3L-Person: Report

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Abstract

This is an introductory text to a collection of selected papers from the VI International Workshop on Professional Retraining and Life-Long Learning using ICT: Person-oriented Approach (3L-Person 2021), held in Kherson, Ukraine, on the October 1, 2021. The volume presents the contributions to the workshops affiliated with the ICTERI 2021: the 17th International Conference on ICT in Education, Research, and Industrial Applications.

Keywords

ICTERI 2021, 3L-Person 2021

1. Theme of the Workshop

The Workshop's goal is to bring together researchers and practitioners from areas Information/Communication Technologies (ICT) and Education/Training (E/T), to support the bridging process between ICT opportunities and education/training needs. Their mutual influence is increasingly accelerating, sometimes in unexpected ways, with original ideas and innovative tools, methodologies, methods and synergies that can and must satisfy life-long learning of a person (from school age to retirement), professional training and retraining in view of the person-oriented approach. It covers such topics as ICT tools' design for: remote learning, adaptive

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learning, day-to-day support for individual's learning, synthetic learning environment, life-long learning of individuals, learning in the workplace, learning/training process of individuals with special needs, teaching/learning safety and security, vocational training and carrier guiding, etc.

All topics allowing for the appropriate ICTs that could break down the time, space and cultural differences of learners and teachers.

The specific goal of this activity is to facilitate a broader understanding of the promise and pitfalls of these technologies and working (learning/teaching) environments in global education/development settings, with special regard to the human as subject in the system and to the integration of humans with the technical, didactic, and organizational subsystems.

2. The Workshop Aims

(i) The identification of needs and opportunities in which coordinated research efforts are required to expand and understand the emerging technologies in education (such as cloud computing, mobile tools and services, network infrastructures, systems of computer modeling, simulation, AR/VR/MR etc.), their effectiveness, the potential risks, and the potential benefits of new ways to educate, learn and collaborate.
(ii) Contribution of novel ICT in E/T.
(iii) Informing the educators about options for global education in near future.

3. Topics of Interest

- **Personal Learning Environment Design**: person-oriented tools, adaptive and intuitive learning, cloud-based learning environment, social networking, etc.
- **Advanced ICT for Professional Retraining and Training in the Workplace**: cloud-based learning tools, mobile-based learning, learning networking tools, etc.
- **Blended and Remote Learning/Teaching with Emerging ICT**: remote learning and virtual classroom, flipped classroom, network-oriented collaborative learning, home-schooling, etc.
- **Educational Robots, Databases and Language Technologies for Open Learning and Research**: innovative and intelligence tools for data analysis; network labs, robotics learning tools; augmented cognition; machine learning; open learning and research platforms etc.
- **ICT in Education of a Person with Special Needs**: openness and accessibility of education, e-inclusion; using ICT in educating gifted, underachieved, disabled individuals; ICT for a human development, etc.
- **ICT in Education Safety and Security**: human-system integration, human factors, quality evaluation of electronic learning resources, etc.
- **ICT-support of STEM Education and Professional Career**: network labs, robust intelligence, synthetic environment, augmented cognition, 3D technology, systems of computer modeling and simulation, etc.
- **Synthetic learning environment**: AR/VR/MR, AI in education, computer modeling in teaching process etc.

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6. Conclusion

This volume represents the proceedings of the VI International Workshop on Professional Retraining and Life-Long Learning using ICT: Person-oriented Approach (3L-Person 2021), held in Kherson, Ukraine, on the October 1, 2021. It comprises 13 contributed papers [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13] that were carefully peer-reviewed and selected from 39 submissions. Each submission was reviewed by at least 2 program committee members..

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Distance Learning in Primary School During the COVID 19 Pandemic: Results of the "SMART KIDS" Experiment

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Abstract

The paper analyzes the results of the introduction of the distance learning form (DLF) using electronic educational resources (EER) and the teacher's virtual classroom in primary school. The experiment took place within the framework of the "Smart Kids" All-Ukrainian project during the long quarantine caused by the COVID-19 pandemic. The educational process took place both synchronously and asynchronously. The present paper substantiates the model of organization of distance learning of primary school students using EER and outlines its three main components: the organization of learning; conducting online classes (explaining new material or practicing skills by students) and monitoring the quality of students' independent performance of tasks. The results of the experiment prove that it is necessary to provide teachers and students with computer equipment, Internet access, digital resources for teaching and assessment to implement DLF. It has been