Inquiry in University Mathematics Teaching and Learning, 2021, pp. 327–348). This is evidenced by the comparative results of the exams of two academic groups of students of the 2018 and 2019 years of admission, in the second of which the IBLM strategy was implemented (Figure 1, (Inquiry in University Mathematics Teaching and Learning, 2021, pp. 346)).

3.3. Adaptation of IBLM for the formation and development of mathematical thinking of schoolchildren

The positive results of the approbation (within the PLATINUM Project) of IBL in the educational process of mathematics students of the university prompted the adaptation of the mentioned strategy to school mathematics education. This idea was implemented in 2021 in the mathematics education of fifth-grade students of the I–III Degrees Specialized School № 129 in Kyiv (teacher – Kateryna Hruzdova). We proceeded from the thesis that the cognitive basis and cognitive component of mathematical competence is mathematical thinking, the best field for the formation and development of which is mathematical problems.

We assumed that the use of tools and techniques of IBLM, the competent construction of assistance by the teacher in the form of a system of questions makes it possible to use the developmental potential of the task to the maximum. We changed some problems from the textbook or prepared new mathematical problems from all topics of mathematics of the 5th grade, the solution of which would resemble the work of a mathematical scientist (from experiment, observation to the formulation and testing of a hypothesis), developed pedagogical support for this process in the IBL style, and conducted a pedagogical experiment described in (Astafieva and Hruzdova, 2021). The results of the experiment confirmed our assumption. Diagnostic testing of the level of formation of mathematical thinking in experimental and control classes (30 students in each) showed a significant advantage (from 22% to 39%) of the results of the experimental class in all parameters that characterize mathematical thinking (Astafieva and Hruzdova, 2021). Determination of the level of mathematical thinking in two groups of test takers, carried out using the methods of the theory of fuzzy sets (Zadeh, 1978), showed a sufficient level of mathematical thinking of students of the experimental class (the indicator 0.68 is contained in the term E4, which characterizes a sufficient level), and the level of mathematical thinking of students of the control class (0.36) is in the transition zone from elementary (E2) to middle (E3) levels, and the value of the belonging functions indicates a higher degree (0.9) of belonging to the zone of the elementary level (Figure 2, (Astafieva and Hruzdova, 2021)).

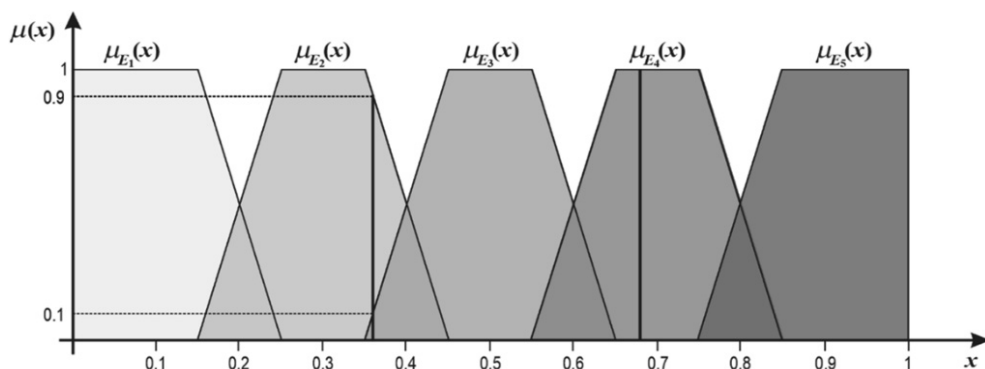


Figure 2. Terms of the linguistic variable “Mathematical thinking”

Source: Own work.

3.4. Using Moodle for IBLM in a distance format

The prevailing circumstances in Ukraine, including the pandemic and Russia’s military aggression, have necessitated the shift of the educational process to a distance format. New distance schools are being established, and one such institution, the “New Generation” distance school, was founded at Borys Grinchenko Kyiv University during the 2022–2023 academic year. Drawing from our positive experience with IBLM in face-to-face education, we have implemented this strategy in the “New Generation” distance school using the Moodle platform. The choice of this platform for IBLM is primarily due to its capacity to actively engage students in the educational process, stimulate their independent search and research work, offer diverse options for differentiated learning, both group and individual work, facilitate effective interaction between the teacher and students and among students themselves, and allow for monitoring the progress of students to enable timely adjustments to the educational process. For effective IBLM, it is necessary that the educational strategy of the teacher and the activities of students correspond to one or another level of Inquiry (structured, guided or open). Therefore, all students should be divided into groups based on their readiness for research-oriented learning. It is obvious that the composition of such groups is dynamic and the teacher’s goal is to ensure that students gradually move to a higher level. The tests used avoid closed-type tasks that only require the selection of a single correct answer from multiple choices, because such tasks do not provide information about the student’s analytical skills, research abilities, or overall mathematical thinking. Instead, tests often involve ‘short answer’ or ‘essay’ tasks. Here are some examples of using Moodle tools to implement the IBLM strategy.

Example 1. Lesson

“Lesson” is convenient to use for learning new material or solving a problem. The structure of a lesson on the same topic is different for different levels of Inquiry. Figures 3 and 4 show the “Lesson” diagrams for Structured and Guided Inquiry, respectively. A screenshot of the collapsed view of the lesson on the topic “Condition of perpendicularity of vectors” for the “structured inquiry” level can be seen in Figure 5.

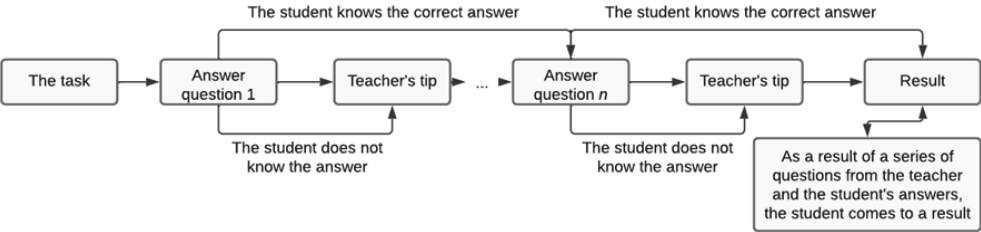


Figure 3. Lesson structure for structured inquiry
Source: Own work.

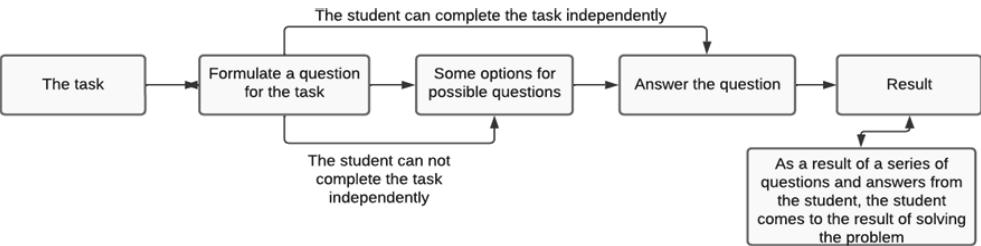


Figure 4. Lesson structure for guided inquiry
Source: Own work.

The condition of perpendicularity of vectors

Preview	Edit	Reports	Grade essays
Collapsed	Expanded		
Page title	Page type	Jumps	
What vectors are called perpendicular?	Multichoice	Next page Perpendicularity of vectors Perpendicularity of vectors	
What is the angle between perpendicular vectors?	Short answer	Next page The angle between the vectors	
Choose the option of the scalar product of vectors if the vectors are perpendicular	Multichoice	Next page Scalar product of vectors Scalar product of vectors	
What is the numerical value of the scalar product of perpendicular vectors?	Short answer	Next page The value of trigonometric functions of some arguments	
Make a conclusion: formulate a proven statement using the construction "if..., then..."	Multichoice	Next page Correct answer with explanation Correct answer with explanation Correct answer with explanation	
Formulate a statement inverse to the proven one	Multichoice	Next page Inverse statements Inverse statements Inverse statements	
Make a conclusion about the correctness of the inverse statement by going through the chain of reasoning in reverse order	Content	Next page The condition of product equality is zero.	
Formulate, if possible, the criterion for perpendicularity of vectors	Multichoice	End of lesson Necessary, sufficient, necessary and sufficient conditions Necessary, sufficient, necessary and sufficient conditions	

Figure 5. Collapsed view of the lesson on the topic: “Condition of perpendicularity of vectors” in Moodle
Source: Own work.

Example 2. The forum

In the forum there is a task: “At the base of the pyramid is a triangle with sides a , b , c . The side edges of the pyramid are equal to each other and have a length of l .

A. Generate the question (requirement) of the task. B. Offer answers to questions formulated by your classmates. C. Discuss, evaluate questions and answers and solutions”.

The effectiveness of using the forum for teaching students to ask mathematical questions, to formulate a problem, that is, to work at the third (open) level of Inquiry, is evidenced by the questions and tasks proposed by students: from the simplest (what is the height / volume / area of the side (full) surface of the pyramid? why are the flat angles of the trihedral angle at the top of the pyramid equal? what angles form the side edges of the pyramid with its base?) to the more interesting (what are the dihedral angles of the pyramid equal to? what is the radius of the sphere circumscribed around the pyramid? what is the volume and surface area of the cone circumscribed around the pyramid equal? why are the volume and surface area of the cone inscribed in the pyramid equal?), and even complex (what is the radius of the sphere inscribed in the pyramid? express the desired radius through the volume and the full surface of the pyramid; find the ratio of the volume of the cone circumscribed around the pyramid to the volume of the pyramid, write down the corresponding formula through the perimeter of the base of the pyramid and the length of the circle of the base of the cone). It is also important that all students asked their questions, each according to their level of conceptual understanding and knowledge of the topic “Pyramid”.

Example 3. Hidden text

Solve the problem

At the base of the pyramid lies a right-angled triangle with a leg α and an adjacent angle β . All lateral edges of the pyramid are inclined to the plane of the base at an angle. Find the volume of the pyramid.

1. What do you need to find in the problem?

► Task requirement

2. What do you need to know to answer the questions of the problem?

► The formula for the volume of a pyramid

3. Make a schematic drawing for the problem. What information, important for drawing a picture, does the condition of the problem contain? Why is this information important?

▼ The figure

Information that all the edges of the pyramid are inclined to the plane of the base at the same angle is important for drawing the figure. If all the edges of the pyramid form the same angle with the plane of the base, then the base of the height of the pyramid is the center of the circle described around the base of the pyramid (explain this fact). Since the base of our pyramid is a right triangle, and the center of the circle circumscribed around the right triangle is the middle of the hypotenuse (why?), then this point is the base of the height of our pyramid.

4. Do we have enough data to immediately use the pyramid volume formula?

► Are all values known?

5. How can you find the area of the base of a pyramid? Which of the methods is more appropriate in this case? Why?

► The area of the base of the pyramid

6. How to find the height of a pyramid?

► The height of the pyramid

7. Write down the volume of the pyramid

► The volume of the pyramid

8. Write a complete solution to the problem

► The complete solution

Separate groups

Figure 6. An example of a task in Moodle with hidden text

Source: Own work.

In order to differentiate the pedagogical support of students' search and research work in the conditions of distance learning (when the teacher does not have direct contact with the student and therefore cannot immediately provide him with the necessary help), it is useful to initially hide part of the text on the page of the educational material with the possibility of accessing it as needed. Moodle allows you to do this in HTML editing mode. In Figure 6, we see a task to solve a stereometry problem, in which pedagogical support in IBL style is provided by hidden text. Completion of this task is not evaluated, which encourages the student to be honest with himself and use the hidden text rationally in order to prepare for the independent solution "for evaluation" of a similar problem.

4. DISCUSSION

Here is some feedback from teachers and students about the usefulness of Moodle tools in implementing IBL in online mathematics education.

Teacher 1. Forums in Moodle allow students to express their ideas, ask questions, share their research, collaborate and learn from each other. Hidden text tasks stimulate curiosity and help students actively explore the material on their own, searching for answers to questions. A wiki allows us to create collaborative projects and research, which develops collaborative and creative thinking skills.

Teacher 2. We use quizzes in Moodle as an effective way to assess student knowledge. Moodle allows us to create different types of questions, but we prefer open-ended test tasks, in particular, "write the answer as a number". Automatic grading helps you save time when reviewing tests. In addition, Moodle has the ability to provide feedback and statistics about student responses, which helps us understand which aspects of the material need more attention.

Student 1. Moodle has been a real lifesaver for me when learning mathematics. It was very difficult to study online without it. Because when you read a textbook and something is unclear or when you have to solve a problem and you don't know where to start, then everything remains unstudied and unsolved, because there is no one to ask. The Moodle Forum provides an opportunity to discuss complex issues with my classmates and receive answers from our teacher. This allows me to better understand the material and get support when I need it. However, it turned out that asking the right question, explaining exactly what you do not understand, what the problem is, is also a difficult task. Also, using the Forum encourages learning to ask questions.

Student 2. Moodle is a very comfortable educational environment for me. I can go through the material at my own pace and refer to it at any time convenient for me. Also, the Forum allows me to discuss issues with my classmates. It is very interesting to see how the same problem (most often – geometric) can be solved in many different ways. In the Forum, we often arrange a kind of competition – who can find more ways, and whose way is the most rational, the most beautiful. It is important that in all our discussions the teacher is "invisibly" present, who at the right moment, when the discussion has reached a "dead end", will lead out of it, help to see the error.

Student 3. The use of hidden text in "lessons" and "tasks" allows me to independently solve problems and check my answers, or at a certain stage to use a hint if

difficulties arise. This tool helps me to better understand and apply mathematics, and it also encourages me to try my hand at solving problems myself, because you know that there is always an opportunity to use help.

Student 4. The Forum allows me not only to get answers to questions, but also to help other students who have difficulties. It gives me confidence. I also feel that we are a team, a community where mutual help and support are valued.

Student 5. Self-tests help me a lot to study. I like to get results and feedback instantly. It helps me quickly identify my mistakes and weaknesses, which gives me the opportunity to improve my knowledge and thus better prepare for the knowledge test. Although the given student feedback does not contain any mention of IBL, but only that Moodle helps them in online mathematics learning, in fact, these feedbacks show that the use of the Moodle platform and its interactive tools helps to support the principles of Inquiry-based learning in the process of online mathematics learning, promoting the active participation of students in their search and research activities, supporting interactivity and interaction between participants in the educational process, developing creativity and the ability to alternative thinking, fostering independence and self-discipline.

CONCLUSION

1. A survey of students and schoolchildren confirmed that the online format of learning mathematics is accompanied by certain difficulties, such as the lack of direct interaction with the teacher, lack of teamwork, lack of self-discipline and the ability to independently organize and rationally allocate time, as well as technical problems.
2. Using the IBL strategy can be an effective solution to these difficulties because, as confirmed by the experiment of teaching students and schoolchildren in the classroom, IBL involves students in active search and construction of knowledge, stimulates their interest and motivation, and also promotes interaction between students and teachers.
3. The use of the Moodle platform contributes to the effective implementation of the IBL strategy at different levels of inquiry (structured, guided and open) in distance learning of mathematics. Moodle allows teachers to effectively organize both group and individual work, interact with students and monitor their progress, and also promotes active involvement of students in research activities.
4. According to feedback from teachers and students, Moodle tools effectively support the IBL principles in online mathematics learning, encouraging active participation of students in search and research activities, fostering their creativity and ability for creative thinking, and promoting interaction and interactivity in the educational process.

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GAMIFICATION AS A MEANS OF FORMING SOCIALLY SUCCESSFUL PERSONALITY OF A TEENAGER

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Abstract: *The article outlines the essence of gamification as an innovative means of forming a socially successful personality of a teenager and presents a description of the successful implementation of a curriculum with elements of gamification in the educational process of educational institutions. To achieve the goal of the research, theoretical methods were applied – analysis, synthesis, comparison, systematization, generalization, specification; empirical methods – observation, questionnaires, blitz-surveys, program implementation and evaluation of results.*

The research took place during the 2022/2023 academic year at the Center for Extracurricular Work “Northern Lights” in the Svyatoshyn district of Kyiv. A total of 214 teenagers from grades 7–9, who were participants in the network of extracurricular activities at the Center and general secondary education institutions in the Svyatoshyn district of Kyiv, were involved in the research.

The content and methodical features of the educational program “Social successfulness” are characterized, in particular, its objectives. The design of the program’s experimental implementation is proposed, a comparative analysis of possible formats of its broadcast is provided, and the gamification tools necessary for its implementation are highlighted.

The study carried out a pedagogical reflection and found that, according to the results of the blitz survey, teenagers articulated two most common portraits of a socially successful personality (based on external indicators of success and personal

qualities). According to the results of the questionnaire, the overwhelming number of respondents positively perceived game tools and acknowledged their own activity during training with the use of gamification as productive.

Keywords: social successfulness gamification tools, game elements, mixed learning, portrait of a socially successful personality

INTRODUCTION

Social successfulness is one of the evaluation parameters of an individual and one of their most important values. The need for the formation of a socially successful personality of a teenager is due to the fact that adolescence is the main and turning point for the formation of a system of personal values in adult life. In this age period, the social situation of human development changes significantly: self-awareness is formed, a stable perception of the surrounding world and society is formed, there is an active search for ways of self-affirmation and ways of self-realization, behavior becomes collective and group.

Today's teenagers are children of the digital age, surrounded by the Internet, gadgets and related information and communication technologies. Therefore, in order to form a socially successful personality of a teenager, it is necessary to create an information-rich and developmental environment that fosters their moral and ethical growth, a desire for knowledge acquisition, and the development of teamwork skills. Adapting the educational process to meet the needs of the teenager, integrating the teenager into the system of modern social relations and enabling them to obtain a positive experience of social successfulness are facilitated through contemporary educational and nurturing approaches. In particular, the effectiveness of the nurturing a socially successful adolescent personality in general secondary education institutions is provided by information and communication technologies. A review of both domestic and foreign scientific sources (Antonov, 2022; Dichev, & Dicheva, 2017; Oliveira, Hamari, Shi et al., 2023; Özel, Nelson, Bertram, & Martignon, 2021; Para, 2021; Taspinar, Schmidt, & Schuhbauer, 2016) indicates that gamification, the application of game elements and principles in non-game contexts, is an important means of forming a socially successful student's personality.

The purpose of the article is to reveal the essence of gamification as an innovative means of forming a socially successful personality in teenagers and describe the successful implementation of a curriculum enriched with elements of gamification elements in both extracurricular and general secondary education settings.

Research questions

1. How does gamification affect the social successfulness of adolescents?
2. What are the objectives and distinctive features of the «Social successfulness» educational program in terms of its content and methodology?
3. What is the design of the experimental implementation of the educational program?

4. What is the most effective format for delivering the «Social successfulness» educational program?
5. Which gamification tools are recommended for use in the process of forming a socially successful personality?

1. THEORETICAL FOUNDATIONS

1.1. Gamification in the modern scientific discourse

Games are among cherished forms of human activity, traditionally used not only for entertainment, but also for educational purposes. We agree with the scientific findings of Cypriot researchers who state that „games have been for a long time a part of the culture and play as a medium for entertainment, learning, teaching, and relationship building. Recently, games have been digitized, leading to an increase in the amount of use and implementation in our daily lives” (Al-Dosakee, & Ozdamli, 2021, p. 561).

The term „gamification” itself originated in the realm of digital media. Over time this term has come to describe „those features of an interactive system that are aimed at motivating and engaging end users through the use of game elements and mechanics” (Seaborn, & Fels, 2015, p. 14). It is important to note that gamification is not the process of creating an entire game, but, rather, the transfer of some of its positive elements, mechanisms and characteristics (such as freedom of participation, motivation, clear rules, purpose, tasks, visualization, competitiveness, and feedback) into non-game contexts.

To date, there is no universally accepted definition of this term. As emphasized by British and Swedish researchers, nowadays „gamification is applied in various contexts, such as education, health, business and sustainability. By implementing game elements, gamification initiatives in these contexts often aim to influence people and promote desirable actions and behavior, for example, when they exercise running, shop, teach and learn. In many instances, gamification is deployed to motivate people to become actively engaged” (Langendahl, Cook, & Mark-Herbert, 2017, p. 2247). Simultaneously, gamification has the capacity to make a particular process or object so attractive that individuals remain engaged with it over an extended period of time. In education, the gamification trend is closely related to the concept of interactivity, which opens up opportunities for dialogue, fosters motivation for self-development and, most importantly, actively engages learners in the educational process. Within the context of gamified education, modern online games are proposed as a means to achieve desired results in the study of specific subjects.

„Gamification offers to „enliven” and diversify educational tasks with the help of the Internet and modern multimedia technologies” (Perryer, Celestine, Scott-Ladd, & Leighton, 2016, p. 328). Hence, American researchers consider gamification a new educational theory and conceptualize the game „not as a simple set of techniques and mechanics, but as a pedagogic heritage and an alternative framework for training and shaping participant behavior that has at its core the concepts of entertainment and engagement” (Dichev, & Dicheva, 2017). Ukrainian scholars unanimously contend

that „the main goal of gamified learning is the acquisition and application of knowledge, and not the usual passing of a stage or obtaining a good grade” (Mykhalova, Semenyshina, Krasnoshchok, & Stupenkov, 2023). In addition, gamification enables the gradual adaptation of the scope and complexity of tasks in accordance with users’ acquisition of new skills and competencies.

We share the viewpoint of Ukrainian researchers, who assert that „gamification in education can be considered both as a method of learning and upbringing, and as a form of educational work, and as a means of organizing a holistic educational process” (Pereyaslavskaya, Smagina, 2019, p. 251). In our opinion, gamification in education constitutes a diverse array of tools and mechanics that significantly enrich the educational experience with entertaining, educational, nurturing, motivational, and social-communicative components.

Thus, gamification in education is a natural stage in its development, enabled by the integration of effective information and communication technologies into the educational process and the powerful activation of the potential within developing individuals who grasp and engage with the features of the game and game mechanisms.

1.2. The potential of gamification in the formation of a socially successful personality of a teenager

Shaping a socially successful personality in a teenager is a long and complex creative process aimed at fostering their productive social engagement and developing qualities necessary for social success, such as perseverance, responsibility, initiative, self-control and the ability to construct a step-by-step strategy for social success. Gamification serves as a means to modernize this process through various digital tools (Internet platforms, mobile applications, games), engaging teenagers by „activating their attention, understanding, interest, perception, thinking” (Pereyaslavskaya, & Smagina, 2019, p. 252) and arousing sincere interest in accomplishing educational goals. Gamification elements turn ordinary exercises into exciting activities and equate enjoyment with learning. Gamification not only turns the educational process into a pleasant, exciting event, but also motivates a teenager for self-improvement using various elements. In particular, the competitiveness embedded in the content of the game promotes competition; prize incentives (premium points, badges, leader lists) are external recognition of the participant’s success; excitement and overcoming difficulties and obstacles stimulate the desire for progress.

The following aspects of gamification become relevant in shaping a socially successful personality: dynamics (incorporating scenarios that require the user’s attention and reaction in real time); mechanics (using elements characteristic of gameplay scenarios: card drawing, bargaining, attack, competition, cooperation); aesthetics (creating an overall gaming experience); social interaction (using techniques that ensure effective communication).

It is worth noting that gamification simplifies the achievement of goals related to shaping a socially successful teenager’s personality without imposing physical and psychological strain. These objectives include increasing learning productivity; recognizing and encouraging leadership, defining each teenager’s personal development

direction, fostering improved communication in the educational environment; uniting teenagers around common ideas, involving them in team activities; supporting reflection regarding their contributions to joint activities, minimizing conflicts; and cultivating moral values, and a desire for self-development.

2. RESEARCH METHODS

The following methods were used to achieve the goal and fulfill the tasks of the research: *theoretical* – analysis, synthesis, comparison, systematization, generalization of materials from psychological and pedagogical sources; specification – enhancing the understanding of the concept of „social successfulness”, coordination of the content of the „Social successfulness” educational program and other relevant documents related to the program and its implementation; *empirical* – observation of teenagers during classes in the program, surveys (questionnaires) to collect empirical information, blitz surveys aimed at gauging awareness of the characteristics of a successful personality, and the implementation of the educational program and evaluation of its impact as perceived by the respondents.

The research was conducted during the 2022/2023 academic year at the Center for Extracurricular Work „Northern Lights” in the Svyatoshyn district of Kyiv. A total of 214 teenagers from grades 7–9 participated in the study. These teenagers were drawn from the network of circles at the Center for Extracurricular general secondary education institutions within the Svyatoshyn district of Kyiv.

The diagnostic tool used for the survey was the „My participation in the „Social successfulness” Program” questionnaire. Among the interviewed teenagers, 59.1% (n=126) were boys, 40.9% (n=88) were girls. 15.2% (n=32) of the teenagers lived in villages, 22.2% (n=48) live in urban-type settlements, 25.3% (n=54) in small towns, and 37.4% (n=80) in larger cities.

3. RESEARCH RESULTS

3.1. Content and methodological particulars of the educational program „Social successfulness”

The educational program „Social successfulness” was elaborated by the Ukrainian researcher K. Bezruk to provide the comprehensive program and methodological support for the education and personality development of teenagers in extracurricular education institutions (hereinafter referred to as the Program). The program’s objectives are centered on the formation and development of soft skills in learners, fostering a mindset of a successful personality in teenagers, and motivating them to strive for success.

The program is designed to facilitate the close interaction between the educational institution and stakeholders in shaping the foundational aspects of social successfulness for learners. It aims to cultivate a range of competencies: cognitive; social; information; life-creating skills. The scope of the Program is designed for one year of study at the basic level, amounting to 144 hours per year (with weekly planning

involving two sessions, each lasting a total of 4 hours. It is aimed at learners in grades 5–9, with a recommended group size of 15 to 20 participants.

The program consists of an explanatory note, the main part and appendices. The main part of the Program contains 7 sections. The first four cover various aspects of creating a basis for social successfulness (self-knowledge, development of social and emotional intelligence and communicative leadership, acquisition of media literacy). The following three sections outline important steps in the personal journey toward success (creating value orientations, recognizing the responsibility of choice, prioritizing goals and setting time limits in a multitasking environment, productive teamwork, and self-development and improvement of the qualities of a successful personality).

The organization of educational activities for adolescents under the Program is planned to include various forms and methods such as training sessions, mini-lectures, individual and group work, brainstorming, role-playing games, discussions, debates, and presentations using the „PechaKucha” method (training brevity and accuracy in communication) (Bezruk, 2022). The effectiveness of the Program’s implementation is assessed through formative evaluation methods, which may include the defense of creative works, the presentation of portfolios, the defense of educational projects or conducting research for a scientific society.

3.2. Design of the experimental approbation of the Program

The experimental implementation of the „Social Successfulness” Program was conducted during the 2022/2023 academic year at the Center for Extracurricular Work „Northern Lights” in the Svyatoshyn district of Kyiv. Classes were conducted twice a week, with each session lasting 2 study hours for each group. To ensure scientific and methodological support, an expert group was formed, consisting of 4 scientists, 5 methodologists, and 8 teachers. A reevaluation of prior scientific research and the reflection on observations made during the educational process proved that, under modern conditions, the „Social Successfulness” program can be implemented in three organizational formats: contact (offline), mixed (offline + online), remote (online). A comparative analysis was performed to assess the advantages and disadvantages of each format (as presented in Table 1), leading the experts to select a mixed format for the experimental implementation.

Table 1. Comparative characteristics of possible delivery formats of the „Social successfulness” program

Advantages	Shortages
<i>Offline</i>	
• Building friendly relations, development of communication skills • Interaction with the reference environment, obtaining real experience of cooperation with peers and teachers. • Fast feedback and the possibility of immediate help from the teacher. • Participation in the implementation of group social projects. • Organization and holding of events; visiting museum and theater locations, cinemas, etc.	• A security issue, especially in war zones or during air raids. • Physical and geographical limitations, the need for a room for classes. • Limited access to technical material and resources that facilitate interactive learning. • Additional costs for providing a working office and office resources. • Lack of time to ensure an individual approach to each teenager.
<i>Offline + online (mixed)</i>	
• Interaction with the teacher and peers. • The possibility of additional visualization. • Safety of the educational process. • The ability to choose a learning format and choose a convenient schedule. • Use of a wide range of materials and resources. • The opportunity to improve technical skills in working with computers and using online tools. • Promptness, ability to track progress and provide feedback. • Effective time allocation.	• The need for fast Internet connection, new and effective technical support. • The need to focus on high responsibility, self-organization and self-discipline. • Information overload is possible. • Technical difficulties; problems with the operation of Internet platforms. • High requirements for computer skills. • Additional time and effort to prepare and implement mixed learning.
<i>Online</i>	
• The ability to choose the time and place for classes and your own learning pace. • Free access to educational resources, video lessons, interactive materials and tools to improve learning. • The possibility of completing additional tasks and studying materials at one's own pace. • Self-organization, self-upbringing, self-discipline. • Expanding the circle of acquaintances.	• The possibility of free social communication is limited. • Lack of quick feedback. • The need for stable hardware and software. • The need for personal space to perform tasks. • Developed time management and concentration. • Possible alienation and feeling of loneliness.

Source: Own work.

3.3. Gamification tools

During the implementation of the Program, various gamification tools were used to enhance the learning experience: creation of a thematic promotional video, visualization of rules of interaction, visualization of successful narratives, chat or forum discussions of the course and results of joint activities, competition and rating, obtaining badges, statuses, certificates, etc. They are presented in detail below.

1. *Creation of a thematic promotional video.* To promote the Program as widely as possible and encourage teenagers to engage in it, a promotional video with a motivational mini-video „To success on your own wings!” was created. This video highlighted the program’s objectives and features, piqued interest with appealing effects, and outlined potential benefits of mastering the Program. The promotional video was shared on popular platforms or channels among teenagers, including YouTube, Instagram, Telegram, Viber, and Microsoft.
2. *Visualization of interaction rules.* In order to successfully implement the Program, it is important to develop a training algorithm that is attractive to teenagers. For this purpose, it is advisable to use simple but effective animations (comics). This could be easily created using online resources featuring a wide selection of bright templates and elements: Canva, Biteable, Powtoon, Vyond (GoAnimate), Moovly, Brush Ninja, FlipAnim, video editor with „Renderforest” templates, Wick Editor. Interactive tools like «word clouds» visual representations of key words in the text were used, with tools such as WordArt or TagCrowd employed to create these „word clouds”.
3. *Visualization of successful narratives.* It is better to convey complex material and explain it in simple words using an example of a well-thought-out story with characters known to teenagers from movies, cartoons, video games, or real life. An example can be the creation of a digital museum „Pantheon of successful personalities” in the form of an interactive page or slides about various famous personalities, where the stories of their success will be told. To implement this task, the participants were offered to use such ideas as:
 - *the virtual exhibition hall*, where each teenager creates his own page about a famous person (with text, images, videos and audio files);
 - *multimedia presentation*, creation of multimedia presentations about famous figures (in PowerPoint or Google Slides programs);
 - *didactic game*, interaction of teenagers with success stories of different personalities (platforms for creating games: Kahoot!, Genially, LearningApps.org, Scratch, Flippity);
 - *the comic or animation* is an opportunity for teenagers to show their creativity and create a comic or animation (resources with a simple and accessible interface: Pixton, ToonDoo, Powtoon, Scratch, Animaker);
 - *video stories* are pupils’ creation of short video stories, videos about the life and achievements of famous and successful personalities (online tools for creating video stories: Clipchamp, WeVideo, Animoto).
4. *Use of mental maps.* Such maps can be used as part of a narrative or as a means of visualizing stories. These maps often contained moving elements, anima-

tions, media elements, hyperlinks, videos and interactive elements. You can use the following online resources: Coggle, MindMup, Canva, Lucidchart, Draw.io.

5. *Chat or forum discussions of the progress and results of joint activities.* The possibility of joint communication is ensured through groups (communities), chats or forums, while the system of individual messages can also be used in parallel. To create a community, you should choose a common platform, for example: Telegram, Viber, WhatsApp, Facebook Groups, Slack, Microsoft Teams and others.
6. *Use of means of stimulation and competitiveness* (receiving premium points, badges, statuses, certificates). A system of scoring points was implemented to encourage active participation, responsible conduct, and task completion within the „Social Successfulness” educational program. Points were awarded for aspects such as engagement in training sessions, participation in mass events, responsible behaviour, conscientious task completion, persistence in achieving set goals, reasoned views, optimism, productive group work, patriotism. For a set of productive actions, it is advisable to use such incentives as badges, trophies or statuses, certificates. For this, a solemn or humorous procedure for the public presentation of the award should be considered.

3.4. Learning results under the Program

In order to carry out a pedagogical evaluation of the participants’ educational outcomes in the Program and to assess the teenagers’ awareness of issues of social success, first of all, a blitz survey was conducted (teenagers answered the question: „What does it mean for me to be socially successful?”). Their answers were quite concise and defined this concept from various facets of personality development. Based on the results of the blitz survey, it can be concluded that teenagers articulated two prevailing portraits of a socially successful person: the first is built on the basis of external, socially recognized indicators of success; the second – personal qualities that reflect individuals’ perspectives on successful activities.

One of the tasks of the experimental implementation of the Program was to gauge the participants’ opinions regarding the influence of game elements (gamification) on their emotional state and productivity. The survey findings revealed that over three quarters of the respondents positively perceived gamification tools. Notably „score incentives” (91%, n=195), „ratings” (84%, n=180) and „discussions on chats/forums” (83%, n=178) were the most well-received elements, which can be explained by the correspondence to the leading types of age-related activities of teenagers – communication and competition. „Mental maps” received fewer selections (69%, n=148), possibly due to the lack of experience in group work on associations in distance learning settings.

A significant majority of the participants (91%, n=195) considered their engagement in training with gamification to be productive. Such self-assessment seems important considering the fact that about half of the participants (43%, n=92) indicated their previous experience with personality development training programs, and therefore, they can make accurate comparisons.

Answers to the question „What do game elements of learning work for?” were distributed as follows (Figure 1):



Figure 1. What do game elements of learning work for?

Source: Own work,

It is noteworthy that here the first two positions were also occupied by „gambling competitiveness” (92%, n=197) and „exchange of positive emotions” (91%, n=195), with „better assimilation of new knowledge” (89%, n=190) coming third.

4. DISCUSSION

We concur with the opinion of American scientists that the introduction of gamification elements is fundamentally important for the effectiveness of personality development programmes, in particular, „addressed to related attitudes, activities, and behaviors, such as participatory approaches, collaboration, self-guided study, completion of assignments, making assessments easier and more effective, integration of exploratory approaches to learning, and strengthening student creativity and retention” (Dichev, & Dicheva, 2017). The results of our curriculum testing, „Social successfulness”, with gamification elements further validate this, as it, motivated adolescents to be active and interact with each other, fostering creativity, attentiveness, and clarity in building and implementing their plans.

Additionally, we believe that the findings of British and Swedish scientists, emphasizing the necessity of incorporating additional elements of game mechanics, are worth considering in our future research. Specifically, we intend to explore the use of mobile applications to ensure the monitoring of learning progress, as well as the introduction of the storytelling method to receive feedback communication, which will assist „to encourage students to engage in learning activities, make decisions on what to explore, and crucially to be exposed to consequences of making poor decisions” (Langendahl, Cook, & Mark-Herbert, 2017, p. 2247).

We agree with German and British researchers regarding the leading role of gamification in distance learning, which has gained relevance during the Covid-19 pandemic (Özel, Nelson, Bertram, & Martignon, 2021). „The extended pre- and post-

test, including psychological questionnaires” proposed by the scientists provide a comprehensive means of assessing the effectiveness of learning using gamification in various ways contributing to the development of gamified lessons. Their conclusions correlate with the results of research conducted by Polish scientist A. Para, who emphasizes that the social, economic and technological changes that have occurred due to COVID-19 will have long-term consequences for education, therefore, in the post-pandemic period, distance learning with elements of gamification will become increasingly important: „The use of gamification in distance education brings positive effects not only in the form of increased pupil motivation and engagement, but also contributes to the development of their competencies such as problem solving, critical thinking and team collaboration” (Para, 2021, p. 28).

We are also drawn to the insights of German researchers on the positive effects of gamification in shaping the successfulness of a modern learner: „Learner success is a process that requires from the teacher the ability to combine both useful and enjoyable, didactic elements along with interactive ones. Tools based on the typical mechanics of gamification are not only fun, which is why they are popular among pupils, but also add to the teacher’s toolbox effective means of increasing motivation to learn and developing soft skills” (Taspinar, Schmidt, & Schuhbauer, 2016, p. 101). Similar to the authors of this study, German scientists believe that mixed learning represents the most optimal format for making a positive impact on the behaviour and knowledge levels of participants.

CONCLUSIONS

Thus, based on the results of our theoretical exploration of the problem, the elucidation of the essence and resources of gamification, as well as the implementation of the educational program „Social successfulness”, we can assert that gamification: helps the adaptation of a teenager within their peer groups, promoting socialization and self-improvement; creates favorable conditions for living and discussing various difficult life situations and effective interaction with peers; expands the possibilities of working with information; stimulates independent and informed decision-making regarding one’s life stance and pathways to achieving social successfulness; increases motivation for success and enables self-monitoring of progress.

The optimal program delivery format is mixed learning, which combines the advantages of offline and online learning, offering students greater flexibility, individualization and access to a variety of resources. In the context of modern information and communication technologies, this approach can provide an effective and engaging learning solution in Times of increased risk, such as during martial law or other crisis scenarios.

The introduction of gamification tools into the practice of forming the social success of a growing personality allows advancing and modernizing the educational process, making it both interesting and useful for teenagers. It is necessary to further research the issues of using gamification tools for children of different ages, filling game technologies for teenagers with content that will allow them to overcome fears

caused by war and losses, and will help them to develop resilience, optimism, and prosocial behaviour in teenagers.

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DEVELOPING INFORMATION CULTURE IN STUDENTS DURING E-LEARNING

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Abstract: *This article examines the peculiarities of the formation of information culture of students in the context of electronic learning in higher educational institutions. It is noted that the development and formation of the information society determines new requirements for the individual in both social and professional spheres of activity. The formation of information culture is a priority task for institutions of higher education, as the educational system must respond to modern challenges and quickly adapt to effective functioning in the information society. Digitization, distance education, e-learning, introduction of new information technologies, interactive forms of communication and interaction – all this makes it possible to transfer the educational process to a qualitatively new level and form the information culture of the individual. The study reveals the meaning of the concept of «information culture»; ways and methods of its influence on the effectiveness of the educational process are determined. Information culture is considered as an integration of socio-cultural and technological aspects. This means that the information culture of the future specialist is formed under the influence of the socio-cultural environment of the higher educational institution, with the mandatory use of electronic learning to acquire the competencies necessary for the full self-realization of the individual in the information society. The main components of the information culture of the future specialist are defined, including: information literacy, information-digital competency, information reflection and self-improvement (self-educational competency). It is noted that the rapid increase in the use of information and digital technologies in education, e-learning, in particular the introduction of distance learning, is associated with the COVID-19 pandemic, as well as with the full-scale war in Ukraine.*

The results of sociological research show that, despite certain problems, emergency distance learning allowed university students to adapt quickly enough to new realities, acquire digital skills and increase the level of information culture. It is noted that the experience gained from introducing distance learning will continue to be applied. However, combining traditional and electronic training is considered to be the most effective approach to forming an individual's information culture.

Keywords: information society, information culture, information competency, information literacy, information reflection, e-learning, information technologies, educational process, higher education, students, teachers

INTRODUCTION

In modern society we observe a changing nature of work as well as the growing role of information and knowledge at all levels and in every sphere of social life. This results from the entry of humanity into a new era of its development – the period of building an information society which has aroused great interest in the aspects of informatization, new information technologies, aspects of the influence of informatization on the development of personality in a qualitatively new environment. In this context, a person constantly experiences not only the need for information, but also a lack of certain skills and abilities that must be used in everyday activities. This is particularly urgent in the professional sphere, where the demands on specialists are constantly increasing, including the formation of independent thinking and learning, the ability to monitor changes in various spheres of society and the ability to respond to them critically, the ability to make decisions in complex non-standard situations, which requires deep contextual awareness and ICT experience.

The increased focus on developing an individual's information culture and the intensified use of technologies and e-learning practices are driven by several reasons:

- constantly growing information needs of modern society;
- a revolutionary increase in Internet coverage over the last decade and a increasingly easier access to it;
- dynamic progress in information and digital technologies, distribution of software products to ensure electronic and distance learning, its organization and management;
- active use of information technologies in almost all areas of human activity;
- dynamic broadening of potential opportunities of information technologies in terms of their impact on the individual and society as a whole.

Therefore, the priority task of modern education system is to develop students' information culture for full-fledged activity in key areas of life. In modern conditions, education is the most powerful source of information culture, because in the modern educational process, both traditional and innovative means, methods, and learning technologies are used which contribute to the formation and development of a new type of personality, capable of acting in the context of information society. Digitalization, distance learning, e-learning, introduction of new information technologies, interactive forms of communication, enables the educational process to transition to

a higher quality level, which allows professors to grow the information culture of the individual.

1. PREVIOUS RESEARCH

Previous research into the development of the individual's information culture presents this problem as relevant and quite a few of its aspects are studied closely by modern scientists.

The current research on the individual's information culture is grounded in theories of the information society put forth by D. Bell, M. Castells, M. McLuhan, E. Toffler, A. Turenne. These theories emphasize the critical role of knowledge and information in the modern society.

Numerous scholars study the conceptual foundations of information culture, as well as the problems of its formation in the modern information society (Ukhanova, 2021), (Kovalchuk & Mikhailina, 2023), (Palekha et al., 2020).

Researchers stress that developing information culture of future specialists in educational institutions is a necessary condition for the full inclusion of an individual in the modern information society and future professional activity (Charkina, 2021), (Trubnyk et al., 2019). Studies devoted to the information culture of future teachers (lecturers) hold particular significance (Babenko, 2012), (Hurevych & Atamaniuk, 2023), (Klymenko, 2010).

Importantly, the integration of e-learning into the system of higher education was one of the most effective means of fostering individual information culture. Scholars look into various aspects of the establishment and development of e-learning, the emergence of new information and communication technologies and their integration into the educational process, the transformation of the educational institution in the context of establishment and development of the information society globally and in Ukraine (Kravchenko, 2016), (Areshonkov, 2020), (Kucherak, 2020).

The authors of the present study have a number of publications devoted to certain aspects of the implementation and active use of innovative technologies, e-learning in institutions of higher education, in particular, on network communication and its positive impact on the efficiency of the learning process (Shelomovska et al., 2017), on the use of mass media in education (Shelomovska et al., 2019), on cloud instruments in training students of socio-humanitarian specialties (Shelomovska et al., 2020).

However, the papers mentioned above primarily focus on specific aspects of introducing modern technologies into the educational process and often neglect their influence on the development of an individual's information culture, which is a current necessity.

Therefore, **the purpose of this paper** is to study aspects of developing information culture in university students in the context of e-learning, as well as to pinpoint the general trends in the implementation and use of distance and e-learning during the pandemic and wartime in Ukraine and its impact on the level of information culture of students.

The paper aims to address the following **research questions**:

- What is the structure of the concept information culture?

- How does e-learning and distance affect the process of developing information culture in students?
- What kind of general trends in the implementation of e-learning and distance learning are pinpointed by the sociological research on the state level of Ukraine?

2. PRESENTATION OF RESEARCH RESULTS

2.1. The concept of information culture

Information culture is a highly relevant concept today. However, it still does not have any unambiguous interpretation in the scientific literature. Definitions of information culture often reflect the specifics of research and the field of knowledge. So, let's consider the definition of information culture by various scientists.

Information culture is often considered a part of both individual and societal culture. It varies according to the intensity of information interaction and all information relations. This concept makes it possible to forecast the direction and speed of change in terms of handling information for the purpose of its further elaboration based on the acquired knowledge (Palekha et al., 2020).

Information culture reflects the level of development of information relations in society, as well as people's activity in the information environment. Information culture is designed to give individuals information freedom which equals guaranteed access to all the necessary information, as well as to provide opportunities for information communication and for the development of people as individuals (Kovalchuk & Mikhailina, 2023).

Information culture of an individual is based on knowledge about the information environment, the laws of its functioning and development, the ability to navigate in the boundless universe of endless messages and data, to rationally use the means of modern ICTs to meet information needs (Blystiv & Halaz, 2015).

Some researchers add a legal aspect to the interpretation of information culture. Thus, information culture is interpreted as reflecting a combination of material and intellectual human values that enable the effective application of various methods of processing information, including being a participant of informational legal relations. This definition focuses on the legal regulation behind modern technologies, in particular, the use of artificial intelligence as a phenomenon that has positive prospects, but carries great risks (Ukhanova, 2021).

Therefore, when researching information culture, it is necessary to acknowledge that on the one hand, it contributes to the acceleration of technical progress, affects the development of both the individual and the society as a whole, and on the other hand, it has a significant negative impact. Thus, modern information environment presents numerous threats: destruction and distortion of information, disclosure of confidential information, hacking, illegal interference in the activity of computer systems, disabling them, etc. (Charkina, 2021). Thus, the manifestation of an individual's information culture in the process of using information technologies should be based on the principles of respect for human dignity, humanism, strict observance of human

rights and freedoms, critical perception of information, as well as responsibility for the consequences of one's information activities.

In the broader European and global academic context surrounding information culture, a relatively lower level of research interest in the topic can be observed. This may be due to the broad nature of the concept, which serves as more of a conceptual framework, thus leading studies to concentrate on a specific component of the information culture structure.

Nevertheless, two wide information culture approaches are evident through the literature. Information culture is defined as an environment where information is well-managed and efficiently utilized. One defines information culture as an environment where information tends to be managed well and used efficiently (Oliver, 2017). This approach is commonly implemented in corporate settings and forms a part of the organizational culture. It encompasses the typical information and communication practices in an institution, as well as the accepted attitudes towards information as a resource and specific collaborative efforts to process information. It is argued that each company possesses a distinct information culture that sees information as a valuable resource for accomplishing corporate objectives (Hansen, Widén 2017). Within this knowledge management approach, information culture is regarded as a time-varying feature of the collective information behaviors arising from information and knowledge management processes within an institution. This develops due to the continuous evolution of information needs, along with the conscious or unconscious development of employees' knowledge (Deja, 2023).

The alternative viewpoint posits that the notion of information culture is a multifaceted, all-encompassing concept which reflects cultural values, attitudes and behaviors associated with learning and information. This encompasses an individual's awareness of their own information requirements, as well as their ability to effectively and ethically identify, obtain, evaluate, organize and apply information to address concrete issues and problems. It is a mental framework and an essential component of lifelong learning as a human right in the information age (Elamrousy, 2022). Information culture, with broad implications, is believed to be vital to the transformation of the European educational system (Virkus et al., 2020).

Overall, the analysis of scientific works devoted to the study of the information culture of the individual made it possible to determine that, most often, the information culture is considered as: 1) a component of the general and professional culture of the individual; 2) a set of certain human qualities that allow working with information; 3) a certain level of experience with information and communication technologies; 4) information processing methods; 6) expertise of a specialist in modern society; 5) the ability to work with information and use information technologies to work with it; 7) the ability to analyze and critically interpret information.

When defining the concept «information culture» in our research we are relying on an integrative approach which includes both broad (general humanitarian, sociocultural) and narrow (informational and technological) aspects. Thus, the first aspect includes such components of general culture as value attitudes, motivation, informational needs of the individual which encourage people to search for, process and use the necessary information. In this aspect, the key role is played by the principle of

humanization which indicates that any information should serve the development and improvement of the individual and society in general. Regarding the second aspect, a certain level of mastery of information technologies for full functioning in modern society comes to the fore. It should be emphasized here that the latest technologies, electronic means of learning, digital resources in general are considered the foundation for the information culture of the individual, for their creative potential, for the development of competencies necessary for the full self-realization of the individual in the information society.

Analyzing scientific literature identified the main components of the individual's information culture model. These include:

- *information literacy*, that is, mastering the system of signs and their meanings, work instruments, in particular means of information cognition, as well as their application in professional activity, the ability to navigate information flows, etc. Information literacy is needed for critical perception, evaluation and use of information and media in personal life and professional activity. Simply put, information literacy is our ability to consume and interpret the information that comes our way;
- *information and digital competency* is realized through mastering a computer, e-mail, and Internet technologies; work with library catalogs; experience and willingness to work with information flow in oral and written, printed and electronic forms; awareness of the virtual world meaningfulness; willingness to use various sources of information and information technologies for professional purposes and in the process of self-improvement, as well as willingness and ability to reasonably limit the use of information technologies. Computer literacy forms the foundation of information literacy and information-digital competency. Computer literacy is the knowledge, skills and abilities in the field of informatics that every person needs in order to adequately use the potential of ICTs in their activities;
- *informational reflection* is needed by individuals to track the goals, process and results of their efforts to develop information culture, as well as to be aware of those internal changes that occur in the individuals themselves. The following components are covered by reflection of a person as a subject of information culture: being aware of one's own level of information literacy and competency, features of the value-meaning sphere, adequate understanding of one's competencies in the field of information technologies, etc. Information reflection can only be demonstrated when one has developed information literacy as well as information and digital competency;
- *informational self-improvement* (self-educational competency) is at the top level among the structural components of an individual's informational culture. The transition to a new information society poses a difficult challenge for each individual: not only mastering existing types and methods of activity, but also their constant improvement, development of professional skills, abilities and qualities. It should be emphasized that the ability to independently acquire, structure, and transfer information is a crucial professional competency in any field. Noteworthy, it is informational reflection that precedes informational

self-improvement that gives impetus to the desired trajectory of improvement and updating of knowledge. The structural model of information culture is presented in Figure 1. This model arranges all components in order of importance while also showing how they complement each other.

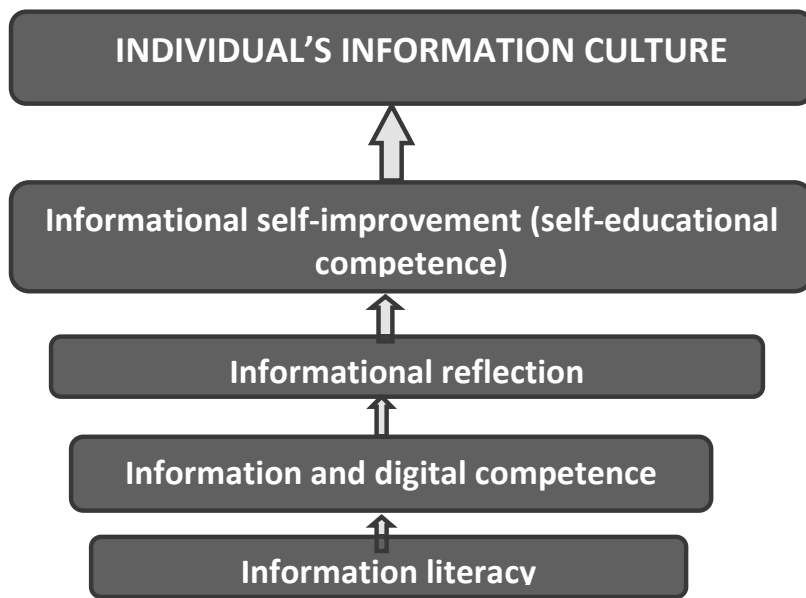


Figure 1. Structural Model of the Individual's Information Culture

Source: Own work.

Rapid informatization is promoting a shift in the educational paradigm: from imparting a certain amount of knowledge to students, to their independent acquisition of the necessary information, interpreting it and using it in professional activities throughout their lives. The self-education activity of a modern day specialist should include at least several components: self-education in the field of professional activity, information technologies, as well as self-improvement in the field of fundamental knowledge.

It has been demonstrated that modern information technologies allow future specialists to gain access to a significant amount of state-of-the-art information, facilitate its search, and also provide tools for information processing. The skills and abilities of professional self-education should be formed during the period of professional training. In the era of booming information society, information technologies are becoming an important means of self-education. The use by future professionals of job related Internet sites, simulation games, participation in network professional communities, webinars, use of social network services, programs for instant messaging, training on Internet courses, etc. will contribute not only to the motivation for self-education, but also enables future specialists to acquire the necessary professional information productively and in the optimal time frame as well as form professional skills and abilities (Nevmerzhyska & Pahuta, 2018).

2.2. Developing information culture in students

The most active and, in our opinion, effective period in the formation of the individual's information culture is university study period. It is there that the person is immersed in a socio-cultural environment, where the main task is to obtain information and competencies to meet their needs both in personal life and in future professional activities.

Noteworthy, the sphere of higher education has significantly changed over the past several decades due to the introduction of new information technologies, interactive forms of communication which allow one to bring quality change to the process of reproduction of knowledge, both in terms of educational management and acquisition as well as perception of information.

E-learning is a study mode that allows participants to use in the educational process Internet technologies, electronic teaching and methodical as well as multimedia materials, electronic libraries, virtual laboratories and workshops, etc. It can be argued that e-learning appeared with the use of computers and the Internet in education. Today, according to a 2022 study, approximately 82% of Ukrainians use the Internet at least once a week, with 78% of them using the Internet daily (Korystuvannia Internetom sered..., 2022).

In the field of education, the percentage of respondents who use Internet technologies is much higher, because, understandably, new challenges in society are reflected in the transformation of the educational system, which is manifested in the active use of information technologies.

It should be noted that the introduction of e-learning into the educational process occurs at two levels – spontaneous (initiative) and institutional. At the spontaneous level, the implementation of e-learning elements is carried out unsystematically, mostly on the initiative of teachers and students, and is mostly fragmentary. For example, students' remote interaction with teachers takes place via e-mail, social networks, mobile applications, amateur use of remote interaction technologies for certain disciplines, etc. Simultaneously, a conscious, systematic, regulated and controlled use of information and communication technologies is ensured only at the institutional level which. This includes e-mail, social networks, mobile applications for distance education, as well as platforms and systems of e-learning and the organization of their control, information and cloud environments, automated learning process management systems, etc. which are presented on the websites of higher educational institutions or their divisions.

The significant increase and intensification of e-learning, the use of information technologies in education, in particular the introduction of distance learning, is linked to both the COVID-19 pandemic and the full-scale war in Ukraine.

In general, researchers dealing with the implementation of innovative technologies in the educational process, in particular distance learning, stress that this form of education has many advantages. The fundamental difference between distance learning and traditional form is that it is based on the student's independent activity. This type of activity is designed to teach young people to independently study the outlined sources, perform practical and individual tasks, clearly formulate their thoughts and

take responsibility for learning. Distance education students have the opportunity to study at a convenient time, in a convenient place; to combine study and work, to independently choose the pace and speed of study, which is how individualized learning manifests itself. Also, among the advantages of distance learning, one can note the possibility of round-the-clock access to educational materials, constant support and consultation of teachers, video lectures in online mode. The indisputable advantage of distance learning is the mastering of new information technologies by both students and teachers.

If, under traditional forms of education, the main task of the student was to memorize the material and then reproduce it, with the use of remote technologies students develop the skills of comparison, synthesis, analysis, evaluation, discovery of connections, planning, group interaction using ICTs and distance learning technologies. So, despite the fact that the pandemic significantly disrupted the traditional educational process in higher education institutions, it opened up opportunities for accelerated transformation of modern education in the field of information technology application. These developments also contributed to the faster adaptation of universities in the conditions of martial law in Ukraine. There are several official analytical documents that summarize the problematic issues of the quality of educational services during the quarantine period and in the conditions of martial law in Ukraine. Thus, in the period from May 6 to 13, 2022, the State Service for the Quality of Education of Ukraine conducted an anonymous online survey of applicants and scientific and pedagogical workers of higher education institutions of all types and forms of ownership. In the study, they authors focused on the management of the educational process and the quality of distance learning in the 2021/2022 academic year, problematic issues of the quality of educational services during the period of martial law were identified, and the dynamics of processes related to the use of distance learning technologies in war conditions were studied, compared to the previous period of distance learning. About 27,000 respondents from 54 institutions of higher education took part in the survey: 20,907 students of higher education and 5,997 scientific and pedagogical workers (Analitichna dovidka schodo..., 2022). The results of the study indicate that during martial law period, almost all institutions of higher education (99.8%) switched to distance learning without any obstacles.

Simultaneously, due to unresolved problems of a material and technical nature, domestic universities cannot consider the development of distance technologies in the organization of the educational process as a separate strategy, unlike universities in European countries. According to teachers, only a third of Ukrainian universities have the opportunity (material and human resources) to decide centrally on the use of information technologies in the organization of the educational process (33.4%), while others (63.7%) in most cases transfer the responsibility to faculties, departments or the teachers themselves. Almost 3% of the surveyed scientific and pedagogical workers are not aware whether their university supports the development of distance learning technologies during martial law (Fig. 2)

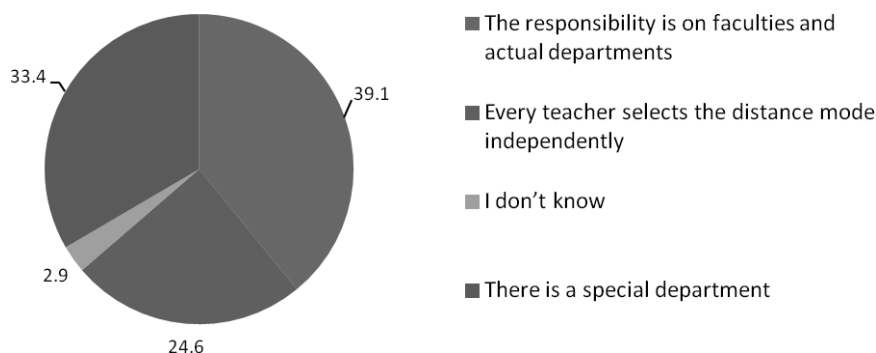


Figure 2. Percentage Distribution Concerning Modes of ICT Use by Universities

Source: Own work.

The analysis of the quality of the educational process and the respondents' use of e-learning technologies showed that the most effective in the educational process for the majority of teachers were virtual educational environments (74.6%) and video communication (ZOOM, Skype, Meet and others) (87.8%). But, unfortunately, only 60% of the interviewed applicants have access to such means in the current situation. At the same time, 74.3% of those seeking education were absolutely positive about the use of messengers for learning, with them being the most accessible tool in the conditions of martial law. In comparison to previous surveys, the percentage of students who find distance learning ineffective has decreased by half (to 6.5%). (Fig. 3).

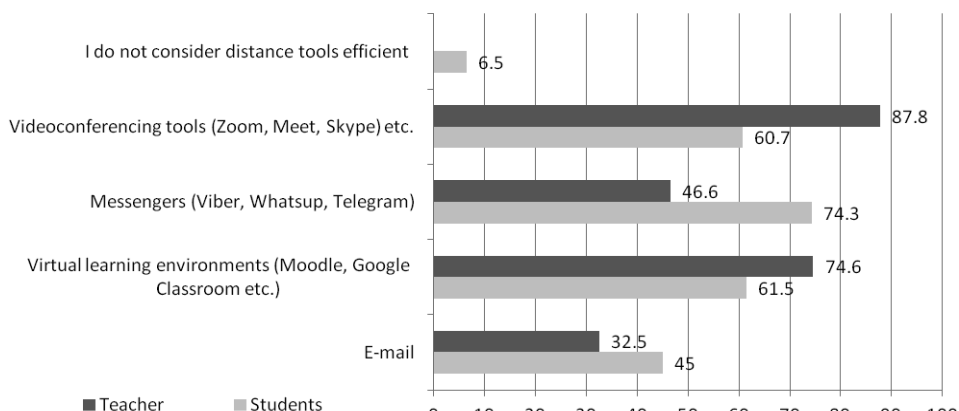


Figure 3. Percentage Distribution as to Digital Tools, Used by the Participants of the Educational Process

Source: Own work.

Even though most universities coped well with the organization of training during war, the applicants are reporting certain problems that degrade the quality of electronic learning technologies. The biggest challenge for students is lack of uninterrupted access to the Internet (55.8%), and every fifth student surveyed points to a lack

of self-organization (19.7%) and lack of the necessary equipment (17.3%). Undoubtedly, these challenges make it difficult to participate in distance learning during martial law. At the same time, we should note that compared to the results of 2020, half as many students of higher education accept the risk of biased evaluation by teachers and complain about the irregularity of communication with the teacher (Fig. 4).

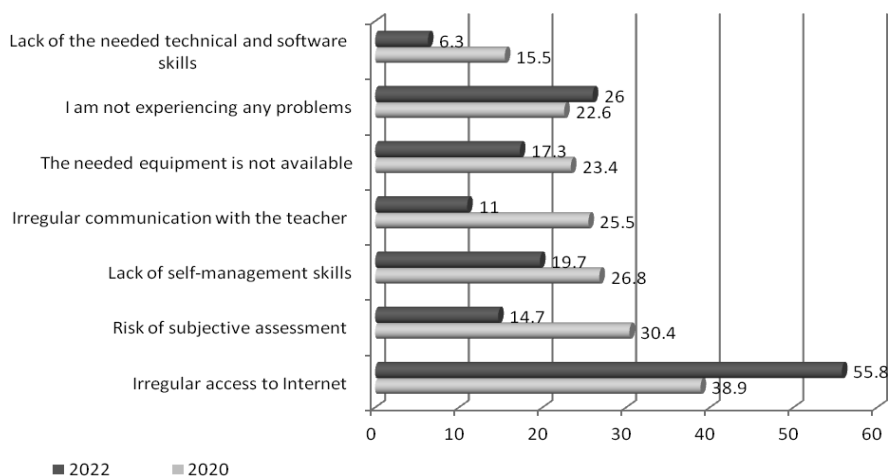


Figure 4. Percentage Distribution as to Problems Faced by Students in Distance Learning (comparison of 2020 and 2022)

Own research, based on (Informatsiino-analitychna dovidka..., 2020)
and (Analitichna dovidka schodo..., 2022)

Source: Own work.

The cited results of sociological surveys of participants in the educational process clearly show that e-learning and distance learning are an important factor and indicator of the development of students' information culture. Such forms of education help develop ICT competencies and boost cognitive skills. In addition, e-learning is psychologically acceptable for students, as it makes it possible to transfer the ability to use gadgets from everyday life and leisure to the educational process.

Thus, fostering information culture in the context of e-learning in a higher educational institution helps improve the quality of the provision of educational services in the information society.

At the same time, according to expert opinions of university teachers, e-learning in higher educational institutions makes it possible not only to improve the quality of educational services, but also helps develop information culture in students only in case of hybrid form of education (Khyzhniak L & Khyzhniak K., 2016). It is exactly this mixed study mode that enables the formation of information culture not only in terms of technology (introduction and use of electronic learning, information and communication technologies, etc.), but also from socio-cultural point of view – the development of the value-meaning aspect of ICT use, the implementation of the principle of humanization, increasing of the creative potential of the individual,

the formation of critical thinking, «live communication» with all participants of the educational process which is an integral part of the formation of the individual's general culture.

3. DISCUSSION

These promising developments in the evolving educational environment align with previous research, suggesting that the COVID-19 pandemic was a unique opportunity for the spontaneous introduction of digital technologies in Ukraine, leading to a long-term digital transformation of higher education (Sorokina et al., 2022).

The current phase in the development of higher education is perceived as globally unpredictable. However, the educational community has also reached a point of no-return (Silva & Alvarez, p. 23, 2021), (Gajewski, 2021). Consequently, the educators are welcome to invite the best attitudes, practices and tools into the coming period. However, despite the increased use of online learning tools (Aristovnik et al., 2023), studies suggest that the era of fully online education has not bridged but rather widened the digital divide in terms of actual access to education (Meulenbroeks et al., 2022), which is a painful fact to acknowledge and the one demanding solutions of the side of the educational management.

Faced with increasingly severe local security challenges, Confronted with yet harsher local challenges to national security, the Ukrainian educational environment finds itself in a more vulnerable position when it comes to fostering student information culture.

CONCLUSION

Developing information culture of a modern specialist is an urgent need of the modern age. In the information society, the expertise and skills necessary for processing information, using digital technologies, largely determines how efficiently professional and social functions of a modern individual are performed.

An individual's information culture is a qualitative characteristic that forms part of their broader professional culture, reflecting their ongoing readiness in professional information-related activities.

The very concept information culture is defined within an integrative approach, which includes both broad (general humanitarian, sociocultural) and narrow (informational and technological) aspects. Thus, information culture includes *information literacy*, *information and digital competency*, *informational reflection* and *informational self-improvement*.

Thus, the introduction of distance learning in institutions of higher education which was spurred by the pandemic and the full-scale invasion of the Russian Federation in Ukraine, gave a rather positive result for all participants of the educational process. Thus, a comprehensive analysis of the problem has identified the following conditions for the effective development of individuals' information culture in universities:

- universities are focused on developing the ability to learn, work with a large amount of information, critically perceive, evaluate and use information;

- the available university infrastructure of information technologies and e-learning tools which includes software, technical and telecommunication tools used in the educational process;
- scientific, educational and methodological provision of the educational environment with access to electronic versions;
- enriching the curriculum by courses that contribute to the development of digital knowledge of students, promote the development of information culture;
- optimal combination of forms and methods of training that activate cognitive activity, including the project method of training;
- professional-oriented problem presentation of educational material;
- formation of students' informational reflection;
- focus of the educational process on self-improvement, self-development of personal and professional qualities of the individual throughout life;
- training pedagogical staff to be confident users of ICTs.

Therefore, one of the tasks of higher education today is to teach individuals to effectively apply information technologies, enabling them to fully realize their potential in the information society, to be able to independently find the necessary information, monitor one's personal and professional skills, monitor changes and respond to them, to be able to make decisions in complex non-standard situations, which is possible only within a robust information culture.

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EVALUATING THE TOOL FOR ENHANCING PRE-SERVICE TEACHERS' DIGITAL COMPETENCIES IN PROFESSIONAL COMMUNICATION AND COLLABORATION

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Abstract: *This study critically examines a tool designed to assess and enhance pre-service teachers' digital competencies in professional communication and collaboration. With the growing importance of technology integration in education, it is crucial for future educators to possess strong digital skills. The research aims to evaluate the effectiveness of the tool through a comprehensive assessment process that involves data collection through assessments and observations to gather insights into initial competencies, progress, and perceptions of the tool's effectiveness. The findings contribute to the existing knowledge on digital competencies in teacher education and inform the development of targeted interventions. Ultimately, the study aims to equip pre-service teachers with the necessary digital competencies for effective communication and collaboration in educational settings.*

Keywords: digital competencies; tool evaluation; initial teacher education; professional communication; collaboration

INTRODUCTION

The development of digital competences among pre-service teachers is crucial for their successful professional realization. Mastery of digital professional communication and collaboration competencies is indispensable for effective 21st-century teaching and learning processes. The increasing emphasis on digital competences for pre-service teachers has spurred a surge in research and publications dedicated to this topic. Scholars and educators are increasingly recognizing the importance of understanding and enhancing the digital competences and capabilities of future teachers, contributing to a growing body of knowledge in the field. According to Bergum Johanson's (2023) findings, “the main factors contributing to their competence in digital interaction and communication are the students' attitudes toward and experiences with virtual communication solutions. The students' mastery of emotional

engagement with virtual collaboration solutions also played a definite but smaller role in their digital competence.” Other factors in the acquisition of digital competency that could be considered influential, though not determinative, include gender, age, and academic degree according to Cabezas-González (2021).

Other researchers, such as Reisoğlu (2020), focus on the competences that should be developed, primarily information and data literacy, communication and collaboration, digital content creation, safety and problem-solving, knowledge and practice related to professional engagement, teaching and learning, assessment, and empowering learners. In the literature overview of teachers’ professional digital competence, Ewa Skantz-Åberg (2022) and coauthors distinguish seven recurring aspects of teachers’ professional digital competence: 1) technological competence, 2) content knowledge, 3) attitudes toward technology use, 4) pedagogical competence, 5) cultural awareness, 6) critical approach, and 7) professional engagement, with technological and pedagogical competences being the most prominent. They also conclude that the concept of teachers’ professional digital competence still appears to be ambiguous and elusive, requiring further research in the field.

1. THEORETICAL BACKGROUND

The Key Competences for Lifelong Learning adopted by the European Parliament and the European Council include transversal competences (digital, learning to learn, civic competences) and the meta-competence of learning to learn (adjusting to change, managing, and selecting from huge information flows) (European Commission, 2019). Teachers should understand, deploy and assess key competences; this entails interdisciplinary collaboration skills, as underlined in the document Assessment of Key Competences in initial education and training Cedefop (2020). Assessing the digital competencies in the beginning of initial teacher education and the process of developing and upgrading them for the purposes of professional communication and collaboration are the focus of this research.

The development of digital competences is a priority topic in the policy and publications of the European Commission. There is an apparent growth in academic research publications on digital competences focused on specific areas such as the transition from digital literacy to digital competence (Falloon, 2020), teachers’ digital competencies in higher education (Basilotta, 2022), subject-specific technology-related professional competence of teachers like digital competencies for teaching in science education (Kotzebue, 2021).

Gaftandzhieva mentioned that according to a survey conducted among 19,987 teachers in higher education institutions, only 53.03% of the teachers surveyed use social networking sites to share research interests and connect with colleagues. This finding indicates a need to improve the digital competencies of educators on how to use software solutions for professional communication and collaboration. (Gaftandzhieva & Doneva, 2021)

Alonso-García et al., (2023) stated that another aspect to take into account when evaluating digital competences is the branches of knowledge. Therefore, the grouping

by branches of knowledge can be used as a reference to visualize which aspects are more developed and which need further reinforcement.

Sillat et al., (2021) in their systematic literature review stated that there is an opportunity to build a wider scale research on digital competences when basing the instrument design on a common framework. One of the options presented is DigCompEdu which could be used in understanding educators' digital competence. Simultaneously, we can argue that localized competence models better describe the implementation context.

Basilotta (2022) indicates that the growth of academic articles coincides with the publication of the European Framework for Digital Teachers Competence - DigCompEdu (Redecker & Punie, 2017) which is proving to be a key document. The DigCompEdu is a framework describing what it means for educators to be digitally competent and provides a general reference frame to support the development of educator-specific digital competences in Europe and aims to detail how digital technologies can be used to enhance and innovate education and training. Professional Educators' digital competences are grouped together in six areas. Using digital technologies for communication, collaboration and professional development is defined as 'Area 1 – Professional Engagement'. The area is divided into the following subunits: organizational communication, professional collaboration, reflective practice, digital continuous professional development (CPD).

Alternative approaches for assessing and enhancing digital competencies in the context of pre-service teacher education are presented by International Society for Technology in Education (ISTE). The ISTE has developed a set of standards that outline the skills and knowledge educators should possess to effectively integrate technology into their teaching practice. These standards provide a framework for assessing and enhancing digital competencies. (ISTE Standards)

The Technology Integration Matrix (TIM) is a tool developed by the Florida Center for Instructional Technology. It provides a rubric-based framework for evaluating and enhancing teachers' technology integration skills. The matrix consists of five levels of technology integration and can be used to assess and guide the development of digital competencies. (TIM)

The Technological Pedagogical Content Knowledge (TPACK) framework emphasizes the integration of technology, pedagogy, and content knowledge. It helps pre-service teachers understand how to effectively use technology in the context of specific subject areas. The TPACK framework can be used as a guide to assess and enhance digital competencies (Kurt, 2019) According to the results of the survey pre-service teachers portrayed a positive attitude towards the lessons that were conducted in accordance with TPACK. TPACK practices attracted the attention of preservice teachers and they actively participated.

In conclusion, the provided articles and frameworks hold significant importance in the field of education and contribute to defining educators' digital competencies and transforming educational experiences through technology integration.

1.1. Problem Statement

Despite progress and some excellent examples of innovation, combined efforts have so far not resulted in systemic digital transformation in education and training stated the recently published document ‘Commission calls for massive boost in enabling digital education and providing digital skills’ issued on 18 April 2023. The recommendation on Member States are to ensure universal access to inclusive and high-quality digital education and training, to address the digital divide, to start early by providing digital skills in a coherent way through all levels of education and training. The Bulgarian Ministry of Education and Science aligns its policies with the European Commission’s priorities, with a particular emphasis on systemic digital transformation. This is evident in the state requirements for teacher professional qualification, as described in Ordinance (MON, 2021), which emphasize the development of competences related to the application of information and communication technologies in the learning process, supporting student mastery of learning content through e-learning and blended learning, independent and group work through ICT, and acquiring skills for motivating and supporting students’ digital skills development, including techniques for enhancing presentation skills.

The problem statement aims to address the challenge of achieving a high level of digital competences among educators. Despite some progress and innovation, efforts have not fully realized the desired outcomes, as evident in the need for universal access to inclusive and high-quality digital education and training, effectively integrating digital competences across all levels of education. The policies of the Bulgarian Ministry of Education and Science align with the European Commission’s recommendations, emphasizing the importance of developing teacher competences in applying information and communication technologies (ICT) for learning in the digital environment. A critical consideration lies in equipping pre-service teachers with the necessary competences to use digital technologies for communication, collaboration, and professional development, enabling them to become confident and competent educators through the Initial Teacher Training (ITT) program. As Skalka (2021) stated cooperation in the educational system can be beneficial for all participating groups.

Addressing these challenges and achieving successful digital transformation requires a comprehensive approach to developing educators’ digital competences and creating an inclusive and technologically advanced educational environment at all levels.

1.2. Research Question

In the context of this study, two research questions are addressed. Firstly, we sought to determine the efficacy of the designed tool in assessing the initial digital competencies of pre-service teachers, specifically in the domains of professional communication and collaboration. Secondly, we aimed to identify and explore the digital competencies possessed by undergraduate students before they embark on their study of specialized didactics. These research questions serve as the foundation for our investigation into the assessment and understanding of digital competencies among

the targeted participants. The determination of the initial level is of crucial importance for achieving the goal set forth by the Work Package 4 of the project 'Digital Sustainable Ecosystems – Technological Solutions and Social Models for Ecosystem Sustainability (DUEcoS).' The activities in this work package aim to shape and enhance the digital competencies of students preparing to become primary education teachers. The goals and tasks defined in WP 4 are contextualized within the Digital Education Action Plan (2021–2027) and the European Framework for Digital Competence of Educators (DigCompEdu).

The research goals during the entire project duration encompass the formation and development of digital competencies in various areas, including „Professional Engagement“ subareas communication and cooperation (Area 1) for undergraduate students preparing to become primary education teachers, as well as digital competencies in „Digital Resources“ (Area 2), „Teaching and Learning“ (Area 3), „Assessment“ (Area 4), „Empowerment of Learners“ (Area 5), and „Supporting Learner Digital Competencies“ (Area 6). Upon successful project completion and based on the findings of this and future studies, the envisioned outcomes encompass the attainment of accessible and high-quality digital education. Additionally, the project aims to equip prospective primary education teachers with the necessary competencies to effectively utilize digital technologies in a professional capacity. Furthermore, it endeavors to develop updated academic courses that integrate the study of specialized didactics with digital competencies, while also establishing a digital library containing electronic educational resources generated as an integral part of this project.

2. METHODOLOGY

2.1. Research Design

This research aims to assess the designed tool and the initial digital competencies of pre-service teachers in a systematic manner. To achieve this, a mixed-methods approach combining a questionnaire and performance-based evaluation is employed. We created our questionnaire because the existing scientific literature does not provide a tool that is suitable for our research goals. The aim of this diagnostic process is closely aligned with the objectives and tasks set for achievement in the subsequent stages of the project. As a result of engaging with the research instrument, students reflect upon their digital skills and experiences, provide descriptions, and select appropriate examples of activities performed with various web applications. They further develop their ability for adequate self-assessment based on objective criteria and are motivated to pursue further accomplishments.

2.2. Review of the tool

The evaluation tool has two parts - the first one is a self-assessment questionnaire and the second one is performance-based part. The questionnaire has been piloted and it aims at mapping the digital competences, strengths and weakness of students to help plan an effective future intervention. The added value of two is evident in

performance-based part that provide different ways of capturing information. For example, when compiling examples of their work in e-portfolios, learners' submit information in a variety of formats, including images and text, video and audio files, presentations and e-books. This contribute to developing and applying digital competence specifically and communication competence more generally.

2.3. Structure. Dimensions

The self-assessment questionnaire consists of carefully crafted items to gauge pre-service teachers' self-reported digital competencies and experiences, towards area of Professional Engagement focusing on communication and collaboration. This tool originally included a total of 9 items, distributed into four analytical dimensions: credentials and personal digital devices used; competences to use applications from Google Workspace, Microsoft Office 365, digital tools for cloud-based services and organizing, storing, and processing files, digital tools for conducting video conference calls. All of them offered the added benefit of convenient sharing and effective collaboration with others. They are designed to enhance communication, collaboration, and efficiency among users in a cloud-based environment that is a key feature matching the results to the goal of teacher professional communication and collaboration. Diagnosing the dimensions of the student's competences to know and work with these applications is absolutely necessary for achieving the goals of the project. Participants responded using a four-point Likert-type scale with the options:

"I don't know this tool." (Unknown)

"I have heard of this tool." (Name)

"I can describe it." (Describe)

"I can apply it." (Apply)

In this scale, participants had to choose one of these options to indicate their familiarity and proficiency with the mentioned tools.

In case the respondent states "I can apply it", he/she should provide an example below. The questions cover aspects such as familiarity with digital tools for communication and collaboration, confidence in using them, exposure to specific software, online platforms, and tools for videoconferencing and chats. The detailed description of the aspects, items and response domains is provided in Table 1.

The performance-based evaluation involves completing tasks related to professional communication, cooperation and collaboration aspects bounded to the questionnaire aspects and items. Their assessment involved peer assessment and feedback procedures.

Table 1. Aspects of pre-service teachers' digital competences

Aspect	Item	Response domain
Sociometric Data	What is your age, gender and study program?	Open question
Device	What kind of device you use daily?	Multiple choice
Google Workspace	Rate your competences regarding the use of Digital Tools from the Google Workspace group.	Four-stage Likert scale
Microsoft Office 365	Rate your competences regarding the use of Digital Tools from the Microsoft Office 365 group.	Four-stage Likert scale
Cloud Tools	Rate your competencies regarding the use of Digital Tools for cloud-based services for the organization, storage and processing of files.	Four-stage Likert scale
External Storage	Where and how do you organize and store your files outside of cloud-based services?	Open question
Video Conferencing	Rate your competences regarding the use of Digital Tools for conducting video conference calls	Four-stage Likert scale
University Digital Communication & Collaboration	Select and highlight actions. List of action phrases provided.	Multiple choice
Video Apps	List of mobile apps you use for video calling.	Open question
Total 9 Aspects		

Source: Own work.

2.4. Instrument validation

Before the full-scale implementation of the questionnaire, a pilot test was carried out to identify any potential issues. The responses received from the pilot were analyzed to validate the instrument through a psychometric analysis. The main findings of the validation are summarized according to the indicator's consistency and correlation. The internal consistency of the results received was verified by means of Cronbach's alpha coefficient and a result of 0.89 was obtained, a value proving that the consistency of the results obtained by the questionnaire was relatively high.

The cross-correlation between items in the questionnaire showed values that were relatively low, so that the items can be considered sufficiently different from each other and that the variables correlate in a directly proportional manner.

2.5. Sample and Procedure

The study was conducted online between 15th February and 30th May 2023. The sample consisted of 121 second-year students enrolled in the specialties of Primary Education Teacher, Primary Education Teacher with a Foreign Language, and Special Pedagogy at the Faculty of Education at Plovdiv University “Paisii Hilendarski” (112 females (92.56%), 9 males (7.44%), aged between 20 and 23 years, with a mean age of 20.53 years and a standard deviation of the participants’ ages (SD) of 0.50. On average, they were in their 4th semester of the teacher training program. The teacher training program in Bulgaria consists of an eight-semester bachelor’s program and an optional four-semester master’s program that qualifies students to teach at the primary level. It is divided into subject-specific didactics taught at the primary level, psychology-pedagogical content courses, as well as interdisciplinary courses in educational science that include ICT in education.

The questionnaire was administered at the beginning of subject-specific didactics courses, ensuring that the topic of technologies in teaching was only addressed after the questionnaire. Depending on the type of specialization, participants were offered the same questionnaire either in paper form or as an online version. Before taking part in the study, participants were required to read and agree to an informed consent form, and their participation was voluntary and anonymous.

3. RESULTS AND DISCUSSION

3.1. Quantitative results by areas

The presented information reveals the usage of various Google applications (Apps) among the respondents, who are pre-service teachers. The data indicates that Google Sites (see Figure1) has the lowest usage rate and many of them might not perceive its practical applications for creating websites. In contrast, Google Translate stands out with a significantly high usage rate among respondents as shown on Figure 1. They report extensive practical application for language translation and perceive it as a popular and valuable tool. The data indicates that both Google Slides and Google Drawings have relatively low usage rates among pre-service teachers. This suggests that these applications might be underutilized or not extensively incorporated into their educational practices. There could be various reasons for this, such as a lack of awareness of their functionalities or limited exposure to their potential applications in teaching and learning contexts.

The data in Figure 2. represents the responses of pre-service teachers on their competences regarding the use of digital tools from the Microsoft Office 365 group. The respondents used a four-stage Likert scale, ranging from “Unknown” (low competence) to “Apply” (highest competence).

Overall, the pre-service teachers showed higher confidence in using Word, Excel, and PowerPoint, with a majority of respondents rating themselves at the highest level of competence (Apply) in these applications. OneDrive and Outlook also had a significant number of respondents at the highest competence level.

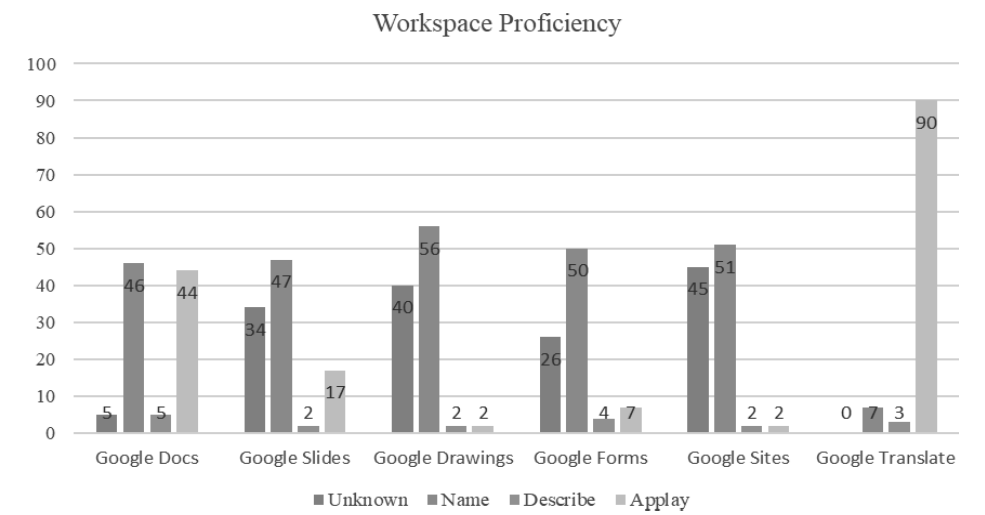


Figure 1. Google App Usage Trends Among Pre-Service Teachers
Source: Own work.

However, the data reveals that pre-service teachers generally feel less confident in using OneNote and Class Notebook, as a higher number of the respondents rated themselves at a lower level of competence (Unknown) in these applications. This information suggests that there might be a need for further training or support to enhance the pre-service teachers' competence in using OneNote and Class Notebook. Conversely, it also highlights their relative strength in using other Microsoft Office 365 applications.

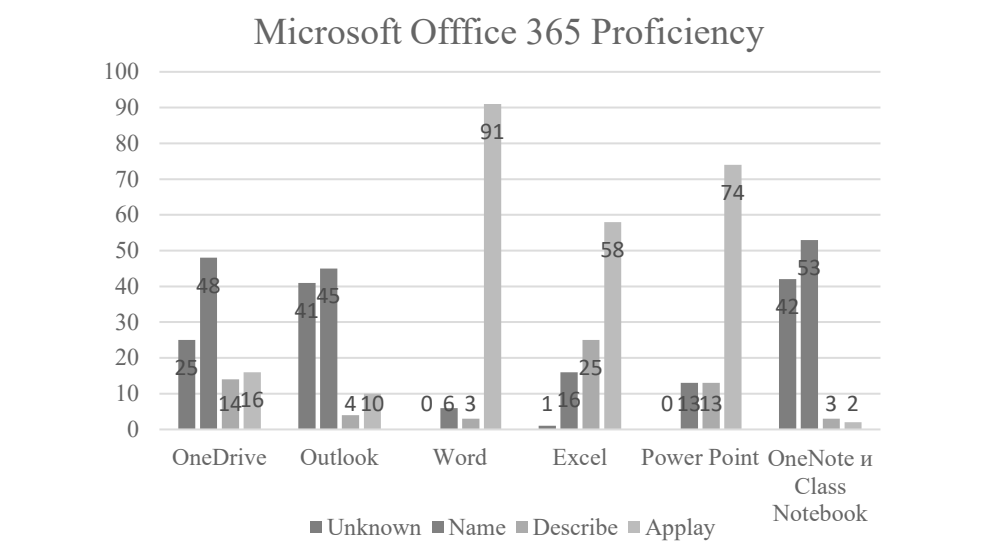


Figure 2. Microsoft Office Usage Trends Among Pre-Service Teachers
Source: Own work.

Cloud-based services for organizing, storing, and processing files are part of the measured digital competencies. The data obtained on the four-point scale where “Apply” category represents the highest Likert scale value, indicating a higher level of usage or application of the cloud storage services among the respondents is presented in Figure 3. The Box Drive received the lowest number of mentions in the “Apply” category representing that it is not being actively used or applied by the respondents. Google Drive performed well in the “Apply” category, receiving a high number of mentions with a count of 43. This indicates that Google Drive is widely used and applied by the respondents. Its strong integration with other Google services and ease of access likely contribute to its popularity for practical applications. OneDrive received the highest number of mentions in the “Apply” category, with a count of 43. This places it on par with Google Drive in terms of user application. One Drive’s close association with Microsoft’s ecosystem and seamless integration with Microsoft Office suite likely make it a preferred choice for users when it comes to practical usage. Analyzing the data solely based on the “Apply” category reveals that OneDrive and Google Drive are the most dominant cloud storage services among the respondents. Both services received the highest number of mentions in this category, indicating widespread use and application.

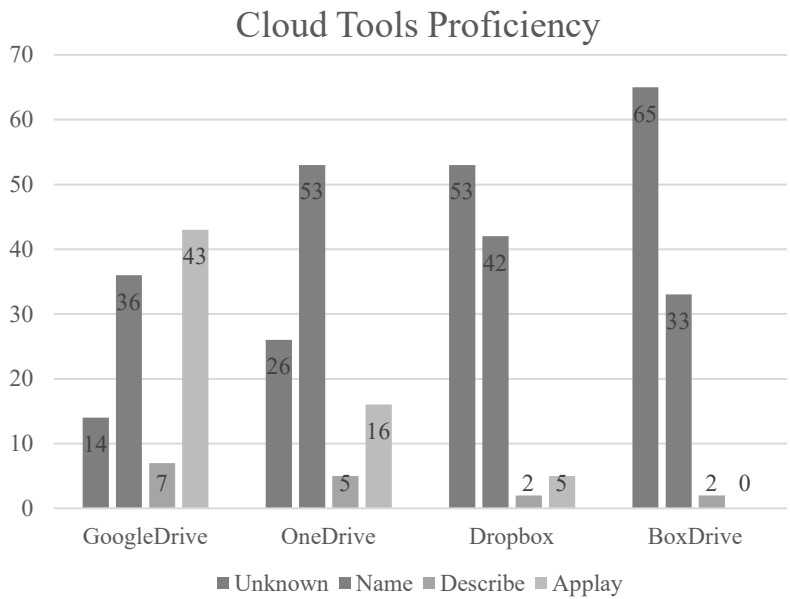


Figure 3. Cloud Tools Usage Trends Among Pre-Service Teachers

Source: Own work.

The fact that more than 90% of the surveyed individuals report storing and organizing their information on the devices they use (predominantly laptops and smart-phones) or on flash drives, despite being aware of cloud storage options, is noteworthy. This finding highlights the need to incorporate information and tasks related to enhancing understanding and significance of cloud storage and its connection to

communication and collaboration for professional purposes into the future curriculum for the development of digital competencies.

Regarding the conduct of video conference conversations and their application in education, all students share that they use Google Meet, which is entirely understandable, as the paid version of the application is utilized for training purposes within the Faculty of Pedagogy.

3.2. Quality results

Valuable qualitative data were obtained from the questions, which required respondents to provide descriptions of application or explain specific examples for applying the respective aspect (see Table 1). The analysis of the responses provides valuable information, serving as a measure to either confirm or challenge the self-assessment expressed by the respondents regarding the respective aspect. The examples provided by the undergraduate students allow for a better understanding of the purposes for which they use the applications. The data derived from the descriptions of the respective aspects indicates a satisfactory level of comprehension of applications and functionalities, as well as the appropriateness of their selection for specific study-related tasks. Students have reported a high level of understanding and frequent utilization of Microsoft Office Word, PowerPoint, Google Translate, and Google Drive in the context of their academic and research endeavors at the university. The same conclusion can be reached regarding the items that emphasize ethical aspects of ICT use, specifically respecting copyright and adhering to safety guidelines.

The analysis of the results regarding activities performed by pre-service teachers reveals that they engage in a limited scope of activities, such as chatting, information seeking, content sharing, asking, and answering questions, and sending emails and messages. However, the analysis of the practical tasks indicates that these activities are carried out at an unprofessional level, leaving significant room for development and improvement.

CONCLUSION

The digital competencies formed and developed during the Initial Teacher Training (ITT) program are of crucial importance for teachers' professional development and the digital transformation of education. The approach used in this study includes questionnaire, peer assessment, feedback procedures, and performance-based evaluation, enabling a more comprehensive and practical diagnosis of pre-service teachers' competencies in the area of "Professional Engagement".

The presented and discussed results lead to the following conclusions:

The research instrument utilized for initial diagnosis demonstrates a noteworthy level of precision, detail, and informativeness, providing a substantial dataset specifically pertaining to pre-service teachers' digital competencies, with a particular emphasis on the domains of professional communication and collaboration. As a result, it can effectively serve as a robust foundation for making well-informed decisions in the context of designing and implementing new educational programs for preparing future teachers and ensure digital transformation of education on all levels.

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The study “Evaluating a Tool for Enhancing Pre-Service Teachers’ Digital Competencies in Professional Communication and Collaboration” reflects only the author’s view, and that the Agency is not responsible for any use that may be made of the information it contains.

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DEGREE OF READINESS OF TEACHERS IN UKRAINE TO USE ICT IN THEIR PROFESSIONAL ACTIVITIES: 2019–2022

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Abstract: *The article presents a comparative analysis of Ukrainian teachers' readiness to incorporate ICT into their professional activities. It presents the results of a longitudinal study that began before the Covid-19 pandemic, continued during the pandemic and after it, including a series of teacher surveys. The article explores changes in teachers' attitudes toward digital tools during this period; shows the dynamics of the expansion of tools and assesses changes in teachers' self-assessed ICT competence. Additionally, it identifies the digital resources for the implementation of professional functions, most favoured by Ukrainian teachers. Statistical analysis revealed that, following the implementation of distance learning, 1.4% of teachers reported high-level ICT competence, while 2.1% reported sufficient competence. However, a considerable 14.6% rated their ICT competence as inadequate. This period of distance learning unveiled gaps in teachers' ICT proficiency, prompting a more accurate assessment of their ICT competence. The study demonstrates that, based on the needs of full-time, distance and blended learning, teachers increasingly rely on ICT tools for lesson preparation, interactive content development, and student progress monitoring, facilitated by digital services offering virtual classrooms and electronic journals. Obviously, the demand for ICT tools is greatest in the context of distance learning. However, even during onsite education, Ukrainian teachers widely use digital resources.*

Keywords: ICT competence of teachers, digital content in education, face-to-face, distance and blended learning

INTRODUCTION

From 2020 to 2023, the integration of ICT tools into the Ukrainian education process evolved significantly. Over several consecutive years, Ukrainian schools implemented face-to-face, distance and blended learning approaches. It is evident that distance learning cannot be achieved without teachers possessing ICT skills. Therefore, for the successful execution of professional activities, teachers must be familiar with ICT tools and possess information and digital competence. When referring to ICT (information and digital) competence of a teacher, we understand their ability to solve standard and problematic tasks that arise in professional activities using ICT tools. The basis of ICT competence is the teacher's awareness of the existence of digital resources for performing work functions, their knowledge, skills and competences in specific online services and platforms.

The purpose of the article is to analyze the results of a longitudinal study of the readiness of primary school teachers to use ICT in their professional activities during the period preceding before the Covid-19 pandemic, and after the pandemic but before the start of the war in Ukraine.

The research questions addressed in this study include:

1. to compare the level of ICT competence among primary teachers before the pandemic period (hereinafter referred to as BPP) and the post-pandemic period (hereinafter referred to as PPP);
2. to compare the list of services that teachers worked with during the BPP and PPP;
3. to find out and compare the difficulties encountered by teachers in using these services during the BPP and PPP.

Research hypothesis: the transition to distance education has led to an increase in the level of ICT competence among primary school teachers.

Research methods: general scientific logical methods (including analysis, synthesis, comparison, generalisation), empirical methods (involving literature study, pedagogical observation, surveys using Google Forms), and mathematical processing techniques (for determining percentages and arithmetic means).

1. STATUS OF READINESS OF PRIMARY SCHOOL TEACHERS FOR THE APPLICATION OF ICT IN FACE-TO-FACE EDUCATION (BPP)

Research by Ukrainian and foreign scientists convincingly proves that ICT is widely implemented by teachers in professional activity. Analyzing changes in the use of ICT in Bulgarian schools over the decades, scientists have identified various digital tools that were employed in the educational process until 2018. These include interactive whiteboards, computers, educational games, and even augmented and virtual reality (Terzieva, Paunova- Hubenova, Dimitrov, & Dobrinkova, 2018). Further-

more, scientists emphasize the appropriate use of interactive whiteboards, tablets, digital educational materials, advanced audiovisual technologies, electronic learning systems, webinars and multimedia presentations in the educational process. Czech researchers found that teachers, although aware of the need for further integration of ICT into the educational process, use ICT without the necessary training (Klement, & Klementova, 2016). Romanian teachers also recognize the advantages of using ICT in educational activities, but they rank ICT competence as one of the least important competences they wish to improve (Popa, & Bucur, 2015).

In 2019, Bulgarian scientists conducted a study on the integration of ICT tools in the process of face-to-face learning. It was established that only 56% of teachers had the necessary technical equipment, 53% had access to special software, 50% had e-learning resources, 55% had access to fast Internet. The teachers mostly used computers, projectors, educational websites and e-textbooks. In terms of using educational content created with the help of ICT, the majority of teachers preferred presentations, educational videos, electronic textbooks, specialized software, additional electronic resources. Difficulties arose when using electronic tests, educational games, virtual laboratories and simulations. Teachers attributed their low level of ICT competence to the absence or insufficient number of relevant ICT courses. They also noted that the available courses and internships in the field of ICT are characterized by insufficient practical orientation of the material (Terzieva, Paunova-Hubenova, Dimitrov, & Boneva, 2020).

Slovak researchers encountered similar issues and emphasized that most accredited courses are aimed at obtaining elementary or advanced skills in working with digital technologies, mainly addressing technological aspects (Zahorec, Haskova, & Munk, 2019). Czech researchers also emphasized that teachers need courses aimed at providing not technological, but methodical guidance for ICT implementation, offering methodical recommendations and specific examples of using ICT in specific lessons, etc. (Neumajer, 2012). In conclusion, there are studies by foreign scientists regarding the expediency and state of ICT use by teachers in the educational process even before the Covid-19 pandemic, particularly in the context of face-to-face education. These studies indicate that teachers understand the importance of introducing ICT in the educational process, but they need professional guidance to enhance their ICT competence. Obviously, the question of how the results of the survey of European teachers align with the results of the survey of Ukrainian teachers regarding the use of ICT in professional activities up to March 2020, before the pandemic, is of great interest. In the spring of 2019, we conducted a survey of primary school teachers (Skvortsova, Britskan, 2019). Based on the obtained results, we can state the following:

1. regarding the availability of experience in using ICT in professional activities: it was found that 100% of respondents possessed computer skills and experience in using ICT in their professional activities.
2. as for teachers' self-assessment of ICT proficiency, 15.5% of respondents considered themselves highly competent, 26.3% – good, 15.5% – average, 20.0% – insufficient, and 22.7% as having no ICT competence. It should be noted that these levels are based on self-assessments encompassing skills such as working with the file system, text editing, creating presentations, perform-

ing calculations using Excel, processing graphic images, installing necessary software, working with e-mail, working with the Internet, creating websites, blogging and working in professional online services (Skvortsova, Britskan, 2019). In general, these results generally correlate with the results of the study (Terzieva, Paunova-Hubenova, Dimitrov, & Boneva, 2020) regarding the self-assessment of ICT competences among Bulgarian teachers.

3. in terms of how teachers acquired ICT competence, 10% of respondents reported gaining it during their higher education; 50% – through participation in seminars, methodical meetings and training; and 40% – independently.
4. most teachers recognized the need for ICT in the education of modern junior high school students: most teachers agree that it is necessary to implement ICT in the education of modern schoolchildren. In particular, 90% of respondents believed that it is appropriate to use educational games, 70% preferred multimedia presentations, 80% saw value in interactive exercises, 70% in educational videos and audio recordings, 80% in educational programs, 60% in tests and quizzes. Comparing the results of our study with those of Bulgarian scientists (Terzieva, Paunova-Hubenova, Dimitrov, & Boneva, 2020), we observed that teachers prioritize the use of ICT in preparing presentations for lessons and educational videos. Bulgarian teachers also reported difficulties in using electronic tests, educational games, virtual laboratories and simulations, while 60% of Ukrainian teachers preferred tests and 80% favoured interactive games.

It should also be noted that Ukrainian respondents' recognition of the advantages of using ICT in educational activities correlate with the results of a survey of Romanian and Czech teachers (Popa, & Bucur, 2015; Klement, & Klementova, 2016), which revealed that teachers were well aware of the need for further implementation of ICT in the educational process.

5. regarding teachers' understanding of the feasibility of using devices in the education of younger schoolchildren, in particular in the process of learning mathematics: 70% of respondents considered it necessary to use devices for interactive tasks via online services. However, many respondents noted a lack of information about the peculiarities of teaching mathematics to junior high school students using modern devices.

Therefore, the survey results indicate that primary school teachers have a certain level of ICT competence. But most teachers need methodical help to improve it. This is confirmed by the fact that 100% of the surveyed teachers are ready to work on improving their ICT competence, particularly in creating educational interactive content.

In March 2020, we conducted the following survey of primary school teachers regarding the use of ICT in professional activities (Skvortsova, Ishchenko, Britskan, 2020).

Comparing the results of the 2019 teacher survey, we noted an increase in the number of respondents who acquired ICT competence while studying at a higher education institution, from 10% to 22%. At the same time, the percentage of teachers who improved the relevant skills and abilities through seminars decreased, from 50% to 44%.

Regarding the reasons inhibiting the introduction of ICT in professional activity, 66% of teachers cited issues with indicated that they have problems with the material support of the class; 24% mentioned the excessive saturation of educational material; 18% felt psychologically unprepared for ICT integration; 64% lacked sufficient time for ICT implementation, and 70% indicated insufficient knowledge about ICT.

Regarding the ways of using ICT in professional activities, 93% of respondents reported printing materials for classes on a computer; 96% – searched for educational information on the Internet; 98% conducted lessons using computer equipment; 62% used ICT in project activities; and only 24% of respondents created educational and gaming content using Internet resources. So, in the pre-pandemic period, we had a small percentage of teachers who saw online services as opportunities to create interactive exercises for students.

It should be noted that the obtained results correlate with the findings of a questionnaire survey of Bulgarian teachers. The vast majority of them used computers, projectors, educational websites and e-textbooks, while a minority of teachers used multimedia tools, e-references, e-resources and educational games (Terzieva, Paunova-Hubenova, Dimitrov, & Boneva, 2020).

In 2020, before the Covid-19 pandemic, our data indicated that 98% of teachers already worked with scientific and methodical literature available on the Internet, and 73% of teachers attended Internet webinars; (Skvortsova, Britskan, & Haievets, 2020). Therefore, even before the introduction of distance learning, Ukrainian teachers were widely using ICT quite widely in their professional activities.

6. regarding digital resources used by teachers in their professional activities, 20% of teachers were introduced to platforms for creating electronic journals and diaries; 73% participated in Internet webinars; 24% were familiar with online services for creating educational and game content; 33% used social networks in their professional activities, or created their own sites and blogs. In 2019, while 90% of teachers considered it appropriate to use educational games, 70% opted for multimedia presentations, 80% preferred interactive exercises, 70% found value in educational videos and audio recordings, 80% in educational programs, 60% in tests and quizzes. It is important to highlight that, despite their lower ICT competence, Ukrainian teachers still valued interactive games, but had mainly low level of ICT competence (Skvortsova, Britskan, 2019), then in February 2020, 84% of teachers indicated that they independently work on improving their ICT skills, and even before the introduction of distance learning, 20% of respondents used platforms for creating electronic magazines and diaries, only 24% – had experience of independent creation of educational and game content using Internet resources, and the most popular among teachers were online services LearningApps and Google Forms (Skvortsova, & Britskan, 2021). It is important that 98% of primary school teachers in Ukraine used ICT to conduct lessons even before the Covid-19 pandemic. In conclusion, the results of surveys conducted in the pre-pandemic period – until March 2020, indicate that primary school teachers in Ukraine possess

basic ICT knowledge and skills. However, many teachers lack the skills to work with online services for creating educational and game content (Skvortsova, Ishchenko, Britskan, 2020). Nevertheless, there is a clear understanding among these teachers of the role of ICT in improving the effectiveness of the educational process (Skvortsova, Britskan, 2019; Skvortsova, Ishchenko, Britskan, 2020; Skvortsova, Britskan, & Haievets, 2020).

2. STATE OF READINESS OF PRIMARY SCHOOL TEACHERS TO USE ICT IN THE DISTANCE EDUCATION PROCESS

The relevance of ICT utilization in the teacher's professional activity emerged in March 2020, in connection with the transition of educational institutions to distance learning, due to the initial outbreak of the Covid-19 pandemic, and subsequently, the full-scale war in Ukraine.

Distance learning, whether in synchronous or in asynchronous modes, cannot be implemented without ICT-based means. It is evident that teachers must increasingly integrate ICT into their professional duties. Let us explore how teachers' readiness to use ICT in their professional activities has evolved based on data from Ukrainian and foreign researchers.

The analysis of the results of an all-Ukrainian survey conducted by the National Academy of Pedagogical Sciences of Ukraine provides ample evidence that when selecting tools for organizing distance learning in educational institutions, 88.2% of respondents favoured Viber, 62.7% preferred the website of the educational institution, 45.5% chose Google Classroom, 42.7% picked "Na Urok", 37.7% used Skype, 28.5% opted for Zoom, 20.9% utilized Telegram, 2.4% selected ClassDojo, 18.5% went with "My Class", 16.2% used Google Disk, 13.3% employed WhatsApp, 10.3% depended on Electronic diary, 6.2% relied on Classtime, 4.7% used Microsoft Teams, 3.4% chose Moodle, 2.9% preferred Google Meet. Notably, researchers have observed that teachers have begun to explore new online tools and look for user-friendly educational platforms to facilitate group distance learning. Among the main obstacles to the implementation of ICT, limited access to the Internet was identified – 35.2%; a lack of experience – 58.7%; unfamiliarity with online tools – 20.2%; unclear guidance from school administration – 10%; and insufficient motivation – 7.8%. Respondents have also identified constraints unrelated to the education system, such as network congestion, students' limited internet access, unprepared parents, and inadequate technical support and equipment at home, etc. (Ovcharuk, & Ivaniuk, 2020). The results of a study conducted by Spanish scientists (Panos-Castro, Arruti, & Korres, 2022) investigating ICT usage in primary schools during the pandemic indicate an insufficient level of teacher preparedness for the use of ICT, despite educational policies aimed at introducing ICT in schools. Survey findings show that the majority of respondents independently acquired the skills they needed to use ICT. These surveyed teachers expressed interest in lifelong learning programs featuring tools like Google Classroom, Google Sites and Google Meet, among others.

Portuguese primary and secondary school teacher training, along with the challenges faced during the pandemic were the focal points of research by Henriques, Correia and Dias-Trindade (2021). Their survey results indicate that already 67.7% of teachers have received adequate training in using digital resources and learning environments. Anishchenko et al. (2021, p. 130) reported that during the pandemic, Ukrainian teachers mainly used such resources as “Na Urok” (74.4%) and original lessons on YouTube channel (75.8%) for lesson preparation and delivery. Additionally, “Universal Education” (64.6%), “All-Ukrainian School Online” (38.7%), EdEra (33.3%), materials from teachers’ blogs (28.4%), open online lessons (27.2%), Learning.ua (24.7%), Prometheus (19.85%) were commonly used. In summary, the results of the study in 2021 align with the results of the all-Ukrainian online survey conducted in 2020 (Ovcharuk, & Ivaniuk, 2020).

In general, the research results on platform choices for the organization of distance education in mathematics, as conducted by M. Burda and D. Vasylieva (Burda, & Vasylieva, 2021, p. 4), also correlated with these data. Thus, in 2020, digital resources preferences among mathematics teachers were as follows: “Na Urok” (63.6%), “Vseosvita” (44.3%), “My Class” (35.5%), LearningApps (25.1%), GIOS (21.3%), Classtime (19.8%), EdEra (12.9%), Prometheus (9.9%), Khan academy (4.4%), ILearn (3.9%), Matific (2.8%), Mozaik (2%), Notably, 9% of the surveyed teachers reported not using any platforms.

Encouragingly, positive trends were observed in 2021. For example, “Na Urok” was selected by 80.7% compared to 63.6% in the previous year, “Vseosvita” by 60.5% compared to 44.3%, LearningApps by 41% compared to 25.1%, Matific by 5.5% (up from 2.8%), ILearn by 4.6% (up from 3.9%). However, there was a decrease in the popularity of some resources, including “My Class” (26.5% compared to 35.5%), GIOS (12.5% from 21.3%), Classtime (16.9% from 19.8%), EdEra (10.3% from 12.9%), Khan academy (3.2% from 4.4%), Mozaik (1.8% from 2%). The percentage of teachers who did not use any platforms decreased from 9% to 7.4% (Burda, & Vasylieva, 2021). In the context of our research, it is noteworthy that teachers’ responses regarding how mathematics is taught in elementary, basic and specialized education in Ukraine during the 2020-2021 academic year are of particular interest. Researchers found that 16.9% of teachers always create interactive tasks using various online services, while 70.9% do so occasionally. However, 11.9% do not independently develop educational content using software tools. This suggests that these teachers may not have yet mastered the necessary digital skills (Skvortsova, Ishchenko, Halitsan, & Haievets, 2022). In the same academic year, in the fall of 2020, we conducted an online survey of primary school teachers regarding their use of online services (Skvortsova, & Britskan, 2021). Summarizing the results, we reached the following conclusions:

1. the LearningApps service is the most popular for creating interactive exercises, with 82% of teachers being aware of it. However, only 21% of teachers use it in their work. In contrast, only 16% of teachers are aware of Liveworksheets services, with a mere 4% using them. Likewise, 9% of teachers know about Wizer.me, but only 0.8% use it.

It should be noted that in the study conducted by Skvortsova, Ishchenko, Halitsan and Haievets (2022), 74.7% of elementary school and mathematics

teachers used the LearningApps service to create interactive exercises. This aligns with the percentage of elementary school teachers aware of the service. However, in the fall of 2020, only 21% of elementary school teachers used it.

2. A mere 6% of teachers are aware of services for creating educational videos, in particular H5P, and only 0.8% of teachers use H5P.

Our data indicates that services for creating educational videos are not widely adopted among primary school teachers. However, a slight improvement was observed in a subsequent survey by Skvortsova, Ishchenko, Halitsan and Haievets (2022), in which 14.9% of mathematics and primary school teachers use the Learnis service.

Furthermore, mathematics and elementary school teachers also use programs for preparing and editing video tasks: Movavi (46.7%), iMovie (21.8%), Learnis (16.9%), Camtasia (9.6%), Thinglink (6.1%), and 18.4% of teachers are not familiar with the listed software.

3. as to presenting educational content on a virtual whiteboard, 50% of primary school teachers know that they can use the Padlet service, while 4% of teachers preferred Lino.it. Nevertheless, only 16% of teachers among the 50% who are aware of this service use the Padlet virtual whiteboard in their work, and only 2% of teachers among the 4% use Lino.it (Skvortsova, & Britskan, 2021). The percentage of primary school teachers aware of the Padlet virtual board is notably lower in our survey than in a study by Skvortsova, Ishchenko, Halitsan and Haievets (2022), which reported 55.2% awareness among mathematics and primary school teachers, compared to 16% in our survey. This discrepancy may be attributed to the time gap between the surveys (approximately one year) and the likelihood that mathematics teachers are possess a higher level of ICT competence compared to elementary school teachers.

In summary, the analysis of the 2020 research results indicates an insufficient level of online service use by Ukrainian primary school teachers, even with the transition to distance learning. These findings, however, do not directly reflect their ICT competence. However, the majority of primary school teachers are eager to acquire and develop ICT competence, recognizing the additional effort it will require.

Our experimental data align with the research conducted by Manzano-Sánchez, Valenzuela and Hortiguera-Alcala (2021), who studied educational systems and actions in pandemic conditions. They emphasized the need for support not only for teachers but also for parents in setting up digital devices to facilitate effective distance learning. In order to enhance the ICT competence of primary school teachers, with an emphasis on online services in mathematics teaching, we developed and conducted two electronic courses on the Zmist.ua website.

Between November and December 2021, we conducted an online survey of primary school teachers in Ukraine who were aware of these electronic courses. The results of this research (Skvortsova, Britskan, Symonenko, Haievets, 2022) show the following:

1. 77.3% of respondents completed the electronic course in its entirety or covered separate topics, while 22.7% of respondents did not participate in any webinar;
2. to create interactive exercises in mathematics, respondents preferred LearningApps, Liveworksheets, Wizer.me, H5P, Kahoot, Mozabook, Wordwall,

Google Forms, Miksike, and the online platforms “Vseosvita” and “Na Urok”. However, 17.7% of respondents indicated that they do not create interactive exercises prior to lessons.

Regarding the selection of services for creating interactive sheets, the survey results for the 2021-2022 academic year indicate positive trends, compared to the 2020-2021 survey. For instance, 44.6% of teachers now opt for the Liveworksheets service, whereas only 4% did so in the previous survey. Additionally, 8.8% have chosen Wizer.me, up from 0.8% in the previous survey. We can conclude that the percentage of teachers who choose these online services is growing. These findings affirm the value of introducing future teachers to the creation of interactive exercises using Liveworksheets and Wizer.me.

Regarding the creation of educational videos, the data show the following results: 62.4% chose MS Power Point; 46.8% preferred Zoom; 26.3% opted for screen recording programs; 4.9% utilized Skype, 5.4% chose other services, indicating Google Meet, Screencastify, Vegaspro and Kinemaster; 11.2% pointed out that they do not create an educational videos. Additionally, teachers self-assessed their competence in using selected services for creating educational videos, with results indicating 0 points (5%); 1 point (2.5%); 2 points (5.9%); 3 points (22.3%); 4 points (42.1%); 5 points (22.3%). Results for the selection of online services for creating interactive videos differed slightly: 20.2% chose Learnis; 6.1% selected Edpuzzle; 4% preferred H5P, 33.3% opted for other services and 50% reported not creating interactive videos. Similarly, teachers self-assessed their competence in using selected services for creating interactive videos, resulting in 0 points (26.3%); 1 point (7.5%); 2 points (6.5%); 3 points (28.5%); 4 points (22.6%), and 5 points (8.6%).

In comparison to the previous survey, the range of online services for creating educational and interactive videos has expanded. There has also been a positive shift in the use of the Learnis service, increasing from 2% to 20.2%, and H5P, rising from 0.8% to 4%. Consequently, the range of services used by primary school teachers for video content creation is broadening.

Regarding the selection of online services for presenting educational material on a virtual whiteboard, during the 2021–2022 academic year, 66.8% of respondents chose the Padlet service, compared to 16% of teachers who used this service in the 2020–2021 academic year. Moreover, there is a positive trend regarding the Lino. it service, which is now being used by 8.3%, compared to 4% of teachers who were only aware of its existence in the 2020–2021 academic year. It should be noted that 5.9% of respondents chose other services, indicating Notebook, Wordwall and Jamboard, and 4.4% mentioned WikiWall; 26.3% indicated that they do not create virtual boards. Teachers self-assessed their competence in using these selected services, revealing 0 points (14.6%); 1 point (3.5%); 2 points (7.5%); 3 points (22.1%); 4 points (32.2); 5 points (20.1%) (Skvortsova, Britskan, Symonenko, Haievets, 2022).

In summary, the analysis of the survey results in Table 1 confirms that Ukrainian primary school teachers are committed to integrating ICT into their professional activities and have a desire for further development of acquired competencies in using online services.

Table 1. Teachers' choice of digital resources in the pandemic period

Digital resources	Research by scientists					
	Ovcharuk, & Ivaniuk, 2020	Burda, & Vasylieva, 2021	Anishchenko et al., 2021	Skvortsova, & Britskan, 2021	Skvortsova, Ishchenko, Halitsan, & Haievets, 2022	Skvortsova, Britskan, Symonenko, Haievets, 2022
„Na Urok”	42.7%	63.3%	74.4%	—	—	—
„Vseosvita”	—	44.3%	64.6%	—	—	—
„My Class”	18.5%	35.5%	—	—	—	—
LearningApps	—	25.1%	—	21%	74.7%	78.1%
GIOS	—	21.3%	—	—	—	—
Classtime	6.2%	19.8%	—	5%	—	—
EdEra	—	12.9%	33.3%	—	—	—
Prometheus	—	9.9%	19.85%	—	—	—
Khan academy	—	4.4%	—	—	—	—
Ilearn	—	3.9%	—	—	—	—
Matific	—	2.8%	—	3%	—	—
Mozaik	—	2%	—	—	—	—
Author's lessons on YouTube	—	—	75.8%	—	—	—
„All-Ukrainian School Online”	—	—	38.7%	—	—	—
Materials from teachers' blogs	—	—	28.4%	—	—	—
Open online lessons	—	—	27.2%	—	—	—
Learning.ua	—	—	24.7%	4%	—	—
Google Classroom	45.5%	—	—	37%	—	—
Skype	37.7%	—	—	6%	—	—
Zoom	28.5%	—	—	91%	—	—
ClassDojo	2.4%	—	—	9%	—	—
Microsoft Teams	4.7%	—	—	0.8%	—	—
Google Meet	2.9%	—	—	13%	—	—
Moodle	3.4%	—	—	—	—	—
Liveworksheets	—	—	—	4%	—	44.6%
Wizer.me	—	—	—	0.8%	—	8.8%
H5P	—	—	—	0.8%	0.8%	4%
Padlet	—	—	—	16%	55.2%	66.8%
Lino.it	—	—	—	2%	—	8.3%
Learnis	—	—	—	2%	14.9%	20.2%

Source: Own work.

3. RESULT AND DISCUSSION

The solution of the research question, comparing the results of research on the use of ICT by primary school teachers in professional activities during BPP and PPP, leads to the following conclusions:

1. The development of ICT competence in both BPP and PPP has shown significant changes. Our research results are presented in Table 2, illustrating the dynamics of self-assessment by elementary school teachers. Our data analysis shows that in the BPP teachers who self-assessed their ICT competence with the highest scores showed overconfidence, whereas in the PPP, teachers were able to objectively assess their ICT skills and recognized the lack of knowledge in the field of ICT. The number of teachers assessing their own ICT competence at a good level increased by 2.1% and at an average level by 6.6%. At the same time, the number of teachers who assessed their ICT competence as insufficient decreased by 10.2%, and the number of teachers with zero ICT competence increased by 4.6%. These findings indicate that it was during the PPP that primary school teachers, implementing distance learning, identified their ICT skill gaps and objectively assessed the level of their ICT competence formation.

Table 2. Dynamics of formation ICT competences of teachers of Ukraine in the BPP and PPP

ICT Competence level	BPP	PPP	Augmentation
High	15.5	12.4	−3.1
Good	26.3	28.4	+2.1
Average	15.5	22.1	+6.6
Insufficient	20.0	9.8	−10.2
Absent	22.7	27.3	+4.6

Source: Own work.

2. In the PPP, Ukrainian teachers will expand the range of services for creating interactive exercises, mastering those with which they were familiar, as well as new services. If in BPP only 24% of teachers in private schools created interactive tasks in LearningApps and Google Forms services, then in PPP 82.3% of teachers mastered services for creating interactive exercises, namely: LearningApps, Liveworksheets, Wizer.me, H5P, Kahoot, Mozabook, Wordwall, Google Forms, Miksike, and the online platforms “Vseovista”, “Na Urok”.
3. If primary school teachers in Ukraine encountered certain difficulties in creating and using electronic tests, educational games, virtual laboratories and simulations during BPP, then in the PPP they mastered services for creating tests (in particular, Google Forms, Classtime, Plickers).

Consequently, the transition to distance learning due to Covid-19 had a positive effect on the development of ICT competence among primary school teachers in Ukraine. They particularly excelled in mastering new services for creating educational inter-

active content, often by participating in courses focused on the use of ICT in professional activities.

If we compare the results we obtained with the results of a study by Mexican researchers (Leon-Valdez, Garcia-Lopez, & Cuevas-Salazar, 2021), which explored related aspects we find that we have obtained slightly worse results regarding the completion of courses on the use of ICT in professional activities and regarding the ICT competence of Mexican primary school teachers in 2021 year, namely:

1. 40.7% of Mexican primary school teachers had never attended any ICT courses, whereas 44.7% had completed one or two courses, 12.7% – three or four, 2% – five or more (Leon-Valdez, Garcia-Lopez, & Cuevas-Salazar, 2021). 49% of Indonesian mathematics teachers indicated that they knew about the specifics of ICT use through attending trainings and reading specialised literature (Fathurrohman, Nindiasari, Anriani & Pamungkas, 2021). In contrast, 77.3% of Ukrainian primary school teachers had completed at least one electronic course on the use of ICT in educational activities (Skvortsova, Britskan, Symonenko, Haievets, 2022).
2. in terms of conditions for working with ICT, 40.1% of Mexican teachers noted that the institution always had computer equipment (Leon-Valdez, Garcia-Lopez, & Cuevas-Salazar, 2021). As can be seen, material and technical support in Mexican schools in the private sector is worse than that of private schools in Bulgaria, 56% of respondents noted (Terzieva, Paunova-Hubenova, Dimitrov, & Boneva, 2020). The situation with material and technical support for the educational process is also better in Ukraine (Anishchenko et al., 2021).
3. as for the use of ICT, 70.41% of Mexican teachers indicated that they always used a computer for school-related tasks, such as planning, activities, presentations, etc. (Leon-Valdez, Garcia-Lopez, & Cuevas-Salazar, 2021) compared to 78% of Ukrainian teachers, who constantly used ICT in their professional activities, while 22% used it periodically. Notably, Italian researchers studying distance education, including primary school teachers, highlighted the use of technology for creating educational content, primarily among primary school teachers and those taking advanced training courses. In contrast, secondary school teachers, mainly in the humanities, attach more importance to factors related to assessment and lesson quality (Menabò, Skrzypiec, Sansavini et al., 2022).

CONCLUSION

The analysis of both domestic and foreign studies shows that the forced transition to distance, online and blended learning compelled teachers to enhance their ICT competence. Consequently, the research hypothesis is confirmed. Teachers mastered ICT tools either independently, including by watching specialized webinars, participating in master classes, and enrolling in relevant courses.

Moreover, teachers' self-improvement in the field of ICT was primarily aimed at mastering basic tools, programs, and services crucial for facilitating distance learning (Google Meet, Zoom, Google Classroom, ClassDojo, etc.). Therefore, most teachers

stopped at this stage, where they secured a fundamental toolkit for their ICT skills. However, there are also teachers who went beyond the basics, enriching their repertoire of services with platforms enabling the creation of interactive content in various formats. Mastering such services requires advanced knowledge in the field of ICT and relevant technical and methodological skills. As a result, there is a pressing need for higher education institutions to prepare teachers for the use of ICT during their professional training.

Therefore, it becomes evident that primary school teachers are primarily directing their attention towards the effective organization of the learning process (face-to-face, distance, blended) using ICT tools and enriching lessons with videos and interactive content.

The potential for further research lies in studying changes in the selection of online services by primary school teachers.

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EXAMINATION OF SOLUTION TIMES TO COMPUTER SCIENCE AND PHYSICS TASKS: A STUDY IN SLOVAK AND HUNGARIAN SECONDARY SCHOOL STUDENTS

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Abstract: *The paper is based on a wider empirical study which was performed as part of a project examining scientific, mathematical and algorithmic thinking of secondary school students in Slovakia and Hungary. Here, some results are presented, focusing on the evaluation and comparison of students' responses to computer science and physics tasks by considering the solution times. In all four computer science tasks, we found significant differences in response times between correct and incorrect answers, while in physics tasks, there was a significant difference only in one of the four tasks.*

Keywords: STEM, secondary education, computer science, physics, solution time

INTRODUCTION

In today's knowledge and information-based society, unsurprisingly, there is a high and still growing demand for specialists who have the necessary expertise and skills in STEM (science, technology, engineering and mathematics) areas. The importance of STEM education is widely recognized, and there are many publications and research projects worldwide dealing with this topic.

One of the main research objectives of a larger project realized at our university with financial support from the grant agency VEGA (Slovakia), was to identify the reasons for low interest in STEM subjects among Slovak and Hungarian secondary school students. The project studied the scientific, mathematical, algorithmic and problem solving thinking, understanding difficulties of students, and their learning styles and attitudes towards STEM sciences, including computer science (Juhász & Tóth, 2021; Szarka et al., 2021; Svitek, 2022). In this paper, we present some partial results of this larger project, focusing on the assessment of computer science tasks and physics tasks. We show data suggesting that analysis of solution times can provide additional insight into students' algorithmic and scientific thinking.

1. ALGORITHMIC AND SCIENTIFIC THINKING

In recent years, algorithmic thinking has received increased attention. It is an important core competency in computer science which together with problem solving, can be considered one of the basic pillars of computational thinking (Wing, 2006; Korkmaz et al., 2017). Moreover, some researchers regarded algorithmic thinking as the most susceptible part of computational thinking for being measured in educational research studies (Román-González et al., 2018). According to Futschek (2006), algorithmic thinking is a set of different abilities, and its fundamental purpose is to construct algorithms that can solve given problems.

Algorithmic thinking is a fundamental skill that should be incorporated into the curriculum at all levels – its importance in primary education as the basis of learning has been already recognized by many researchers (Futschek & Moschitz, 2011). Futschek (2006) emphasizes that problems fostering the development of algorithmic thinking should not be too simple, but the problem statements should be easily comprehensible. Programmable robots as well as online puzzle-based game learning systems can also enhance algorithmic thinking skills and puzzle-solving performance (Czakóová, 2020; Hsu & Wang, 2018).

Scientific thinking can be defined as a type of knowledge seeking which encompasses any instance of purposeful thinking that has the objective of enhancing the seeker's knowledge (Kuhn, 2002). It can be described by the following processes: analysis of phenomena and problems, formulation of questions and hypotheses, selection of methods, data collection, making observations, investigation, display and analysis of data, identification and control of variables, pattern recognition, design and execution of experiments, testing hypotheses, evaluation and interpretation of results, making inferences, and communication and presentation of results (Kuhn, 2002; Adey & Csapó, 2012; Szarka & Juhász, 2019).

Scientific thinking involves many cognitive capabilities including, but not limited to, analogical reasoning, casual reasoning, induction, deduction, and problem solving (Dunbar & Fugelsang, 2005). However, Kuhn (2002) emphasizes that science education does not necessarily involve scientific thinking. One recent and influential approach to science education is the inquiry-based learning approach. It is a teaching method that encourages students to ask questions and propose hypotheses, collect data that test the hypotheses, reach conclusions, and then reflect upon both the

original problem and the thought processes they used to solve the problem (Dunbar & Fugelsang, 2005). A detailed analysis of inquiry-based learning in the context of STEM education can be found in (Morze et al., 2018).

2. METHODOLOGY

Conducted in September and November 2021 with the financial support of a project VEGA, the survey involved 1517 first and second year secondary school students from Slovakia and Hungary. In Slovakia, a total of 18 secondary schools took part in it, of which 12 were with Hungarian teaching language, one with Slovak teaching language and 5 schools were with both teaching languages – Hungarian and Slovak depending on the class. In Hungary, the survey involved five secondary schools. The sample distribution by gender was as follows: 628 male students (41.4%) and 888 female students (58.6%), one participant did not provide the gender.

In the survey, the following five measurement instruments were used: background questionnaire, STEM assessment test, logical thinking test (Raven, 2000), inductive reasoning test, and Kolb's learning style questionnaire (Kolb, 1984). The most extensive measurement tool was the STEM assessment test with 20 tasks, which contained 4–4 tasks (items) from school subjects such as physics, chemistry, biology, mathematics, and informatics. The test items were chosen from elementary school curricular materials, taking into account that part of the participants were first year students who have just begun their secondary school studies. Data acquisition was performed on computers and tablets under the personal supervision of a project team member. Participants completed the measurement instruments online using a specifically designed and previously tested framework (Tóth et al., 2021), which allowed test-takers to securely log in with a unique pre-generated username and password. This online measuring system displayed only one test item at a time, and the students were not allowed to return to a previously solved task. Since the system allowed the measurement of the time students spent on solving each item, it became possible to examine their responses taking into consideration the elapsed solution time, which is usually not available in traditional paper-based surveys. Thus, in this study, we have formulated the following research questions:

RQ1: Are there any solution time differences between correct and incorrect answers on computer science and physics tasks?

RQ2: How the number of responses changes if only answers provided over a specified time are taken into account? What can we conclude from this change?

2.1. Computer science tasks of the STEM assessment test

Task CS1 (queuing): Estimate the minimum number of adjacent swaps that are needed if we want to reverse the order of 12 animals.

Description: There are animals standing in a row, arranged from the tallest to the shortest. We can only swap two adjacent animals at a time. If we have 3 animals, then at least 3 adjacent swaps are needed to reverse their order, while in the case of 6 animals, 15 swaps are required, and in the case of 9 animals, 36 swaps are necessary.

Answer choices: a) 45 b) 55 c) 66 d) 78 e) 91.

Task CS2 (river crossing): How can the soldier get to the other side so that after the crossing the boys and the boat are on the initial bank of the river? Give a correct sequence of river crossing steps.

Description: A soldier reaches the river he has to cross. The river is deep and there is no bridge nearby. There are two boys with a rowboat on the river bank. However, the boat is so small that it can either hold two boys or the soldier (each person can row the boat and each of the boys can pass by himself).

River crossing steps:

The boy in the yellow shirt rows the boat across the river.

The boy in the blue shirt rows the boat across the river.

Both boys row the boat across the river.

The soldier rows the boat across the river.

Task CS3 (ladybug robot): Which color flag will the ladybug robot reach, if it executes the sequence of instructions in Figure 1?

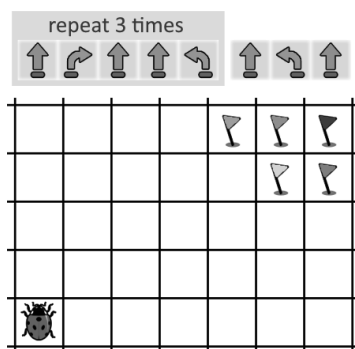


Figure 1. Task CS3 (ladybug robot)

Source: Own work.

Description: The ladybug robot knows three basic instructions: it goes forward by one square using , turns right by 90 degrees using , and turns left by 90 degrees using .

Answer choices: a) grey b) green c) blue d) yellow e) orange

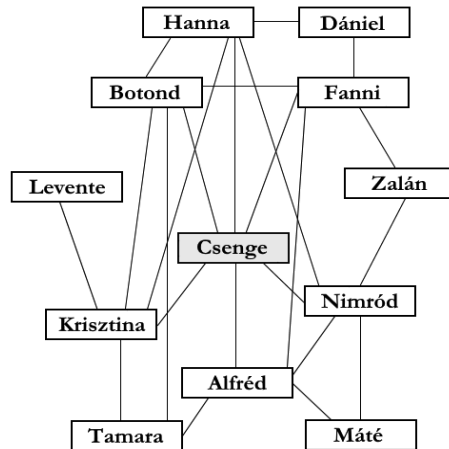


Figure 2. Task CS4 (social network)

Source: Own work.

Task CS4 (social network): Csenge wants to upload a photo on the social network, but she does not want Alfréd to see it. Mark the correct answer!

Description: Csenge and his friends have registered to a social network. Each contact is illustrated in Figure 2, the line means that the two people know each other (e. g. Nimród and Csenge are friends, but Tamara and Csenge are not). If someone on the network shares a photo with a friend, his or her friends will also see this photo.

Answer choices:

- Csenge can share the photo with Hanna, Krisztina and Fanni.
- Csenge can share the photo with Hanna, Krisztina and Nimród.
- Csenge can share the photo with Botond, Krisztina and Alfréd.
- Csenge can share the photo with Botond, Nimród and Fanni.
- Csenge can share the photo with Botond, Hanna and Krisztina.

2.2. Physics tasks of the STEM assessment test

Task PH1 (Archimedes): What will happen? Choose the letter of the correct answer.

Description: According to Archimedes' principle, when a body is placed in a liquid, the body will be subjected to a buoyancy force that depends on the density of the liquid and the volume of the body below the liquid level (immersed in the liquid). The experiment shown in the Figure 3 is performed at the school. A red cube is suspended at one end of a metal bar supported in the middle and a green sphere at the other end of the bar. In the open air, there is a balance between the two bodies shown in Figure 3 a), and then the bodies shown in Figure 3 b) are placed in a vessel filled with water so that the whole system is completely immersed in the water. What will happen?

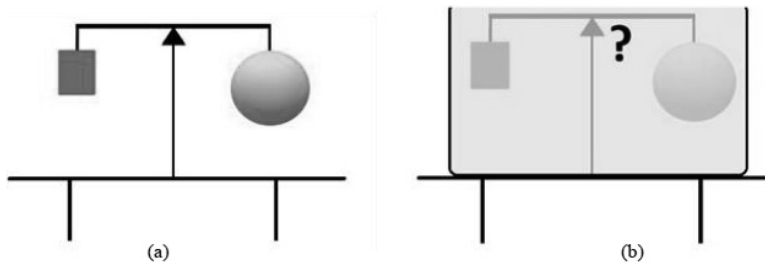


Figure 3. Task PH1 (Archimedes)

Source: Own work.

Answer choices:

- The final result depends on the mass of the bodies.
- The red cube rises.
- The green ball rises.
- Balance is maintained.
- I do not have enough information to predict the outcome of the experiment.

Task PH2 (density): Put the steps of the experiment in the right order.

Description: The density of a solid can be determined by dividing its mass by its volume. The volume of regular geometric solids (cubes, rectangles, spheres, etc.) can be calculated. Tamara, on the other hand, was given the task of determining the density of an irregular solid, a stone. Yes, but Tamara has only been given a list of the tools she needs, but she does not know the exact order in which to carry out the experiment.

Required tools: scale, graduated cylindrical measuring flask, stone

Help Tamara and put the steps of the experiment in the right order by assigning a number to them! The first step is given to help.

Experiment steps:

- Find the density of a stone as the ratio of its mass to its volume.
- Fill the cylindrical measuring flask with an adequate amount of water and read the volume of water.
- Measure the mass of the stone. – 1.
- Read off the rise in the water level on the measuring cylinder flask, this is equal to the volume of the stone.
- Carefully put the stone into the measuring cylinder flask.

Task PH3 (circuit): Which statement is true? Mark its letter.

Description: The two most common ways to connect loads are in series and in parallel. A series circuit has elements connected in series, or one after the other without the wire branching. The current flowing through all elements connected in series is the same, no matter how many resistors are encountered along the way. If one load breaks down, the circuit breaks. A parallel circuit has elements connected in parallel – that is, one point in the circuit branches, with wires going to two different elements, and then the branches rejoin again. The voltage across each element connected

in parallel is the same. The voltages on each load depend on its resistance. If one load breaks down, the others will continue to work regardless.

On Christmas Eve, Peter is reading his favourite book by the light of a table lamp with the Christmas tree lights on, when one of the lights burns out. What will happen?

Answer choices:

- a. The table lamp will glow brighter.
- b. The Christmas tree lights and the table lamp will stay lit.
- c. The Christmas tree lights will go out.
- d. The other Christmas tree lights will stay lit.
- e. The table lamp will also go out.

Task PH4 (*sound*): Choose the letter of the correct answer.

Description: The speed of sound depends on the density of the medium through which it is travelling. In medium with higher density, the sound propagates faster. The density of iron is higher than the density of air, so...

Answer choices:

- a. the sound propagates more slowly in the iron.
- b. the sound propagates faster in the air.
- c. the sound propagates at the same speed in iron and air.
- d. the sound propagates faster in the iron.
- e. the sound does not propagate in iron.

3. RESULTS

This section presents the evaluation of computer science (CS) and physics (PH) tasks by considering the time consumption. The percentage distribution of correct and incorrect answers given by students to the three computer science multiple-choice tasks and three physics multiple-choice tasks is shown in Table 1. As the table implies, at least one student selected each of the answer choices for all tasks. Evidence that students used all five of the answer choices suggests that the distractors are functioning as intended. It can be stated for all computer science tasks and physics tasks PH3 and PH4, that the majority of students was able to mark the correct answer. Task PH1 proved to be the most difficult one, with a very low success rate of 18.7%, which implies that Archimedes' principle is a topic difficult for lower grade secondary school students to understand and apply in solving tasks.

During our study, we examined the amount of time students spent on solving test tasks. The online system continuously measured the time (in seconds) for each participant attending the survey. The measurement of time began with starting a new task and ended with the entry of the answer, which automatically opened the next task. Thus, the time required for solution of a task also includes the time needed for reading and understanding the text. For a given task, a very small amount of time could indicate that the student simply marked the answer without reading the question and task description. Contrarily, a large amount of time could imply that the student found this task to be difficult. Table 2 summarizes the basic statistical indicators of time consumption for each task.

Table 1. Percentage distribution of correct (in bold) and incorrect answers to multiple-choice tasks

Task	N	Answer choices				
		a	b	c	d	e
CS1 – queuing	1517	10.4	20.0	42.0	24.1	3.5
CS3 – ladybug robot	1514	18.8	45.0	7.5	14.9	13.8
CS4 – social network	1513	11.6	6.6	5.2	8.0	68.6
PH1 – Archimedes	1517	34.9	11.3	18.7	21.0	14.1
PH3 – circuit	<i>1514</i>	<i>3.6</i>	<i>18.6</i>	59.2	<i>16.7</i>	<i>1.9</i>
PH4 – sound	1514	4.4	8.4	9.4	61.4	16.4

Source: Own work.

Upon analyzing the data presented in this table, it can be stated that students spent visibly longer time solving the computer science tasks. The mean solution time was the highest in task CS1, which is not surprising, because students have to read the longer text of the task, they have to understand the process of reversing the order of the animals, and then they have to estimate (or calculate) the requested minimum number of adjacent swaps based on the known data. In tasks CS2 and CS3 we observed roughly similar mean solution times. Task CS4 with mean time consumption of 121.7 seconds also managed to attract the attention of participating students. We assume that the popularity of the topic plays a role in this, since the vast majority of secondary school students actively uses social networking sites.

Table 2. Basic statistical indicators of time consumption by tasks

Task	Statistical indicator				
	N	Mean	SD	Rel. SD	Median
CS1 – queuing	1517	197.1	123.9	0.629	175
CS2 – river crossing	1510	147.9	83.7	0.566	134
CS3 – ladybug robot	1514	145.2	89.2	0.614	130
CS4 – social network	1513	121.7	65.5	0.538	117
PH1 – Archimedes	1517	107.4	51.0	0.475	99
PH2 – density	1517	100.3	52.6	0.524	92
PH3 – circuit	1514	<i>97.5</i>	<i>69.1</i>	<i>0.708</i>	<i>89</i>
PH4 – sound	1514	53.2	35.1	0.660	46

Source: Own work.

In physics tasks PH1, PH2 and PH3, the mean solution times are roughly equal, the difference between them is within 10 seconds. Task PH4 has the least solution time among all tasks, with mean time consumption of less than a minute. It is important to emphasize that the length of the task description was the shortest in this test item. As presented in Table 2, in all computer science and physics tasks, the median value is lower than the mean value. Comparing the solution times, there are remarkable

differences between students, as shown by high standard deviation (SD) values. High SD rates imply considerable personal differences (Tóth et al., 2021). To compare the differences between the tasks, a relative standard deviation was calculated for each task. The high relative standard deviation values of tasks PH3, PH4, CS1 and CS3 imply that these tasks had a more difficult text to understand.

For each task, the difference in the solution time values between the groups of students who did and did not solve the given task correctly were analyzed using a non-parametric test, because solution times do not distribute normally, a finding consistent with the literature (Lasry et al., 2013). Normality testing was performed using the Shapiro–Wilk test. The results of the Mann–Whitney U-test are summarized in Table 3. The obtained data show that in computer science tasks CS1, CS2 and CS4 correct answer solution times are significantly longer ($p<0.05$) than the time taken to give incorrect answers. Longer solution times suggest that students spend more time reading the text of the tasks, understanding the question, and thinking about the solution. In task CS3, however, the incorrect answer solution time proved to be significantly longer ($p<0.05$) than the correct answer solution time. This result indicates that the distractors are not automatic choices for participating students. Furthermore, the lower proportion of correct answers to this task suggests that cyclical execution of several consecutive instructions is a serious challenge for many students in the lower grades of secondary schools.

Table 3. Comparison of the solution time values between successful and unsuccessful students

Task	Mean solution time		Median solution time		Mann–Whitney U	P value
	correct answers	incorrect answers	correct answers	incorrect answers		
CS1	210.5 (N=637)	187.3 (N=880)	187	168	252301.5	0.001
CS2	152.1 (N=938)	141.5 (N=572)	138	127	237356.5	0.000
CS3	137.6 (N=682)	152.1 (N=832)	118.5	137	251499.0	0.000
CS4	132.8 (N=1040)	98.1 (N=473)	124	94	163498.5	0.000
PH1	108.0 (N=283)	107.3 (N=1234)	98	99	170216.5	0.508
PH2	100.7 (N=774)	100.0 (N=743)	91	93	285637.5	0.823
PH3	96.9 (N=897)	98.5 (N=617)	90	87	257736.0	0.023
PH4	52.8 (N=930)	53.9 (N=584)	45	48	271285.5	0.974

Source: Own work.

Table 3 also shows, that in physics tasks PH1, PH2 and PH4, there are no significant differences in solution times between correct and incorrect answers. In task PH3, the incorrect answer solution time proved to be slightly significantly longer ($p<0.05$) than the correct answer solution time.

Table 4. Mean solution time taken (in seconds) for correct (in bold) and incorrect answers in multiple-choice tasks

Task	N	Answer choices				
		a	b	c	d	e
CS1 – queuing	1517	166.0	184.5	210.5	194.2	219.4
CS3 – ladybug robot	1514	157.3	137.6	135.8	157.2	148.3
CS4 – social network	1513	113.0	103.4	67.5	91.7	132.8
PH1 – Archimedes	1517	106.4	105.1	108.0	109.1	108.5
PH3 – circuit	1514	83.6	102.4	96.9	89.3	168.9
PH4 – sound	1514	45.6	48.8	51.6	52.8	60.0

Source: Own work.

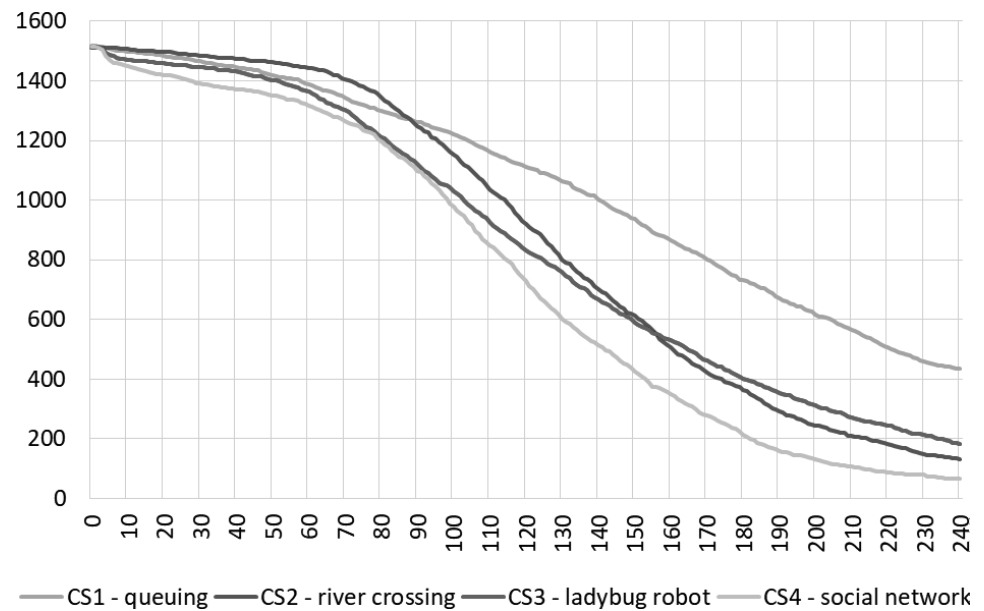


Figure 4. Decreases in the number of responses to computer science tasks depending on the number of answers provided over the specified solution time

Source: Gubo & Végh, 2022.

Table 4 presents the mean time consumption in seconds measured for multiple-choice computer science and physics tasks of the STEM assessment test broken down to individual answer choices. Upon analyzing the data presented in this table, it can be stated for all six tasks that students who gave the correct answer have spent enough time for reading and understanding the text of the given task. In task CS4, there were some students who marked answer choice c) in a visibly shorter time. They probably did not understand the question correctly, as this answer choice also includes the name Alfréd, who should not see the photo shared by Csenge. Furthermore, in task PH3, those students who selected answer choice e), spent much longer time solving

this task. After eliminating the three outliers, the mean solution time decreases to 88 seconds, approximately to the level of the mean solution time of the other answer choices.

The chart in Figure 4 illustrates for computer science tasks, how the number of students decreases if only answers provided over a specified time shown on the horizontal axis are taken into account. We assume that attentive reading the entire text of these tasks may have taken students at least 30–40 seconds.

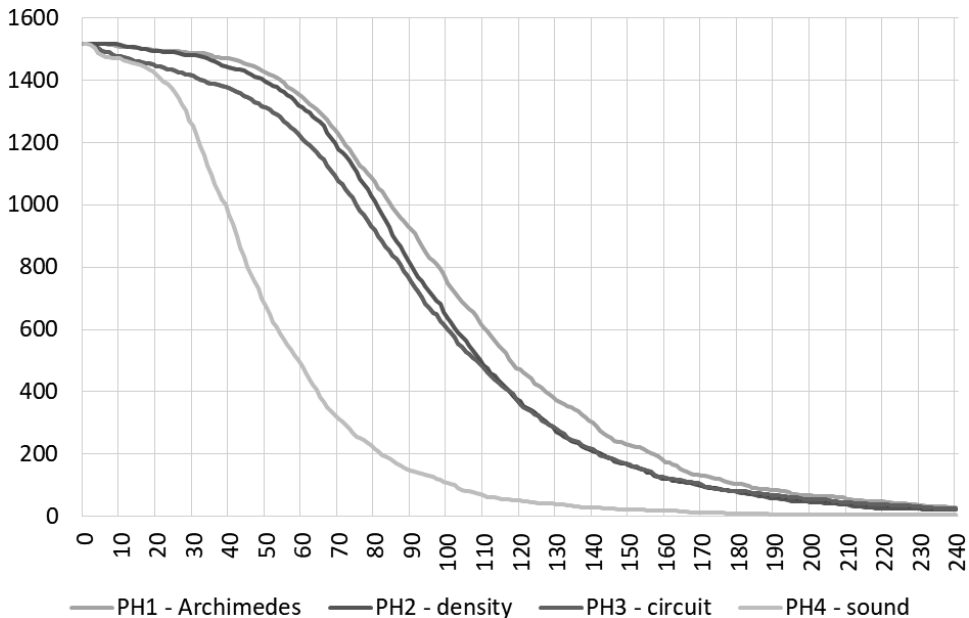


Figure 5. Decreases in the number of responses to physics tasks depending on the number of answers provided over the specified solution time

Source: Own work.

The smallest decrease was observed in task CS1, which proved to be the most time consuming task, where some of the distractors were already difficult to exclude clearly. In other three computer science tasks, around 70–80 seconds on the horizontal axis, the curves begin to slope more steeply downwards. This means that the majority of students needed at least this amount of time to read, understand and solve these three tasks. The most noticeable decrease can be seen in task CS4, which is not surprising, as after reading the text and analyzing the graph displaying acquaintances more than two third of the students solved the task correctly. It is also clearly noticeable that around 190 seconds the curves begin to flatten out again. From this, we can conclude that students rarely spent more than this amount of time to solve the tasks. Figure 5 shows similar decreases in the number of student responses to physics tasks. We assume that in tasks PH1, PH2 and PH3 the attentive reading of the text requires at least 1 minute, while in task PH4 at least 30 seconds. From this chart, we can observe that in tasks PH1, PH2 and PH3 the shape of the curves are roughly

similar – they begin to slope more steeply downwards around 50 seconds solving time, and begin to flatten out again around 120 seconds. In task PH4, the greatest decrease among all 8 examined test tasks can be observed. It is not surprising, as this task has the shortest description length and more than 60% of the respondents was able to provide the correct answer.

Based on the obtained results shown in Figures 4 and 5, it can be stated that the majority of students devoted enough time for solution of analyzed test tasks and did not rush to answer. It especially holds for computer science tasks.

CONCLUSION

The present paper examined the relation between students' performance in solving computer science and physics tasks of the STEM assessment test and time consumption on task solution. It was confirmed for all tasks that one of the preconditions of achieving a good result is the proper utilization of the time, however, spending too much time on the solution does not necessarily bring better performance. Correct answers took significantly more time than incorrect answers only in three computer science tasks (CS1, CS2 and CS4), while in the remaining computer science task (CS3) and in one physics task (PH3), solution times for correct answers proved to be significantly shorter. In other three physics tasks there were no significant differences between correct answer and incorrect answer solution times.

By taking into consideration the decreases in the number of responses to each task depending on the number of answers provided over shorter time (40–50 seconds), it can be concluded that, in general, students took the survey seriously and did not just answer without reading the questions and task descriptions carefully. Higher time consumption in computer science tasks could be explained by the relative complexity of these tasks – task CS1 requires calculation or prediction based on the given data, in task CS2 students have to specify a proper sequence of the river crossing steps, in task CS3 they have to execute a sequence of instructions, and finally, in task CS4 they have to analyze an acquaintance network.

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GEOGEBRA AS A CONSTRUCTIVISM TEACHING TOOL FOR VISUALIZATION GEOMETRY USING VR AND AR

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Abstract: *GeoGebra software, with its constructivist teaching approach, proves to be a powerful tool for visualizing geometry and preparing future teachers for an immersive educational experience using Virtual Reality (VR) and Augmented Reality (AR). By integrating VR and AR capabilities into GeoGebra, educators can revolutionize geometry learning, offering students a dynamic and interactive environment to explore geometric concepts. With VR, students can step into virtual geometric worlds, enhancing their spatial understanding and promoting hands-on learning. They can manipulate shapes, explore 3D constructions, and visualize abstract concepts in a tangible way. On the other hand, AR complements real-world environments by overlaying virtual geometric elements, making learning contextual and engaging. For future teachers, this integration serves as a valuable training ground for incorporating cutting-edge technology into their classrooms. As they experience combined VR and AR-enhanced geometry lessons, they are gaining their confidence and expertise. In this way, GeoGebra empowers educators to create transformative learning opportunities, fosters their deeper understanding of geometry. It also nurtures a generation of tech-savvy teachers ready to shape the future of education. In this contri-*

bution, we present our experience with the use of GeoGebra software in combination with VR and AR in the geometry courses for future mathematics teachers. Results of qualitative research indicate the beneficial influence of GeoGebra software on the enhancement of students' geometrical competences during their teacher training.

Keywords: GeoGebra, Virtual Reality, Augmented Reality, teacher training

INTRODUCTION

In training future mathematics teachers, a primary task is to guarantee the level of their education in geometry. High school graduates come to universities with varying levels of knowledge in this area. During the geometry courses, we try to bring them to a higher level of understanding and remove any misconceptions they may have brought with them to college.

Van Hiele's (1986) levels of geometric thinking emphasize the gradual development of students' ability to understand and analyse geometric concepts. The first level, visualization, is a foundational step in this development and is critical for the further development of geometric thinking. Given the importance of visualization in geometric thinking, it is essential that geometry instruction begin with this basic step and gradually lead students to higher levels of abstract and critical thinking.

According to Duval (1999), visualization is not merely about seeing but involves cognitive processes to interpret and understand what is seen. Thus, the act of visualization in mathematics is a multi-faceted process that goes beyond mere imagery and involves various representations to facilitate understanding (Duval, 2006).

If visualization is considered as a key building block in geometry teaching, a crucial issue is the appropriate choice of visualization tools and measuring their impact on the effectiveness of teaching.

In the past few decades, digital technology has left an indelible mark on the educational sector, shifting paradigms, and introducing innovative methods to impart knowledge. One such transformative tool is the GeoGebra software, which offers a platform combining geometry, algebra, spreadsheets, graphing, and calculus (Hohenwarter & Preiner, 2007). Rooted in constructivist pedagogy, this software enables learners to construct their knowledge actively.

But as the technological landscape has evolved, so has the need to integrate more advanced and immersive technologies. The integration of Virtual Reality (VR) and Augmented Reality (AR) into GeoGebra heralds a new era in geometry education, leveraging immersive experiences to make abstract geometric concepts more tangible. At the same time, these approaches can be combined with more traditional ones to demonstrate alternative ways to problem solving. Such combination leads to deeper comprehension and allows discussing different faces of the problem (Lovászová & Hvorecký, 2002).

In our paper, we describe our experience with connecting the capabilities of the dynamic GeoGebra software with VR and AR environments in the classroom and seek to answer whether such a revolutionary form of teaching is a suitable means of visualizing geometry.

1. THEORETICAL BACKGROUND

1.1. The Constructivist Paradigm in GeoGebra

Constructivism posits that learners actively construct their own understanding and knowledge through experiences and interactions with the world (Piaget, 1952). Vygotsky & Cole (1978) suggest that knowledge is co-constructed through interpersonal interactions and cultural tools. Constructivist classrooms often emphasize problem-based learning, collaborative projects, and real-world applications to facilitate meaningful knowledge construction (Brooks & Brooks, 1993). In contrast to traditional educational approaches that might see learning as the passive reception of information, constructivism views learners as active agents, interpreting and creating knowledge based on their unique experiences and schemas (Fosnot, 1998). Thus, the learner leads learners to discover new ideas independently (Hejný & Kurina, 2001). GeoGebra, as a dynamic mathematics software, aligns well with these principles. Its dynamic interface facilitates active geometric exploration (Stahl, 2014). Users can manipulate objects, observe changes, and draw conclusions from these changes, actively constructing their understanding of geometric concepts.

GeoGebra, with its interactivity, offers a dynamic platform to engage students in geometric investigations, aiding in deepening their spatial understanding (Hohenwarter & Jones, 2007). GeoGebra supports multi-representational views, enabling learners to transition between 2D and 3D visualizations, thus strengthening their spatial visualization capabilities (Laborde, Kynigos, Hollebrands, & Sträßer, 2006). Research by Edwards & Jones (2006) showed that the integration of GeoGebra in geometry teaching improved students' problem-solving skills, as they could visually test and verify geometric properties and theorems. With GeoGebra, the abstract nature of many geometric concepts becomes more concrete, leading to increased student engagement and motivation (Arbain & Shukor, 2015). The software's dynamic interactivity provides an environment for students to explore, conjecture, and validate their understanding, promoting a deeper conceptual grasp (Dick & Hollebrands, 2011).

As educators increasingly leverage technology to foster spatial understanding, GeoGebra remains a vital tool in deepening students' geometric intuition and spatial reasoning abilities (Hohenwarter, Hohenwarter, & Lavicza, 2009).

1.2. Visualization: Bridging Abstract and Real-World Geometry

Visualization connects abstract geometric concepts with concrete real-world phenomena. Thus, it helps in translating complex relationships or properties into tangible experiences. As Zimmerman & Cunningham (1991) note, "Geometric representations and constructions serve as bridges between concrete manipulations and abstract reasoning".

Visualization in geometry helps bridge cognitive gaps by making implicit knowledge explicit. Arcavi (2003) observes that "often the visual representation can provide insights and understanding where other representations fail".

The need to coordinate among various representations (like symbolic, verbal, and graphical) is vital for comprehension. Visualization aids this coordination. Duval

(2006) emphasizes the necessity of transitioning between different semiotic representations in mathematical cognition.

According to Bishop (1980), visualization is not just for those with a propensity for it but can act as a mediator for all types of learners, enhancing understanding. It is thus suitable for diverse learning styles, making geometry more accessible.

Visualization provides context, linking theoretical knowledge to real-world applications. Giaquinto (2007) suggests that visual thinking in geometry can bridge the gap between abstract thought and tangible, real-world geometric situations.

1.3. VR and AR: Bridging Real and Virtual Geometry

Virtual Reality (VR) and Augmented Reality (AR) technologies have revolutionized the pedagogical landscape, particularly in the realm of geometry teaching, fostering enhanced spatial visualization (Sorby, 2009). Integrating these technologies into classrooms has shown potential to reduce the abstraction of geometric concepts, making it more learner-centric and interactive (Kaufmann & Schmalstieg, 2002).

Research by Kellman et al. (2022) highlighted that VR and AR applications in geometry can improve students' spatial reasoning capabilities, bridging the gap between 2D representations and 3D mental models. VR and AR are groundbreaking technologies that can significantly enhance the teaching of geometry by deepening students' spatial imagination. Such technologies connect theoretical knowledge and practical application, making geometry more accessible and relatable for all learners. The hands-on experience provided by VR and AR can help students develop a more intuitive understanding of geometric properties and spatial relationships.

Using VR technology, we can enrich students' mathematical modelling skills to address real-world issues (Cahyono, 2023). They will become more active in taking part in activities related to mathematics. Similarly, a mobile application with AR features can be a useful problem-solving tool to bridge the gap between real-world situations and mathematical concepts (Cahyono et al., 2022).

With AR, students can merge theoretical geometric constructs with real-world objects, grounding abstract concepts in tangible experiences (Ibáñez & Delgado-Kloos, 2018). AR overlays digital information onto the real world, offering students the chance to manipulate and study geometric objects in their immediate surroundings, making abstract concepts tangible.

2. METHODS

2.1. Survey

The study took place during the summer term of the 2022/2023 academic year and at the beginning of the winter semester of the academic year 2023/2024 at the University of Ostrava. It was held as part of a geometry courses designed for prospective mathematics teachers, with participation from 19 first- and second-year bachelor's degree students specializing in teaching for the second grade of elementary schools. The methodology of the research was grounded in qualitative analysis, employing action research with a focus on the method of observation.

In our observations, we focused on the improvement of students' geometric competences in relation to the use of GeoGebra applications, together with VR and AR technologies. According to National Council of Teachers of Mathematics (2000), geometric competence encompasses a range of skills and understanding in the field of geometry, crucial for navigating various academic and real-world contexts. It includes the ability to recognize and understand the properties and relationships of geometric shapes, as well as the skill to apply geometric concepts in problem-solving scenarios.

2.2. Training Future Teachers: Building Confidence and Expertise

Future mathematics teachers at the University of Ostrava take a course in planimetry and stereometry in the second and third semesters, where they could deepen their knowledge in the field of plane and spatial geometry.

The course in planimetry begins by establishing basic geometric principles in the Euclidean plane. We build their theoretical geometric knowledge based on the principle of axiomatic construction of geometry. Students verify the validity of these rules by simple construction tasks by finding the intersection of sets of points of a given property. Gradually, we build into these problems the need to use more complicated concepts, such as congruent mappings. During the course we develop their classical drawing skills as well as their digital competence by using the GeoGebra software. The course in stereometry follows planimetry. Here a fundamental problem appears. Students are not always able to grasp the causal relationships and connections with geometric concepts in the plane and in space. Most of them have negligible knowledge of spatial geometry, they know little about basic 3D shapes, and we can build their knowledge from scratch.

2.3. Implementation: Experiencing VR and AR in Teaching Geometry

Powerful information and communication technologies (ICTs) allow us to see virtual reality environment (VRE) as a tool to modernise the delivery of knowledge and skills, particularly to enhance the engaging nature of university humanities courses with interactive, practical elements (Korenova et al., 2022). According to Duhaney & Young (2011), the essence of this modernisation depends on effective communication between lecturers and students using modern ICT. VRE provides opportunities for students to engage and experiment. The sense of presence in this virtual environment is characterized by real-time interactions in 3D space and the representation of users through avatars, as reported Tachi (2013).

We have moved part of the classroom into the VRE, especially home training in the form of blended learning. GeoGebra applets implemented in this environment fulfilled the function of visualization and had a positive impact on the development of algorithmic thinking and spatial imagination of students (Schmid & Korenova, 2022). Students enter the VRE through avatars, which reduces the risk and fear of failure and thus increases their intrinsic motivation (Korenova, Hvorecky, & Schmid, 2023). They can interact with each other, creating a space for collaborative learning, that fostering teamwork, communication, and critical thinking skills, and communicative competencies (Tran, Pytlik, & Kostolányová, 2020).

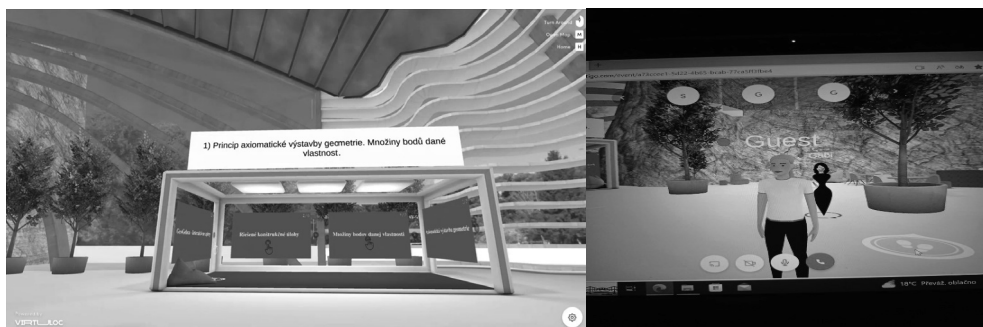


Figure 1. Blended learning in VRE

Source: Own work, 2023.

We also focused on this aspect: In selecting appropriate teaching materials, we should not overlook the importance of their attractiveness and ability to engage students if we are to achieve a deep and relevant understanding of the knowledge that these materials convey (Hvorecky & Korenova, 2023). Our innovative teaching model fully met this requirement.

We wrapped up our planimetry course with a gamified test in the VRE, aimed at assessing our students' capacity to apply their learned knowledge in problem-solving. During the stereometry course we teach the students positional problems, such as finding the intersection line of two planes or the intersection point of a line with a plane. They then apply this theoretical knowledge to solve practical problems, such as slicing solids through planes. This is where GeoGebra3D comes in as a great visualisation tool (Figure 2). The ability to move space allows us to see the situation from different angles. We can vary the position of given objects, which changes the lens of the object created by the construction. This contributes to a better spatial visualisation and subsequent understanding of the geometric context.

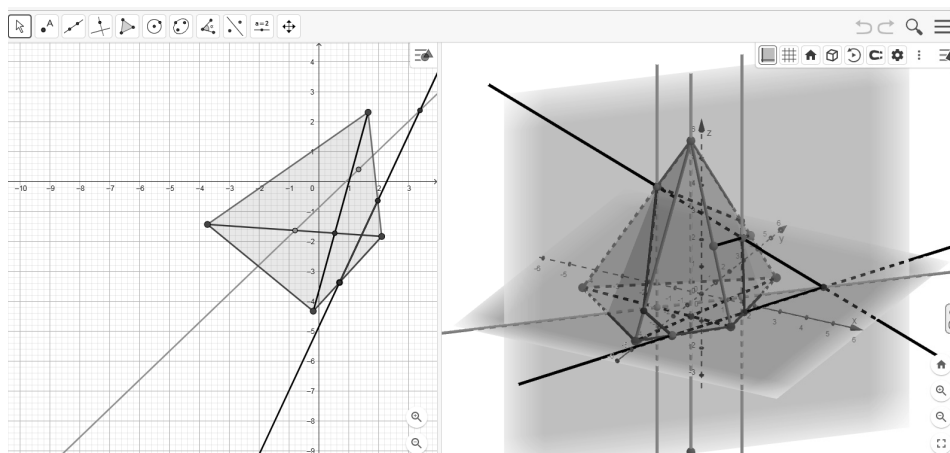


Figure 2. Visualisation of knowledge used by slicing solids through planes

Source: Own work, 2023.

The AR application in GeoGebra also helps us to better visualise the situation when we embed the virtual model from the GeoGebra into real space. This can overlay a previously constructed real solid model, as shown in Figure 3. This is how we teach students to understand the relationship between the real model and its virtual representation.

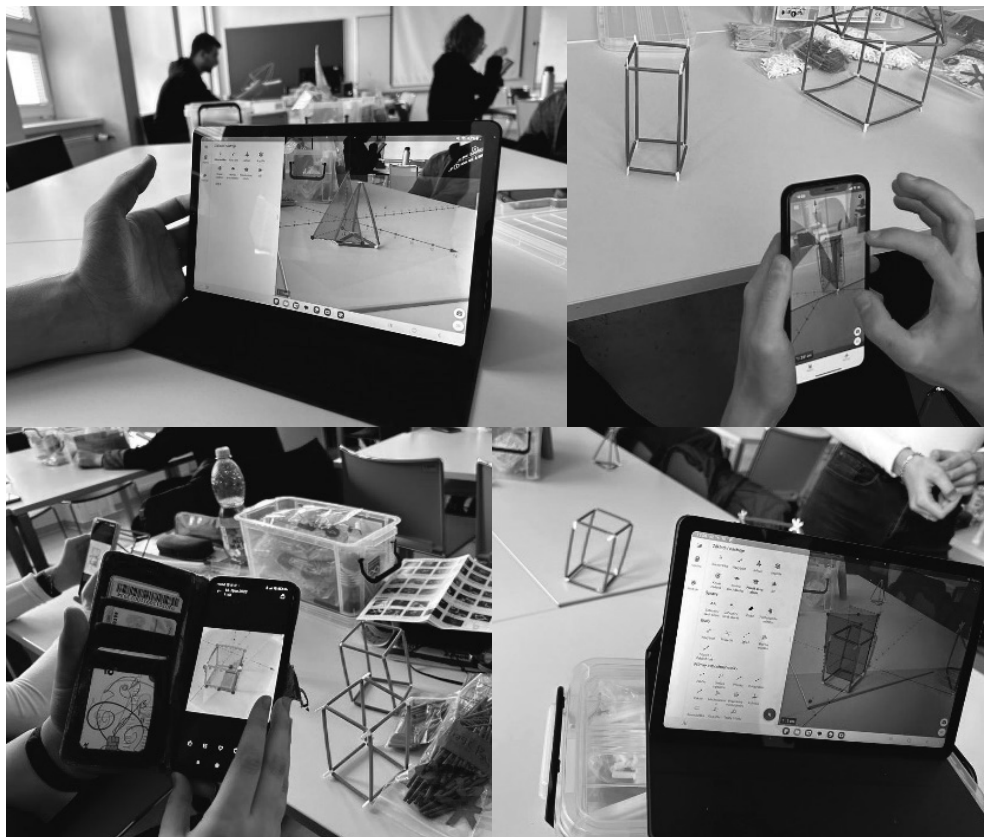


Figure 3. Overlaying real solid model used GeoGebra AR app

Source: Students' work, 2023.

To better understand the causality of relations and properties between planar and spatial elements, it is useful to transform the topic, the set of points of a given property, from plane to space. Adding another dimension complicated this task, but augmented reality allowed students to explore, verify and understand this topic. Moreover, they worked in groups during this activity (Figure 4), so that the knowledge they discovered could be discussed and argued with each other.



Figure 4. Modelling a set of points of a given property used GeoGebra AR app

Source: Students' work, 2022.

3. DISCUSSION AND CONCLUSION

To assess the level of our students' geometric competence, we used the results of the gamified test in the VRE, which consisted of 10 practical tasks. The average success rate of the group of 19 students was more than 83 percent.

In addition, we observed a cognitive increase in geometry comprehension in our students' use of the GeoGebra AR application. Based on this pilot study, we would like to investigate this interesting phenomenon in more detail with a larger sample of students in the future. Our main aim is to make learning valuable and attractive for our students. As Hvorecký (2007) said: "Mathematics Teaching will continue until people value it as a vivid, vital and no-nonsense subject".

Thus, in conclusion, we can confirm that GeoGebra software with the integration of VR and AR capabilities is a suitable tool for visualizing geometry as well as developing geometric and digital competencies.

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SURVEY ON THE USE OF ELECTRONIC MULTILINGUAL TERMINOLOGICAL DICTIONARY

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Abstract: *The article provides an analysis of the development and application of the electronic multilingual terminological dictionary. The authors claim that an electronic source of that kind is highly important for the systematization of the Ukrainian terminological base, introducing it in the world scientific context and incorporating the appropriate vocabulary network into the processes of research and development both in the academic and educational institutions.*

The electronic dictionary is a computer database that combines coded dictionary entries that enable a quick search for the necessary words, considering the morphological forms of searching for word combinations that make it possible to determine the correct meaning of a word during translation. The electronic multilingual terminological dictionary is designed to satisfy a wide range of users, such as ESP students, postgraduates, young scholars, specialists in the field of science and technology, employees of international companies, military personnel, and others. The electronic multilingual terminological dictionary provides information on a term in Ukrainian, Polish, English, French, and German languages. Each dictionary entry includes the

grammar paradigm of a lexeme along with a valid explanatory article with appropriate references. To evaluate the expediency of electronic multilingual terminological dictionaries for work and educational processes a survey among the dictionary potential users was conducted.

The survey questions addressed users' needs, the effectiveness of the electronic multilingual terminological dictionary, time, spent searching a term, and demographic information such as gender, age, and occupation of the respondents. The survey demonstrated a high level of user satisfaction with the electronic multilingual terminological dictionary as a reference material, search tool, and valid database. The conducted research allows us to draw a conclusion: the study testifies to the expediency of the use of the electronic multilingual terminological dictionary, as the dictionary is convenient, user-friendly, and allows significant time savings in searching for the necessary information.

Keywords: Electronic dictionary; electronic multilingual terminological dictionary; ESL students; E-learning; terminology; translation

INTRODUCTION

The 21st century is marked by the rapid development of information technologies, a high level of globalization, and constant scientific and technological progress. Therefore, there is a tangible need for the systematic actualization of acquired knowledge and the recording of new achievements and assets, which will contribute to the harmonious development of society. International scientific and socio-economic cooperation and the current state of information technology development necessitate the creation of an electronic multilingual terminological dictionary. This type of electronic lexicographic publication is designed to promote the establishment of further fruitful cooperation, the exchange of skills, knowledge, and experience, and therefore the successful implementation of scientific projects and the introduction of the achievements of science and technology into the life of society.

An electronic dictionary is defined as a computer database that combines coded dictionary articles that enable a quick search for the necessary words, taking into account the morphological forms of searching for word combinations allowing the determination of the correct meaning during translation. The need for an electronic multilingual terminological dictionary is related not only to the need to objectify research, optimize and rationalize the professional work of specialists in various fields of science but also to the growing demand of the average user for adapted objective reliable information of both linguistic and specialized professional nature. The use of an electronic multilingual terminological dictionary will provide reliable and convenient access to an array of relevant factual material, which will contribute to the optimization of the analytical work of specialists of various specialties.

Electronic Multilingual Terminological Dictionary (EMTD) is a digital tool that allows you to get an interpretation of a term, provides comprehensive information about morphological features, reveals the features of the concept, and provides a link to the original source.

Accordingly, the specified electronic dictionary is an indispensable tool for students, young scientists, and specialists in various fields of science, as well as employees of international companies and translation agencies to master relevant fundamental knowledge and enhance professional competence. In addition, the electronic multilingual terminological dictionary makes it possible to carry out a number of further important scientific studies of a linguistic nature.

1. THEORITICAL BACKGROUND

Modern Ukrainian scientists (Karimov et al., 2022; Moroz et al., 2018; Morze, Kuzminska, & Liakh, 2017) increasingly emphasize the necessity to improve the quality of future specialists' professional training within the university educational system, which requires the study and scientific reevaluation of various forms of student education organization, particularly in the online format. Given the ongoing transformation of higher education in Ukraine, aligning with European standards, there is a significant focus on enhancing students' scientific work (Lokhvytska, 2023) and understanding various aspects of the educational process.

In global scientific research and practice (Hamdan & Amorri, 2022; Liu, 2019; Nikou & Maslov, 2021; Stoian et al., 2022; Wagiran et al., 2022; Wickramanayaker, Hewaarachchi, & Brown, 2021), significant advancements of e-learning in universities have been extensively presented. The organization of E-learning has been strengthened due to the implementation of quarantine measures in many countries. It has been proven that online learning contributes to broadening awareness regarding the application of information and communication technologies. It also develops skills in solving non-standard problems and tasks, which, in turn, enhances professionally significant qualities among students to achieve their set goals (Aesaert & van Braak, 2018; Morze, Kuzminska, & Liakh, 2017; Yang & Cornelius, 2004).

Several research studies (Dumfit & Fernandez, 2017; Fernández-Márquez, Leiva-Olivencia, & López-Meneses, 2017; Karimov et al., 2022; Wagiran et al., 2022) have explored the impact of e-learning on the development of students' motivation and volitional efforts in acquiring relevant knowledge. These studies highlight the stimulation of intensive independent search and choice of information sources from different resources, the activation of cognitive activity in solving tasks related to the study of subjects using computer technology, and the acquisition of computer thinking skills. This can be interpreted as the development of a holistic set of personal qualities in students. Researchers Dumford & Miller (2018) noted that online courses develop analytical thinking and a desire to learn more by discovering new Internet resources that present scientific material in an appropriate way. Additionally, according to Al Rawashdeh et al. (2021), e-learning increases the possibility of communication among all participants of the educational process, enhancing their mobility and efficiency in activities.

Castro-Rodríguez (2022) and Ferrero (2020) emphasise the importance of creating a research environment in universities, where students have the opportunity to experiment with their scientific ideas. This process not only contributes to their professional development but also promotes personal growth and development. They

demonstrate independence, perseverance, creativity, and responsibility in their scientific inquiry. They engage in interactions with others, discussing their own research projects, which directly impacts their development as professionals (Nurpratiwi, Amaliyah, & Romli, 2022; Wickramanayaker, Hewaarachchi, & Brown, 2021). The implementation of research tasks that occur online facilitates the development of students' ability to navigate the information space, get relevant information, and operate it effectively. It stimulates their personal interests and needs, aligning with the demands of a modern high-tech society (Becher, 2022; Bellei & Munoz, 2021; Van Eeden, Eloff, & Dippenaar, 2021).

Thus, students' scientific work in the context of e-learning is characterized by enhanced attributes such as *informativeness*, *individuality*, and *activity*. These attributes will be considered as components for conducting empirical research. However, in the presented scientific studies there are no results regarding the characteristics of the strengths and weaknesses of e-learning from the students' point of view, which will be carried out on the basis of their self-analysis.

A significant cohort of scholars, both in Ukraine and worldwide, studied the peculiarities of creating an electronic dictionary. Recently, Ukrainian scientists have been considering the problems of creating electronic terminological dictionaries, mainly in various scientific spheres. An algorithm for compiling an electronic multilingual dictionary of dental terms was developed, as well as the problems that arise during the writing of dictionary entries and the issue of computer support for the implementation of the dictionary compilation project were highlighted (Devyatko, 2016). Terminological dictionaries dealing with special vocabulary were systematized (Petrova, 2021). An analysis of the linguistic features of the functioning of aviation terminology was carried out (Heletka, 2022). The problem of the formation of lexicographic competence in the system of professional training of future teachers in the classes of the philological cycle was considered (Pomyrcha et al., 2017).

What is more, foreign scholars emphasize the importance of an electronic monolingual English learners' dictionary in fulfilling receptive and productive tasks and memorizing the meaning and collocations (Nurmukhamedov, 2016). Temporal labels and specifications of time became a sphere of study in some monolingual dictionaries of English (Nori, 2022). Specialized online dictionaries are viewed as a powerful tool for creating term banks or terminological databases (IATE, CercaTerm, and UNTERM), their advantages and disadvantages are analyzed regarding the sphere of application and the importance of theory and practice in lexicography is asserted in designing and compiling them (Fuentes-Olivera et al., 2014).

The research aims to understand the influence of the electronic dictionary corpus on students' studies and life. The investigation addresses the issue of the evaluation of the EMTD's potential for work and educational processes. Therefore, estimating the value of EMTD use is essential, implying quantitative research design methods, including questionnaires. The electronic dictionary corpus uses various algorithms to query massive databases and finally displays the data the learners need at the fastest speed. Therefore, an electronic dictionary corpus can be used as a way to solve some difficulties, such as obtaining data in unknown fields, exploring the causal

relationship between data, and improving data quality and query speed (Sun, 2021). Moran's dictionary of chemical engineering practice comprises terms of the chemical engineering profession and suggests short discussions of the most contested terms (Moran, 2022). Latvian scholars examine Latvian-English-Latvian electronic lexicographic resources for their adaptability to user needs and reliability. They focus on treating legal terminology where utmost precision is required. Thus, the research reveals the need for a free-access legal terminology electronic database where Latvian terms are equivalents from foreign languages with appropriate support information (Karpinska et al., 2022).

Some scientists conduct a comparative study of popular electronic dictionaries. They outline digital resources to learn a language (Pikilnyak et al., 2021). The study proves that dictionaries help to discover a foreign language and use it fluently. Moreover, the investigation confirms that using digital dictionaries facilitates the educational process. Serbian scholars tend to explore the dictionary use habits of EFL students (Knežević, 2021). The research highlights the typical behaviour of the new generation of EFL learners concerning their dictionary use. In addition, it outlines the need to develop their digital competence with the help of dictionary use.

Different types of dictionaries aimed at particular user groups have been researched, including dictionaries for adults and children (B'ejoint, 2015). A group of scientists presented a work in which two methods for the topic modelling of multilingual document collections (machine translation and the coding of semantic concepts using a multilingual dictionary) are evaluated. The case study used two text collections (of tweets and news articles) in three languages (English, Hebrew, Arabic), covering the ongoing local conflicts between Israeli authorities, settlers, and Palestinian Bedouins in the West Bank. Both methods proved to be valid with some method specific differences (Maier et al., 2022). There are online dictionaries that cover some specific scientific fields: medical informatics and digital health multilingual ontology (Benis et al., 2022). Z. Hann and M. L'Homme came up with a methodology and descriptive model designed to include Chinese collocations in a multilingual resource that focuses on environment terminology. The methodology is corpus-based and the descriptive model is aimed to account for the lexicosemantic properties of collocations (Han et al., 2022).

Fruitful research was carried out in the description and classification of terminological dictionaries and included the principles and methods of compiling terminological dictionaries (Najmiddinov, 2021).

Nevertheless, it remains relevant to investigate the peculiarities of the use of an electronic dictionary through the EMDT example and to evaluate the expediency of this digital tool. Ukrainian terminology is in urgent need of systematization and development because during the Soviet times it was replaced by Russian equivalents in scientific circulation. The terminological studies of independent Ukraine are conducted in each field separately without proper interaction and coordination with the norms of the Ukrainian language (the spelling of 2019 in particular) and the need for interdisciplinary discourse. Therefore, the relevance of a terminological dictionary that systematizes the terms of various fields of knowledge with the dominant consistency of terminological approaches is obvious. The complex systematization of terms

in the context of cross-linguistic parallels is of particular importance when teaching foreign languages (English as ESP in particular) for students of non-philological disciplines. As noted by A. Kirda-Omelyan, an integrated approach allows teachers to create an educational experience that combines several subjects which include multidisciplinary tasks and training projects (Kirda-Omelyan et al., 2022).

The needs of young scientists when mastering the terminological apparatus of the chosen discipline are determined by the necessity to freely use terms both in their native language and in the languages of international partners. Specialists in the methodology of teaching foreign languages in a professional context emphasize that despite the fact that knowledge is a necessary result of training, only skills can operate knowledge in overcoming problems. Therefore, advanced training envisages the development of numerous skills, including recognizing special terms in the original text and choosing their terminological equivalents (Kirda-Omelyan et al., 2022). Therefore, the dictionary conditions the formation of free use of terms in the process of acquiring professional competencies.

2. RESULTS

The electronic multilingual terminological dictionary is designed to satisfy the need of finding information on the relevant terminological lexeme, as well as the peculiarities of its functioning in professional discourse. The EMDT, therefore, is aimed at students, postgraduates, young scholars, specialists in the field of science and technology, employees of international companies, military personnel, etc. Accordingly, the success of educational and professional tasks directly depends on the quality of such a lexicographic publication. The EMTD is easy to use, contains a significant volume of terminological units, and is characterized by a wide range of languages involved, which substantially distinguishes it from similar lexicographic publications. The dictionary is designed to facilitate the implementation of several important educational and professional functions, in particular:

- informative, which consists in providing comprehensive information about the terminology of the relevant field of knowledge, as well as outlining the essential characteristics of a certain concept;
- normative, which involves providing morphological help for the correct contextual use of a terminological lexeme;
- spelling, which is designed to familiarize with the correct spelling of a word.

In addition, the EMTD provides translation equivalents and, if available, indicates their synonymous variants. The dictionary makes it possible to carry out comparative studies in the field of linguistics and contributes to the unification of the terminology of the relevant field, etc.

The EMTD is developed using programming languages and technologies such as PHP, HTML, CSS, and JavaScript- enabling comprehensive functionality for an electronic multilingual dictionary. Using a programming language PHP, the MVC architectural pattern, implemented the panel administrator to manage the system. As a database management system MySQL, a free relational database management system, was chosen as the data source.

backs promptly, and to adapt the functionality of the specified digital lexicographic tool to the users' needs.

In particular, to study the demand for such kind of terminological lexicographic materials, the survey participants were asked to define the frequency of use of such reference sources.

The results of the study indicate a relatively high frequency of using lexicographic sources for searching and/or clarifying the necessary information on a relevant terminological lexeme. Therefore, more than 60% of potential users of the electronic multilingual terminological dictionary need to use reference sources permanently. More than 20% of respondents often refer to a lexicographic reference source. Therefore, the results of the survey prove the importance of creating a multilingual terminological publication.

As a rule, the respondents use bilingual (53%) terminological dictionaries, as they need to find translation equivalents of a specific terminological unit. 34% of potential users prefer multilingual terminological publications, which significantly reduce the time of searching for the necessary information and diversify it. 13% of the respondents use monolingual (interpretive) dictionaries, as they highly value the thoroughness and completeness of the description of a necessary terminological lexeme. Respondents note the need to use several dictionaries simultaneously since the lack of multilingual terminological sources often requires double, or even triple searches, in particular in Ukrainian – English, or English – French language pairs, etc.

The vast majority of respondents (53%) use electronic dictionaries in their professional and learning activities. Electronic dictionaries are convenient to use, provide a quick search for the necessary lexeme, eliminate the need to print, and instead allow you to copy the necessary information and edit it accordingly. In addition, electronic dictionaries might be quickly renewed and updated, and therefore provide valid and up-to-date information important for a user. 34% of the respondents use both paper and electronic lexicographic sources. Respondents emphasize the absence of highly specialized electronic terminological dictionaries, which makes them use traditional paper sources. The lack of electronic multilingual terminological sources is also evident. Accordingly, this indicates the relevance and necessity of an electronic multilingual terminological dictionary. 13% of the users prefer paper sources, arguing for the clarity of presentation of the material and the absence of hyper textual links distracting attention, as well as significantly less eye strain. This group of respondents believes that this type of dictionary helps to reduce fatigue and increase concentration at work. Other advantages include the possibility of using such a dictionary when the Internet is not accessible. However, respondents note the need for relatively more time to thoroughly study the necessary lexical unit.

Respondents agree on the ease of use of the electronic multilingual terminological dictionary and the much shorter time required to grasp the meaning of a terminological lexeme and the features of its use in the context.

Respondents' answers indicate a significant difference in the time required to find a certain terminological unit using a traditional (paper) terminological dictionary and its electronic alternative. In particular, looking up a word in a paper dictionary usually takes 5–10 minutes (58% of respondents). Instead, a search in an electronic diction-

ary usually takes 1-2 minutes (87% of respondents). Therefore, an electronic terminological dictionary definitely provides faster search and is more convenient to use. Among the advantages of the electronic multilingual terminological dictionary, the respondents listed the following:

- ease of use;
- multilingualism;
- a significant amount of information (encyclopaedic reference);
- practicality and availability;
- possibility of timely updating of data;
- quick search;
- possibility to compare a term translation in other languages, and therefore the availability of translation equivalents;
- morphological and grammatical help;
- possibility to systematize the information, etc.

The specified characteristic features of the electronic multilingual terminological dictionary got a positive response among the majority of its potential users. In particular, the ease of use (95% of respondents) of the specified electronic lexicographic publication and its multilingualism (95% of respondents) are highly valued. The dictionary is appreciated for its practicality and accessibility (82%), the significant amount of information presented (65%), and the presence of morphological and grammatical help. Moreover, the respondents highlight the possibility of timely updating of the dictionary register (63%), which is actually appropriate in the conditions of intensive development of society and the scientific and technological revolution.

When getting acquainted with a terminological lexeme, the users mainly need a comprehensive definition, a certain encyclopaedic reference on the term (61%), its translation equivalent (18%), and information about its morphological and grammatical features (16%).

The respondents were also asked to evaluate the expediency of using the electronic multilingual terminological dictionary according to certain criteria. In particular, the potential users of the dictionary evaluated the interface of the electronic lexicographic source.

The results of the survey indicate the respondents' satisfaction with the interface of the EMTD. In particular, potential users of the dictionary note the friendly colour palette of the electronic dictionary, the logic, and the structure, achieved due to the appropriate graphic design of the information page, the presentation of certain information in the form of tables, etc. However, individual users note certain difficulties in searching for terms associated with the peculiarities of filling the dictionary, in particular the incomprehensibility or arrogance of the tables and the display of their content. Nevertheless, in general, these difficulties do not affect the convenience of using the specified dictionary.

Therefore, 78% of respondents consider the EMTD convenient to use. 16% state the relative convenience of the dictionary. Only 6% of respondents deny the convenience of the dictionary, while the majority support the relative comprehensibility of the interface. The partly satisfied users claim that hypertextuality scatters their attention and reduces the effective perception of the material.

In terms of languages, the EMTD receives a fairly high rating. Accordingly, potential users of the EMDT approve the list of languages, as the specified languages are among the most widely used in the world, and therefore will contribute to smooth mutual understanding during communication and the establishment of successful and productive cooperation. The respondents speak positively about the rather significant number of languages represented, which indicates the uniqueness of the electronic multilingual terminological dictionary.

The composition of the dictionary entry and the representation of the terminological lexeme also received positive feedback. Therefore, 86% of respondents comment positively on the available encyclopaedic reference, providing a deeper understanding of the peculiarities of the terminological lexeme. Such an approach also determines the essential characteristics of the concept functioning in the relevant branch of science. Morphological and grammatical information related to the terminological lexeme is considered valid and efficient, as it contributes to the lexeme's correct use in a professional context.

The vocabulary volume of the EMTD was positively assessed. According to the respondents, the amount of 9,000 terminological units is quite sufficient for outlining the basic concepts of the relevant fields and allows them to outline the terminological field of their research. In addition, one of the advantages of the electronic dictionary is the possibility of timely and systematic updating, and thus the volume of the specified digital lexicographic source can be increased over time in accordance with the requests of its potential audience.

The survey indicates the evident importance of the created dictionary for the education and work of a (foreign) student, a graduate student, a young scientist, a specialist, an employee of an international company, an employee of a translation agency, a military serviceman, and others. In particular, the EMTD is useful for a student when studying comprehensive and specific disciplines, it provides a grasping of the detailed essence of a concept, contributes to further scientific research, etc. A graduate student or a young scientist gets access to the distinctive features of a certain concept through the prism of the scholars' vision worldwide, which enriched the source base and significantly expands the range of their scientific research. A translator would use the dictionary in search of translation equivalents, while the encyclopaedic reference available in the dictionary is designed for a deeper understanding of the translation field and contribution to its higher quality. Employees of international companies and specialists in the field will use the electronic multilingual terminological dictionary in their professional speech activities, supporting and establishing scientific cooperation and contributing to the successful implementation of socially significant projects. Respondents were asked to clarify the advantages of an electronic multilingual terminological dictionary.

The results of the study indicate a high assessment of the language representation of the terminological lexemes of the electronic multilingual terminological dictionary (53% of the respondents gave a favorable response).

According to the respondents, the number of available languages is a prominent feature of the dictionary and qualitatively distinguishes it from other lexicographic products. Respondents are also satisfied with the volume of an electronic multilingual

dictionary (22% of respondents), which reflects the basic concepts of the relevant branches of science and outlines their terminological apparatus. 17% of the respondents consider the dictionary's advantage to be the construction of the dictionary entry, because the expediency of the dictionary depends on the material layout, and therefore its popularity among the potential audience.

Survey participants rated the expediency of using the EMTD on a scale from 1 to 5 points, where 1 is ineffective and 5 is effective.

The survey of potential users proves the expediency of using the EMTD, in particular, 69% of respondents note the high expediency of the dictionary in carrying out educational and/or professional activities, rating the dictionary with the highest 5 points. 23% of the respondents rate the dictionary 4 points out of 5, taking into account a number of desirable features, in particular – the ability to return to branches (Main) by clicking on the dictionary logo in the upper left corner; – the ability to choose the number of desired words for viewing (not only 50, but also 100, etc.); – make the “Search” option more convenient to use by placing it on the main page, and not in a separate tab.

Respondents were also invited to give more extensive feedback on the distinguishing features of using the EMTD. In particular, the vast majority of respondents note its convenience and efficiency, because, in a matter of minutes, you can find comprehensive information about a terminological unit in several languages at once, as well as acknowledge the peculiarities of the term use. In addition, the dictionary supports comparative studies across different languages, which is useful for relevant professionals in the field.

3. DISCUSSION

The survey proves the significance of EMTD compilation, as the named digital resource not only saves the user's time (both an experienced specialist and a student dealing with special terms) but also introduces them to an extensive multilingual context. In contrast to numerous lexicographic editions, the EMTD is an example of a language-sufficient dictionary that enriches its target audience and makes international cooperation possible. Moreover, it allows for comparing the terms' usage in European languages. Furthermore, it helps to analyze the interpretation of the term deeply. The lack of a unified interdisciplinary base in scientific and academic discourse forces most researchers to use dictionaries containing terms from only one of the fields of knowledge. Separately specified dictionaries often do not have points of intersection between them and do not correlate with the current standards of the target language, which is improving and developing. The isolation of each scientific field leads to a vague understanding of a word and the loss of the lexeme's terminological function.

The analysis of the papers written by the experts on electronic reference resource development revealed the need for a resource of a comprehensive level and content. Unfortunately, there are bilingual dictionaries that serve purely for translation or monolingual explanatory ones. In addition, industry dictionaries often exist only in

paper form, lagging behind the development of modern science and technology and not meeting the current norms of the target language.

The authors of the article, who are directly involved in the development and compilation of the EMTD, aimed to lay the foundation of a digital resource that facilitates the search for terminological lexemes. In addition, it speeds up the time required for such a search as much as possible. Moreover, it makes it possible to compare the functioning of the term in different European languages and provides detailed encyclopedic and grammatical information about a term. This study demonstrates the results of a survey conducted based on an EMTD trial on a potential audience. At the same time, the survey covers students, experienced scientists, teachers, and practicing professional translators. When conducting the survey, the authors of the article followed the principles of gender and age balance of the audience. Therefore, the survey beneficially highlights the preferences of academic, governmental, and business occupations, thus fully proving the efficiency of the EMTD. For the first time, an electronic dictionary was analyzed from such a perspective. What is more, the authors maintained gender and age balance principles during the survey, neutralizing potential subjectivity in results interpretation.

The survey showed that most users are satisfied with the principle of multilingualism, emphasize its importance for speeding up the search for terms, and adequately evaluate the practical benefit of a multilingual approach. Grammatical data about the term also contributes to the correct application of terms in the work of both students and experienced researchers. The encyclopedic nature of the description, accompanied by confirmed references to academic sources, determines and supports the accuracy of the understanding and application of the term. The multilingualism of explanatory articles provides an opportunity to compare approaches to terms in different scientific schools and enhances access to the term when learning foreign languages of professional communication. A systematized multilingual collection of terms of defined fields can also serve as the basis for a terminological database for the software of ATS and, after proper processing, be converted into Computer Assisted Translation applications, such as “SDL Trados Studio” or “OmegaT”.

4. CONCLUSIONS

Thus, the results of the study testify to the expediency of the use of the EMTD, as the dictionary is convenient, user-friendly, and allows significant time savings in searching for the necessary information. Additionally, the EMTD provides translation equivalents in the most widely used languages worldwide, eliminating the need to use several dictionaries simultaneously. The EMTD provides comprehensive information on the peculiarities of the use of a terminological lexeme and offers a detailed overview of its concept. Thus, it facilitates successful professional communication among specialists in various fields.

The prospects for further research lie in dictionary entry genre investigation that will contribute to better dictionary compilation. In addition, EMTD pedagogical potential requires further consideration. Therefore, it is necessary to work out the algorithm of EMTD use in a language classroom.

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DIGITAL SUPPORT IN THE IMPLEMENTATION OF CHEMISTRY LABORATORY CLASSES

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Abstract: *The article attempts to analyze contemporary problems related to supporting the chemistry teaching process, in particular the integration of materials prepared on e-learning platforms in chemistry laboratory classes. For this purpose, the article discusses the experiences of the “Laboratory for Chemistry Teaching and Contacts with the Social Environment” – the project “Chemist as a detective” and the student project “Anvil.” The primary aim of these projects was to provide students with an improvement in the quality of education as part of the third mission of the university, as well as interest in natural sciences. For this purpose, educational materials were created on the Google Classroom and Wakelet.com educational platforms. Prior to participating in the workshops and familiarizing themselves with the teaching materials, each of the 166 participants completed a brief survey or pre-test. They also took a test after completing the classes. The collected data were used to analyze progress in knowledge and progress in laboratory skills through observations. Individual conversations with students provided insights into their motivation to learn. On this basis, an attempt will be made to develop a modern didactic model combining laboratory classes, student activity with materials made available on the e-learning platform.*

Keywords: individual learning, chemistry, laboratory, educational platform, Google Classroom, Wakelet

INTRODUCTION

In schools teachers and students are increasingly utilizing new teaching resources and methods in chemical education, often relying on Google, one of the world's

largest companies in the IT industry. As part of its mission, Google offers free educational applications designed to modernize and improve the educational process. Google Classroom, the educational platform developed by Google, using advanced technological resources, presents an important market alternative to commonly known Learning Management System (LMS) solutions used in both school and academic education (Szlach, 2019).

The Faculty of Chemistry at Adam Mickiewicz University is actively engaged in various educational initiatives as part of the university's third mission, with the aim of raising awareness about the significance of natural sciences in the modern world, in the daily lives of individuals, and their impact on the environment (Faculty of Chemistry AMU, 2023).

Academic teachers often conduct classes that incorporate practical teaching resources, aiming to not only acquire knowledge but also to motivate students to learn. This approach, in addition to its educational value, adds an element of enjoyment and should encourage participants to expand their (Bartoszewicz & Krzyśko, 2016; Bartoszewicz & Krzyśko, 2021).

During laboratory classes, students acquire manual skills are acquired through chemical experiments, making it essential to expand their subject knowledge. Previous research indicates that students who engage in self-education and online learning using Google Classroom exhibit higher levels of problem solving and critical thinking skills compared to those in traditional classroom settings without technological support (Khezel et al., 2023).

Therefore, it was hypothesized that the inclusion of materials supporting teaching using the anticipatory teaching method would increase the level of students' knowledge.

1. DIGITAL SUPPORT IN THE IMPLEMENTATION OF LABORATORY CLASSES

1.1. Project “Chemist as a detective”

At the Faculty of Chemistry at Adam Mickiewicz University, academic teachers conducted an implementation program for primary school students aimed at popularizing chemical issues in forensics through the project “Chemist as a detective”.

The project employed various methods to achieve its goals and research tasks:

- theoretical methods included the analysis, synthesis, comparison, systematization, and generalization of source materials in the field of flipped classroom
- empirical methods involved the observation of students during the “Detective Chemist” classes and surveys (questionnaires) to collect information about students' perception of the work of an analytical chemist in a forensic laboratory and its portrayal in crime series.

The research took place in the academic year 2021/2022 at the Chemistry Didactics Laboratory of the Faculty of Chemistry of Adam Mickiewicz University. 92 students from grades 7–8 took part in the research. The diagnostic tool of the study was a survey for teenagers called “The Chemist and Crime Series”.

The aim of the classes was to familiarize students with the actual work of an analytical chemist in a forensic laboratory because many researchers point out that the image of a scientist in a forensic laboratory created in crime series is quite different from real work (Bergslien, 2006).

An initial survey conducted among students confirmed their interest in crime series. More than half of the respondents (54.3%) indicated that they sometimes watch such films and only 20% expressing no interest in this type of films.

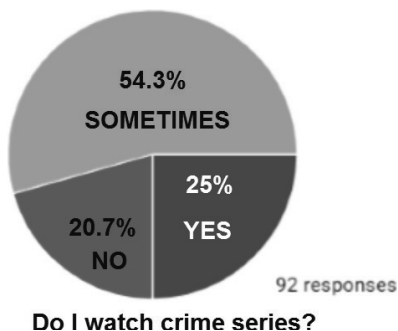


**Figure 1. Students' answers to the question:
Do I watch crime series? Yes 25%, No 20.7%, Sometimes 54.3**

Source: Own work.

Two rounds of classes, lasting two and a half hours, were held in the Chemistry Teaching Laboratory, involving 92 primary school students in the seventh and eighth grades.

The “Chemist as a Detective” classes followed an anticipatory teaching strategy covering four stages (with the first two taking place before the planned lesson):

- **ACTIVATION** – students must activate their prior knowledge to acquire new knowledge at their own pace. They were encouraged to be actively engaged in learning new content, think creatively and critically.
- **PROCESSING** – students were assigned reading materials to be reviewed at home (approx. 45 mins), communicate with each other or learn together in groups, with the teacher available to offer guidance. At this stage, students acquired new knowledge themselves, building on their prior knowledge.
- **SYSTEMATIZATION** – this stage allowed students to further supplement and systematize their new knowledge. It took place during workshops or lessons, where the teacher answered questions, provided additional information, and summarized students' work. This stage also served to evaluate students' understanding of the material.
- **ASSESSMENT AND EVALUATION** – at this stage, the teacher evaluated students' work and achievements according to previously established criteria. Students might take tests or complete surveys, e.g., self-evaluations, using the elearning platform.

According to the assumptions of this teaching method, students prepare theoretically and practically before the classes, following instructions from the teacher. These

preparations included the activation and message processing stages. Then, students were encouraged to ask questions and explore contemporary issues related to the class topic. The information and tasks provided before the lesson are intended to direct thinking on a new topic and motivate students to ask questions. It was expected that the lesson would organize and expand the knowledge acquired in the earlier stages. The systematization stage involved discussing the topic in a problematic and multi-contextual manner with the support of the teacher during in-person classes. The project was also subject to assessment and evaluation after the completion of the classes (Bartoszewicz & Zahorska, 2018).

For the needs of this project, materials were developed for students to read before and during the classes. These materials also included surveys for evaluation purposes. Google Classroom was used as a tool for creating and organizing tasks for students and facilitating communication. The materials were categorized according to the stages of anticipatory teaching implementation:

I. ACTIVATION folder, where the following are available:

- A brief survey
- A presentation with a link to articles: “Crime series from the perspective of a forensic scientist” and an article on food fraud.

Students were expected to read the provided texts without the need to learn them, the purpose was to draw attention to the following key points:

- crime series simplify the analytical processes,
- additional substances are sometimes added to food besides the desired minerals.

II. PROCESSING folder, where students had access to the following materials:

- A brief presentation about forensics
- An experiment that students could conduct at home (the iodine test) – students were encouraged to attach photos to the worksheet.

Students were expected to read these materials without the need to memorize them.

III. Systematization – classes at the Faculty of Chemistry of Adam Mickiewicz University – no materials were provided on the platform

IV. Short test

Przetwarzanie ▾	
Typ elementu ▾	Osoby ▾ Zmodyfikowano ▾
↑	
☐ Kryminalistyka 📎	Właściciel Malgo Bartoszewicz
☒ Tabela 1. Dziedziny kryminalistyki.pdf 📎	Malgo Bartoszewicz
☒ Test - przed wizytą w laboratorium 📎	Malgo Bartoszewicz
☒ Wykrywanie skrobi - ćwiczenie do samodzielnego wykonania w domu 📎	Grzegorz Krzyśko
☒ Wykrywanie skrobi-karta pracy.pdf 📎	Grzegorz Krzyśko
☒ Zasady BHP w laboratorium (e-podreczniki) 📎	Malgo Bartoszewicz

Figure 2. A collection of materials for the “Processing” stage available to students for completing the classes

Source: Own work.

Google Classroom is a free educational platform that facilitates communication between teachers and students, the exchange of additional materials, and skills assessment.

Introduced to the market in 2014, it is designed to support teaching processes and serves as an alternative to well-known e-learning platforms. This service is free for non-profit institutions and individual users.

Google Classroom is also complemented by external solutions, such as:

- Science Buddies – provides many resources for teachers, parents, and students, including ideas for science projects, curricula for teachers aligned with selected learning standards.
- Ptable – an interactive platform that allows students can explore elemental properties, orbits, isotopes, and compounds through a dynamic interface.
- cK12 – contains modules for self-study, learning through games and activities, including chemical and physical simulations. The modular structure allows the use of quiz texts or videos (Szalach, 2019).

To begin using Google Classroom, the first step is to create classes and invite students by providing them with a “class code” generated by Google Classroom, or sending an invitation via the app. After joining the class, students gain access to a tool resembling a social network, allowing them to share necessary files, communicate with their peers, and exchange information.

To read the provided materials, students had to complete the following steps:

- receive the code for teaching activities from the teacher
- visit the Google Classroom platform website (www.classroom.google.com):

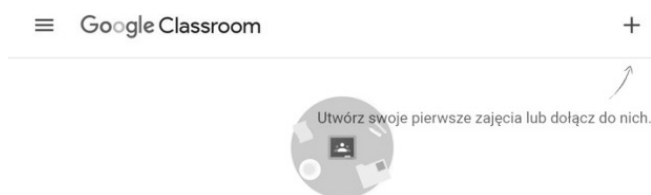


Figure 3. Screenshot of Google Classroom – login location

Source: Own work.

- click “+”, then enter the given class code and join the selected class group:



Figure 4. Google Classroom screenshot – student login location

Source: Own work.

Research in the field of chemistry teaching indicates that online learning via Google Classroom effectively improves students’ critical thinking skills in solving chemistry problems and improves academic performance (Khezel et al., 2023; Paristiowati et al., 2020).

On the dedicated class website, the teacher provided students with teaching materials related to forensics, preparing them for laboratory classes.

These materials covered various aspects, including:

- Introduction to forensic science
- Fields of forensics
- A pre-laboratory visit test
- Detecting starch – a self-conducted experiment task
- A starch detection worksheet
- Health and safety rules in the laboratory (see Figure 5).

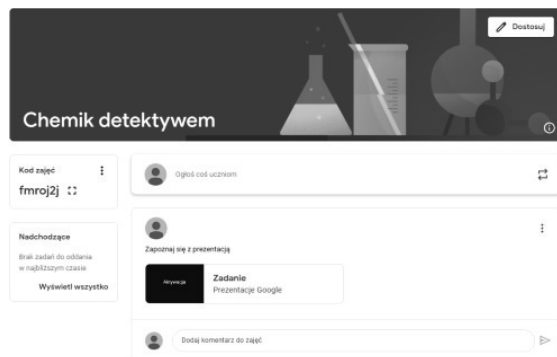


Figure 5. Screenshot of the Google Classroom course – “Chemist as is a Detective”

Source: Own work.

The practical laboratory classes followed the screening of a film that illustrated a story based on which chemical experiments were developed to solve the detective puzzle “Who killed Mr. Flower?” based on chemical and physical analyses commonly used in forensics.

After the film screening, students received folders with the history of Mr. Flower’s work and death and a description of the experiments to be performed, which included:

- The story of Mr. Flower.
- Fingerprints – collecting fingerprints using fingerprint powders.
- Chemical analysis – does cream contain starch?
- Poisonous substances – copper salts in water,
- Forensic anthropology – determining the height of a suspect.

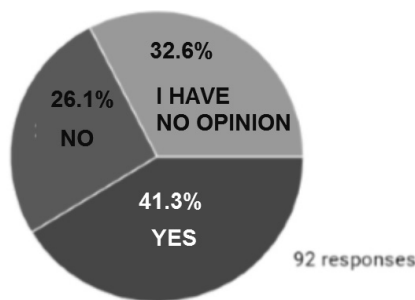
At the end of the class, students presented the results of their work and tried to answer the question posed earlier: “Who killed Mr. Flower?” After completing the classes, students were given the opportunity to complete a test and a survey at home to evaluate the classes.

Based on the implemented project and existing literature, several key benefits of Google Classroom can be identified:

- Easy setup – teachers can create classes and invite selected students.
- Ability to share various materials –tasks, announcements, and questions.

- Automatically saving materials in folders on Google Drive,
- Efficient communication and feedback provided by the teacher.
- Students can share materials and communicate through the class stream or via email.
- No advertising, and teachers' materials and student data are not used for advertising purposes.
- Mobile-friendly: easy to use on mobile devices (Doktorowicz, 2018; Iftakhar, 2016).

The survey results indicate that students are highly engaged and interested in chemical experiments (89.1%), especially those related to history and everyday life. The materials posted on the Google Classroom platform were rated equally highly. However, it is notable that only 43.1% of students indicated that the chemical knowledge discussed during lessons is useful in everyday life, while 32.6% are somewhat convinced of its practical relevance, therefore they indicated that they have no opinion, and 26.1% do not see the connection between what they learn in chemistry classes at school and everyday life (see Figure 6).



Do I think chemistry is a practical subject that will be useful to me outside of school?

**Figure 6. Students' answers to the question:
Do I think chemistry is a practical subject that will be useful to me outside of school? Yes 41%, No 26.1%, I have no opinion 32.6%**

Source: Own work.

When asked whether they would like to participate in future editions of the workshops, 98.9% answered affirmatively.

1.2. Project "LABirynt"

Since 2015, the Parliament of the Student Government of Adam Mickiewicz University has initiated a project supporting student activities, known as "Anvil." This project is open to students, PhD students, and employees of Adam Mickiewicz University who can apply for funding. In the academic year 2022/2023, co-financing was granted to the student project "LABirynt" focusing on teaching basic laboratory techniques. These classes were aimed at secondary school students and university students. A series of eight classes, each lasting three hours, were conducted, with 74 secondary school students registering for the workshops.

Drawing from past experiences (Bartoszewicz & Zahorska, 2018), it was decided to implement “LABirynt” classes in accordance with the anticipatory teaching strategy, specifically using the flipped classroom method. Materials for the workshops were prepared on the educational platform Wakelet (Wakelet, 2023).

Wakelet is a relatively new platform for creating and managing content in the form of collections that can contain links, photos, videos, articles, notes, and other elements. Wakelet allows users to create personalized content organized by topic, making it a valuable tool for storing, organizing, and sharing a variety of educational materials. Users can save important links (from blogs or websites), social media posts (from Facebook, Twitter, Instagram), YouTube videos and images, and then organize these elements into private or public collections. Users can also add notes to each item, ask questions and provide answers. It serves as a space for cooperation between teachers and students in various configurations. Wakelet can be used to improve student understanding through the presentation of digital learning resources as well as for collaboration. Wakelet is suitable for flipped classroom teaching or asynchronous learning. The results of research on the usability of Wakelet indicate that most respondents confirm its ease of use and highly evaluate its use as an interactive digital platform (Quah, 2023).

In summary, the tools provided by the wakelet.com platform are intuitive to use, and the resources located there are publicly available and free. For this reason, it was chosen to include materials in the LABirynt project.

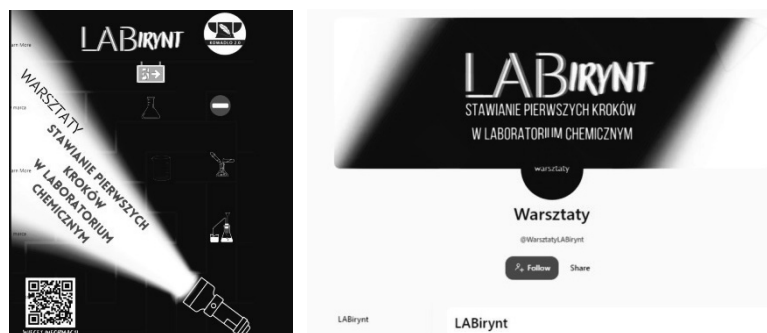


Figure 7. Poster design; Screenshot of the initial course on the Wakelet platform – “LABirynt”

Source: Own work.

Workshop participants familiarized themselves with the materials prepared on the Wakelet platform before the classes started. The materials <https://wakelet.com/@WarsztatyLABirynt> include:

- exercise descriptions,
- educational games,
- photos of laboratory equipment,
- safety data sheets for chemical reagents,
- infographics.

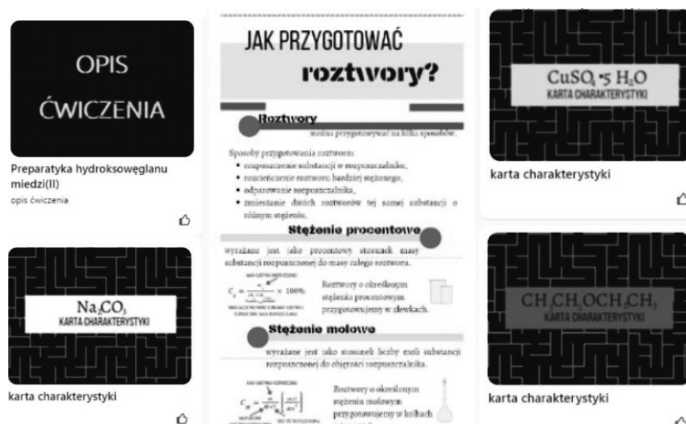


Figure 8. Screenshot of sample course materials on the Wakelet platform – “LABirynt”

Source: Own work.

Thanks to this approach, students came to classes already well-prepared, which is a key element of anticipatory education. The educational materials were categorized according to the stages of anticipatory teaching:

I. ACTIVATION

Pretest – available on the scheduled date on the Wakelet platform.

Materials available on the Wakelet platform:

- photos of laboratory equipment,
- safety data sheets for chemical reagents,

II. PROCESSING – materials available on the Wakelet platform:

- exercise descriptions,
- educational games,
- infographics.

III SYSTEMATIZATION. Following the preparation stage, practical workshops were conducted at the Faculty of Chemistry of Adam Mickiewicz University. These workshops were divided into two parts. The first part concerned the preparation of copper(II) hydroxycarbonate, while the second part involved the titration analysis of acetic acid contained in vinegar. During these workshops project participants gained hands-on experience in fundamental laboratory techniques. They completed worksheets under the supervision of second-cycle students, and finally completed surveys.

IV. ASSESSMENT AND EVALUATION

Post-test – materials available on the Wakelet platform.

Each of the 74 participants completed a pre-test before attending the workshops and before reading the teaching materials. Subsequently, they completed a post-test after finishing the classes. The results are summarized in Figure 9.

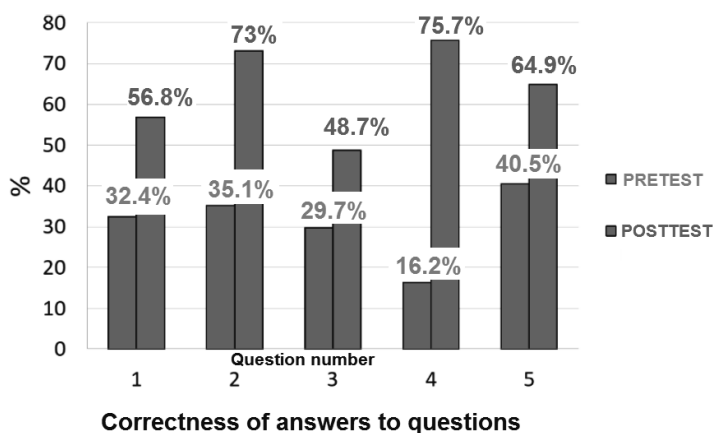


Figure 9. Pre- and post-test results.
Correctness of answers to the questions asked

Source: Own work.

Based on the data collected, progress in knowledge and laboratory skills. Additionally, a survey conducted after the classes, which consisted survey question, which pertained to factors motivating individuals to learn chemistry, 82.4% of the participants indicated that grades were their primary motivator, followed closely by curiosity about the subject (74.3%). When it comes to chemistry, students showed the most engagement and interest in chemical experiments (74.3%). The materials posted on the Wakelet platform were equally highly rated. Students appreciated its intuitiveness and its compatibility with mobile devices, allowing them to access materials at any time and from any place. The biggest problem was accounting tasks. After the class, most students claimed that it was the best “chemistry lesson” they had ever taken part in. When asked whether they would like to participate in the next edition of the workshops in the future, an overwhelming 98.6% responded with an affirmative answer.

CONCLUSION

The use of Google Classroom tools and the Wakelet platform to support chemistry education in the laboratory has a positive impact on the quality and essence of teaching and learning among students. Google Classroom enhances students’ knowledge acquisition, skill development, and competence building within the entire educational environment. This application enables students and teachers to function in a social network due to its mobility, saving time on distributing teaching materials before classes and motivating activates students to continue their work outside the traditional classroom setting. It was found that students develop their skills in teamwork, the use of mobile technologies in the learning and work processes. They also exhibit greater discipline and commitment. This kind of technology allows them to intertwine their study and free time.

The anticipatory learning strategy, also known as the flipped classroom method, allows for individual familiarization with the material at any time and place, both synchronously and asynchronously (before the workshop date).

This strategy also fosters the development of independent learning skills, information search and processing. However, it was noted that, in the absence of real-time contact in the virtual space, a decrease in motivation to prepare when students encountered any problems was observed (Dylak, 2013). Taking this observation into account, as part of the Study@Research competition of the ID-UB research project “TikTok as a tool supporting chemical education”, an educational model will be introduced that combines laboratory classes, student engagement with shared materials on a free digital platform, and real-time meetings with lecturers before the workshops.

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TRENDS IN DEVELOPING DIGITAL SKILLS OF UKRAINIAN STUDENTS IN DUAL STUDY MODE

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Abstract: *This work discusses the issue of intensifying the use of information technologies and acquiring digital competencies by students of professional higher education within the framework of dual study mode. The authors analyze the survey performed among the applicants of one typical institution of higher education regarding the dual form of education. Students showed considerable enthusiasm about promoting cooperation between institutional learning environment and employer companies as to the introduction of dual form of higher education. The authors continue by discussing ways of using information technology to develop digital skills of students of higher business education based on a dual form of education. However, a number of unresolved challenges should be addressed, namely financial issues, regulatory and organizational ones.*

Keywords: higher education, dual mode of study, students, information technologies

INTRODUCTION

As noted previously (Introduction to Tuning-2, 2007, p. 60), students' awareness that "having obtained a university degree does not automatically ensure employment" prompts the need to increase their value with employers, thereby satisfying the relevant needs of the latter (Rashkevych, 2014, p. 16). This means that employers are becoming actively involved in the creation of relevant training programs and the implementation of the chain "specific applicant – specific conditions – specific employer" with the aim of taking into account the features of all three components as much as possible. Previous research has explored the possibilities of using elements of various forms of higher education on the basis of institutional education to meet the need of applicants to expand (individualize) their own learning results (Karimov

et al., 2022). In particular, it was proposed to use a dual form of higher education in combination with an in-depth study of the specifics of metallurgical/chemical production (which are specific to the region) in a distance format to form conditionally stable profiles for the “Management” study program.

At the same time, according to the experts of the Ministry of Education and Science of Ukraine, «dual form of education acquires particular relevance in terms of solving the tasks of rapid post-war recovery of the Ukrainian economy, meeting the demand for highly qualified personnel with in-demand skills, as well as the prospects of Ukraine’s integration into the EU» (Vprovadzhennia polozhennia..., 2023). This opinion was reflected in the Regulation on the Dual Form of Vocational Pre-Higher and Higher Education (Polozhennia pro dualnu..., 2023), developed in accordance with the Strategy for the Development of Higher Education in Ukraine for 2022–2032 (V Stratehiia rozvytku vyshchoi..., 2022), approved by Order No. 286 of February 23, 2022. It is focused on «meeting the expectations of education seekers regarding successful work in their profession, ..., facilitating and speeding up the transition of graduates from the field of education to the labor field, as well as generally increasing their competitiveness on the labor market» (Vprovadzhennia polozhennia..., 2023), i.e., taking into account the components «specific applicant – specific conditions – specific employer».

The goal of the study is to determine the directions of development of digital skills in business education students under the conditions of dual study mode.

The paper is attempting to answer the following **research questions**:

1. How interested are the students and potential employers in the implementation of dual study mode at DSTU?
2. What is the regulatory framework to support the dual study mode in Ukraine?
3. What are the ways of developing digital skills in students of higher business education under the dual form of study?

1. THE CONCEPT OF DUAL FORM OF HIGHER EDUCATION

1.1. Dual system of higher education: a brief introduction

Three German companies are believed to be at the forefront of dual higher education, namely in 1972, when Bosch, Daimler Benz and Standard Elektrik Lorenz agreed to launch a collaborative experiment aiming to enrich higher education with real work practices. They founded the first dual higher educational institution called Beruf-sakademie, with the goal of training graduates with highly demanded professional qualifications as well as high education diplomas (Göhringer, 2002).

Broadly speaking, the majority of definitions for work-based learning mode share the specific three-way relationship between the student or learner, employer or industry and the university, where students are able to integrate theory with meaningful and relevant work-based practices (Dean & Rook, 2023).

Evidently, this approach to university training offers benefits for educational management, since it nurtures highly motivated and responsible students, helps develop cooperation network nodes in the relevant industry, provides a clearer visions of

technological change within different companies as well as invites more applicants to study in a specific dual-mode study programs.

Germany has been a brilliant example for countries, aiming to build and strengthen ties between educational institutions and employers, leading to the preparation of highly-qualified graduates for the given economy (Graf et al., 2014), (Giannelli & Sergi, 2017), (Powell & Fortwengel, 2014).

Overall, the competitive nature of the global economy encourages European educators and researchers to look for efficient and proven educational modes to tackle unemployment and promote entrepreneurship skills. In this context, a research network CWIHE (European Network of Cooperative...) promotes sharing the best practices, knowledge, as well as challenges among stakeholders (universities, enterprises, governments, professionals, etc) in order to help them develop innovative programs that bring the business and academic world closer.

Despite all the promising aspects of real work practice inclusion into university programs, there are numerous challenges and difficulties proving how important it is to foster intense cooperation between all stakeholders and deep awareness and commitment of all participants. One must be driven by sober recognition of specific challenges and resistance factors in a given country and institution (Rienties et al., 2023). It appears to be particularly challenging for small to medium-sized enterprises to provide for diverse needs of students with disabilities and international students. Overall, work placements have been described as resource intensive for all participants. Besides, some work-integrated study programs might require significant funding, often of the governmental origin (Dean & Rook, 2023).

The vibrant topic of higher education enriched by real work experiences for the student reveals quite a broad use of terminology – work-based learning, work-integrated learning, workplace learning, work-based experience) (Rienties et al., 2023) and a group of terms based on the term “dual” – dual study mode, dual studies, dual (work-study) programs.

Moreover, new terms are coined in order to reflect recent challenges faced by the educational community. Namely, non-placement work-based learning (NPWBL) is a solution gaining global popularity as it represents a more sustainable study model enabling students to engage in meaningful work-learning opportunities without the need for extended, physical proximity in a workplace (Dean & Rook, 2023). The Covid-19 pandemic has been another challenge to all kinds of educators, pushing them into online educational environments and thus giving birth to yet another term – online WBL, with academic interest likely to keep growing (Rienties et al., 2023).

1.2. Organizational and normative framework for the implementation of dual study mode in Ukraine

The normative framework for the dual study mode is rather young in Ukraine. Dual form is defined as a method of obtaining higher education that involves a combination of training in educational institutions and other subjects of educational activity with training at workplaces, enterprises, institutions and organizations. Part of the scope of educational activities is performed at the workplace instead of classroom and independent work at the university (Vprovadzhennia polozhennia pro..., 2023).

According to the Ministry of Education and Science of Ukraine, the organization of training specialists in the dual learning mode is a complex and time-consuming process that «requires a more careful balancing of the interests of the parties. Therefore, the cooperation of scientists, educators, employers, their unions and professional associations, public and international organizations is key to developing domestic experience and developing models of training organization based on the dual form of education» (Buchynska et al., 2022, p. 5). The experience gained within the framework of the pilot project (Nakaz Ministerstva osvity..., 2019) of the Ministry of Education and Science of Ukraine in institutions of professional pre-higher and higher education with dual learning mode was reflected in the Regulation on the dual form of obtaining professional pre-higher and higher education (Polozhennia pro dualnu..., 2023) approved on April 13, 2023, which stands out as one of the key documents on the list regulating dual form of education. However, when introducing dual learning mode, one should pay attention to some differences in the normative subordination of all participants of such a process (institution of higher education – enterprise – student). The generalized scheme of documentary and regulatory support for the organization of training in a dual form is shown in Figure 1.

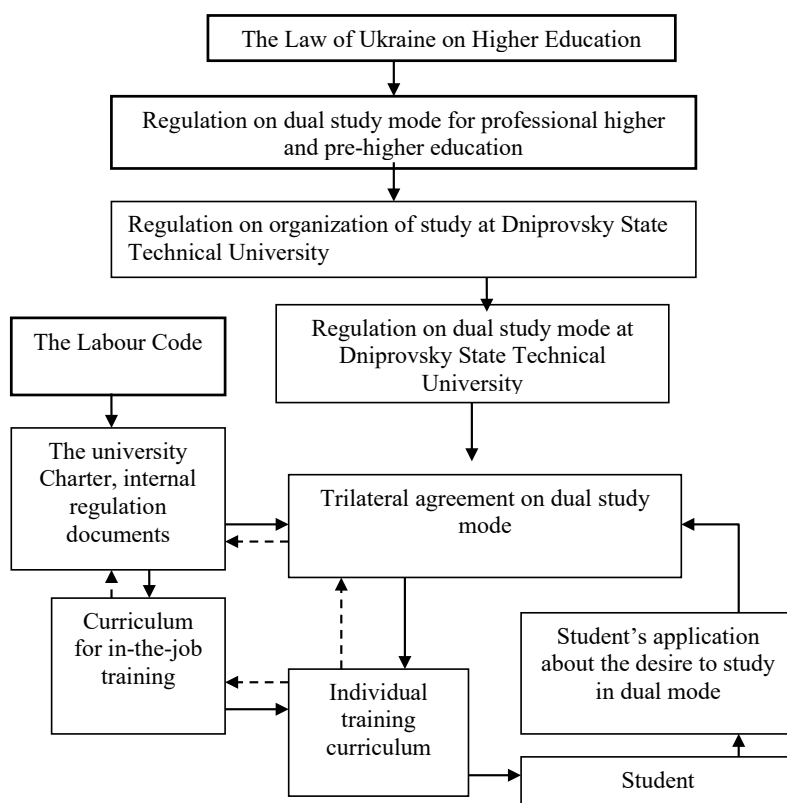


Figure 1. Generalized scheme of documentary and regulatory support for the organization of training in dual mode

Source: Own work.

The given scheme is designed to best focus on the interests and characteristics of all participants in the chain «specific student – specific conditions – specific employer», which is reflected in the Regulation on the dual form of obtaining higher education at Dniprovsky State Technical University (Hlushchenko & Dobryk, 2022).

Taking into account the «variety of specific needs, opportunities and limitations of partner companies and higher education institutions, as well as the expectations of education seekers» (Buhaichuk et al., 2022, p. 13), as well as the non-technical focus of business education, we rely on the model «Higher education with integrated practical training» according to the classification of models of dual higher education of the Main Committee of the Federal Institute of Vocational Training in Germany (Buhaichuk et al., 2022). Overall, there is already some positive experience of training business specialists using a dual mode of education, but it is necessary to take into account the forecasts of experts – «the IT field may take second place according to this form of education» (Kashchenko, 2023), while the first is taken by agricultural companies and enterprises. That is, business education will have to locate itself in a variety of existing models of dual higher education. However, «in the European Union, dual education is one of the drivers of digital and «green» transformation» (Vprovadzhennia dualnoi formy, 2023), and in each of these directions management and economic experts are indispensable.

2. DUAL STUDY AS PERCEIVED BY THE PARTICIPANTS

2.1. Students' perception of dual studies

As a basic institution of higher education the present research involves a typical higher educational institution with both technical and humanities specialties – Dniprovsky State Technical University (DSTU), Ukraine. In order to study the opinion of higher education applicants regarding the introduction of a dual form of higher education, the sociological laboratory of DSTU conducted an anonymous electronic survey based on a specially developed toolkit. The survey included participants from both humanities and technical fields of study.

The study «Dual education mode as viewed by DSTU students» aimed to explore the opinions of the interviewees regarding the implementation of the dual study mode at the university. This mode involves a combination of presence training at the university and practical training at large and medium-sized enterprises within the city and the region. The survey questions were multiple-choice, and a total of 483 responses were collected and analyzed. The employers' perspectives on this issue was also studied, with 10 enterprises classified as large, medium and micro businesses and 3 communal enterprises of the Kamianske City Council. The distribution of respondents by field of science is shown in Figure 2.

Overall: 63.2% of higher education students understand the content and features of dual education; 32.4% learned about this form of education only after reading the introduction to the questionnaire; and a small percentage (4.4%) indicated that they are not familiar with the topic at all.

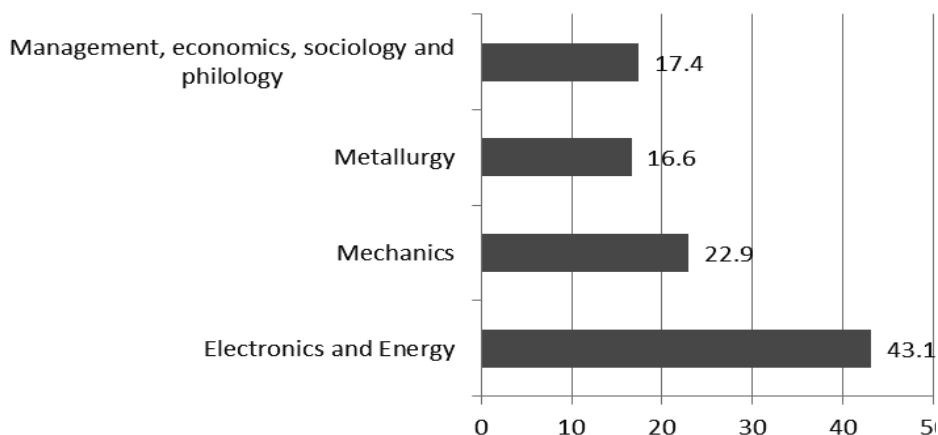


Figure 2. Data distribution concerning the percentage of students from different faculties

Source: Own work based on (Zvit pro rezultaty, 2023).

Moreover, the majority of applicants feel quite positive about the possibility of introducing the dual form of higher education at the university, with only a small percentage (6.3%) opposing such a mode of study. The distribution of respondents' viewpoints is illustrated in Figure 3.

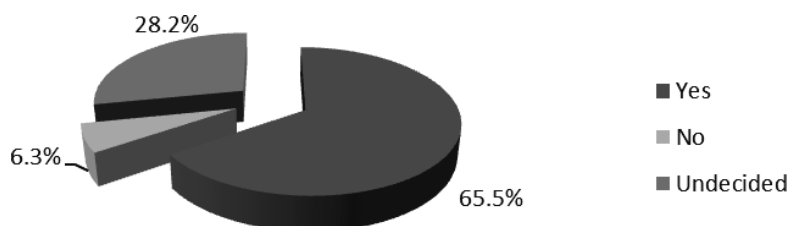


Figure 3. Data distribution concerning students' attitude to the introduction of the dual study mode

Source: Own work based on (Zvit pro rezultaty, 2023).

Applicants' motivations for considering a switch to dual-mode education are shown in Figure 4, highlighting their desire for official employment specialty, along with associated social guarantees.

In general, 23.6% of respondents are ready to switch to dual education, and their distribution according to the degree of readiness to change the educational format is shown in Figure 5.

It is worth noting that nearly half of the survey participants need additional information or clarification of organizational issues to settle this issue. Therefore, despite the 7.9% of students who strongly oppose changing the mode of education, young people are generally interested in this form of education and need fuller information on its possibilities, advantages, and prospects.

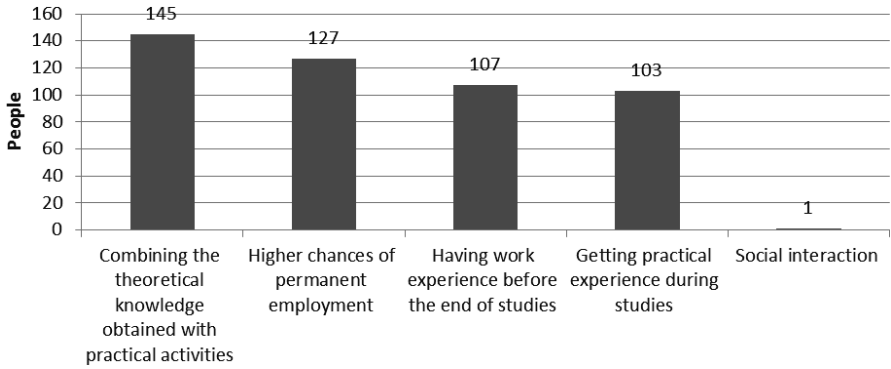


Figure 4. Data distribution concerning students’ motivation to study in the dual mode

Source: Own work based on (Zvit pro rezultaty, 2023).

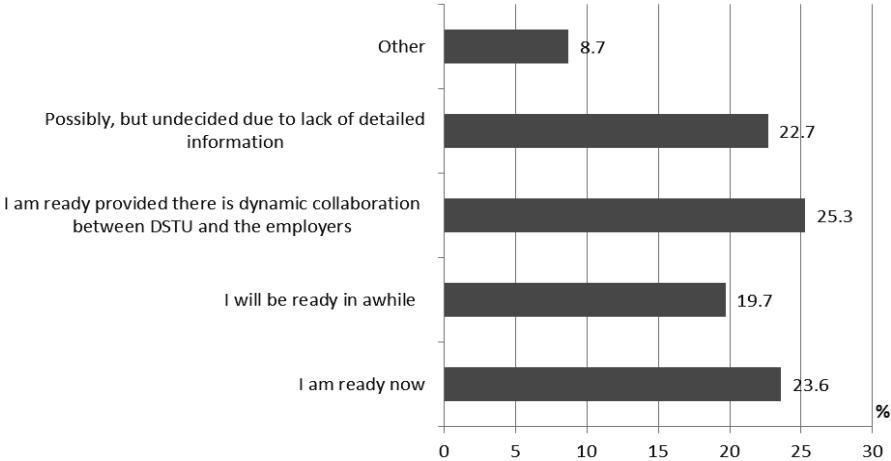


Figure 5. Data distribution concerning students’ readiness to obtain higher education in dual mode

Source: Own work based on (Zvit pro rezultaty, 2023).

2.2. Employers’ perception of dual study mode

The dual form of education is based on a close relationship between employer enterprises and the educational institution «on the basis of social partnership as an indicator of the economic, social and political maturity of society: the educational institution and the enterprise are equal partners who jointly develop and coordinate the educational process, control its results» (Azhazha, 2019, p. 21). This cooperation is heavily reliant on the opinion of employers regarding the introduction of dual form education at basic enterprises. The distribution of opinions among education seekers and potential employers regarding the expected advantages and obstacles in the implementation of the dual form is presented in Table 1. The table shows that both categories of interviewees, in addition to generally recognized benefits, recognized

other advantages (a focus on market needs, enhancing the company's image, and the potential for additional human resources and others).

Table 1. Advantages and obstacles to the introduction of dual study mode

Advantages	Respondents, %				Obstacles
	students	employers	students	employers	
Inviting a prepared specialist right after graduation	31.2	37.5	22.3	16.7	Extra financial costs for the enterprises
Preparing workers, adapted to realia of manufacturing process	30.4	43.8	19.1	33.3	Risky investment (low guarantee of employment for a university student)
Other advantages (focusing on the market's demand, building company's image, a chance to invite additional human resources and other)	38.4	18.7	17.5	16.7	Extra time effort without long-term guarantee
	—	—	10.2	16.7	Absent state support for the business / no students' motivation to work in Ukraine
	—	—	30.9	16.6	other
Total	100	100	100	100	Total

Source: Own work based on (Zvit pro rezultaty, 2023).

In contrast, applicants primarily view financial consideration to be the main obstacle to the introduction of dual study mode at enterprises, while employers complain about the lack of guarantees for retaining students within the company.

Both applicants and employers have also pointed out additional obstacles, including the lack of legislative norms, staffing, the shortage of mentors, and other factors. Besides, currently none of the respondents claimed that they do not see any obstacles in the implementation of the dual form of higher education.

Another financial aspect is the coverage of tuition fees for students studying in dual mode (60.1% of the interviewed students believe that the employer company should cover the cost of tuition, while company representatives unanimously express unwillingness to cover students' expenses). Table 2 presents the attitudes of respondents to the issue of students' salaries (as a percentage of the wages of a full-time employee in a specific position).

Table 2. Percentage distribution of wages paid to students in dual study mode

Per cent from the wages of a full-time employee	Students	employers
up to 40%	16.6 %	66.7 %
from 40 to 80%	64 %	32.9 %
up to 100%	19.4 %	0.4 %
Total	100 %	100 %

Source: Own work based on (Zvit pro rezultaty, 2023).

Thus, the financial aspects of each specific case requires in-depth discussions. As a potential compromise option, it is worth discussing increasing the wage proportion during training.

3. BOOSTING IT COMPETENCIES IN THE IMPLEMENTATION OF DUAL LEARNING MODE

“The fertile ground for the introduction of dual learning mode are the fields where there is a systemic shortage of qualified workers and employees” (Kashchenko, 2023) – recently, the IT field, in particular its non-technical component, belongs to the fields with a constant demand for specialists.

Simultaneously, students of almost all majors express a desire to enhance their IT skills in order to improve their learning outcomes. Previously, there were outlined the following prerequisites of expansion (individualization) of learning outcomes due to active involvement of IT elements and dual learning mode (Karimov et al., 2022):

- Data from a local DSTU sociological questionnaire shows that 62.7% of students combine study and work, with 48.3% partially aligned with the specialty, and 26.3% already work in the field (Profesiini priorityty ta ochikuvannia..., 2020);
- 78% of employers preferred the students’ skills which imply «so-called general competencies that do not depend on the main profile of the chosen profession» (Rashkevych, 2014) – in this context the use of an asynchronous learning mode based on ICTs is expected to bring maximum learning outcomes;
- elements of informal and nonformal learning have proven efficient in higher education when it comes to recognizing and accumulating learning outcomes (Cedefop, 2016).

All of the factors contributing to boosting IT competencies can be effectively implemented when adopting a dual form of education. This approach can partly meet the demands of employers who prioritize «the ability to quickly learn and adapt to new conditions, and also want practical experience even from beginners» (Shumilova, 2023). This can be accomplished by using educational online platforms for Ukrainian higher education students, especially in the context of blended learning (regardless of the study mode, in particular within the limits of the dual form). All the more so, since a similar experience already took place during the quarantine restrictions – «institutions that train students using the dual form were recommended to transfer such

students to distance learning. Among the resources that the enterprise could provide for training are online platforms, educational films, enterprise instructions, etc.» (Naidonova, 2022, p. 3). Thus, online platforms supported by the Ministry of Education and Science and the Ministry of Digital Transformation of Ukraine, are focused on the integration of relevant all-Ukrainian educational courses into the process of obtaining higher education in blended learning mode.

A vivid practical example of the use of online platforms in dual study mode with the aim of enhancing IT competencies of students from various majors is the interactive gamified courses from Ukrainian IT company Genesis and Product IT Foundation for Education, for instance, «Creation and development of IT products», «Marketing of IT products», «Analytics in product IT» (Cooperation, 2023).

The cycle of courses is focused on the acquisition of non-technical competencies in the IT sphere and is based on an interactive online platform (online tasks, videos, cases, testing) that provides access to various learning resources, such as:

- LMS-platforms with an internship simulator in a product IT company.
- Pre-recorded video lectures with expert practitioners.
- Abstracts, infographics and a glossary of terms.
- Video lectures in the format of a dialogue with industry leaders.
- Interactive tasks and tests on the platform.

Since the course is recommended for any specialty and is aimed at the business component of IT activities, we will consider the feasibility of its integration into the master's curriculum of a typical higher education institution in the specialty 073 «Management». The department quality assurance group for the «Management» specialty performed an analytical study of the IT-competencies of the proposed cycle of interactive courses and the competencies of the educational and professional program of the master's course «Management» and found significant overlaps in the field of general and professional competencies potentially developed by the students. The overlapping of competencies of the curriculum for specialty «Management» with the IT competencies of the specified cycle of courses on Ukrainian interactive online platform EdEra is presented in Tables 3 and 4.

In the case under consideration, the competencies of the management curriculum overlap with the focus skills (IT competencies) of the interactive course only partially, which is due to its specialized direction – product IT. Despite this, according to Shumilova, if the online course covers 100 percent of general competencies and a rather significant proportion of professional competencies of the university business course curriculum it can be argued that it is appropriate to integrate online courses into the educational process in order to activate the IT competencies of future business specialists. It will enable them to choose «career directions and employers, because they will be much more qualified than most graduates and, probably, even specialists with experience» (Shumilova, 2023).

Table 3. Overlapping of general competencies of master students with those provided by interactive online courses

Full or partial overlapping	Common competencies according to (Karimov et al., 2023)	Focus skills according to (Cooperation, 2023)
+	Ability to conduct research at an appropriate level	Work in a team;
+	Ability to communicate with representatives of other professional groups of different levels (with experts from other fields of knowledge/types of economic activity);	Creativity and flexibility of thinking;
+	ICT skills;	Search for open information, analysis and judgments;
+	Ability to motivate people and move towards a common goal;	Presentation skills;
+	Ability to act on the basis of ethical considerations (motives);	Market structure, competitor analysis, target audience;
+	Ability to generate new ideas (creativity);	Peculiarities of interaction with technical and non-technical product teams;
+	Ability to abstract thinking, analysis and synthesis.	Methods of influencing user behavior;
100 %	overlapping	Platform policies and features of creating advertising creatives.

Source: Own work.

Table 4. Overlapping of special competencies of master manager students with those provided by interactive online courses

Full or partial overlapping	Special competencies according to (Karimov et al., 2023)	Focus skills according to (Cooperation, 2023)
+	Ability to select and use management concepts, methods and tools, including in accordance with defined goals and international standards;	Measurement and analysis of marketing and product metrics for user engagement and retention;
+	Ability to establish values, vision, mission, goals and criteria which the organization relies on to set directions of development, work out and implement appropriate strategies and plans;	Building a strategy, goals, components, application, selection of promotion channels, performance measurement
+	Ability of self-development, lifelong learning and effective self-management;	Ability to create a personal development plan;
-	Ability to effectively use and develop resources in the organization;	Aspects of interaction with technical and non-technical product teams;
+	Ability to create and organize effective communications in the management process;	Work in a team;
+	The ability to form leadership qualities and demonstrate them while managing people;	Methods of influencing consumer behavior;
+	Ability to develop projects and manage them, show initiative and entrepreneurship;	Presentation skills;
-	Ability to use psychological techniques to communicate with personnel;	Creation and development of IT products;
+	Ability to analyze, structure organizational problems, develop managerial solutions and provide conditions for their implementation;	Decision-making;
-	Ability to manage an organization and its development;	Searching for open information, analysis and making judgments;
+	Ability to apply statistical and mathematical methods and models to study socio-economic processes and systems.	Market structure, competitor analysis, target audience;
73 %	Overlapping	Analytics in product IT.

Source: Own work.

4. DISCUSSION

Enriching dual study mode programs with elements of informal learning can create more extensive employment opportunities for graduates. It is particularly true in extremely uncertain times that all educators are facing in post-COVID-19 era (Silva & Alvarez, 2021: p. 23), (Gajewski, 2021).

Logically, these uncertain times produce success and failure that can serve as valuable learning experiences. Recent research into the opinions of crisis management leaders completing a work-based master's program in the UK revealed both aspects. The study uncovers significant improvements in leaders' adaptive skills, confidence and self-reliance. However, it also highlights universities' limited interaction with leaders (Rowe et al., 2023). These findings align with our previous reflection on enriching the individual learning trajectories of bachelor and master students in the specialty "Management" with maximum recognition and accumulation of learning out-comes from non-formal and informal learning. There must be a vibrant interaction between educators and informal learning platforms for the learning outcomes to enter the study agenda naturally (Karimov et al., 2022).

CONCLUSION

The study has demonstrated that students showed considerable enthusiasm for promoting cooperation between DSTU and employer companies in the implementation of the dual form of higher education, which allows us to ascertain its significant prospects in the country, especially when implementing blended learning mode. Also, this form of study boosts the acquisition of IT competencies and skills of future specialists, regardless of their chosen specialty. However, a number of unresolved issues should be noted, including:

- financial issues (additional costs for both employer companies and higher education institutions, incentives for applicants and companies, state costs, and others);
- regulatory (responsibility of all participants as well as terms of cooperation and others);
- organizational (implementation of asynchronous mode of training and overlapping of courses for institutional and dual forms of higher education, methodical support of online platforms and interactive courses, and others).

As a way of addressing the organizational challenges, it is advisable to consider integrating open online courses into university curricula. This integration should be achieved by deepening cooperation between the State (Ministry of Education), institutions (higher educational institutions and enterprises), and online educational platforms. This cooperation should ensure that online courses align with relevant educational and professional programs and standards, while encouraging partner enterprises to develop their own educational online platforms/courses. Furthermore, relevant departments may explore the possibility of enhancing curriculum specialization within one specialty. For example, they can develop study programs like «Product Management» or «IT Management» within the specialty «Management».

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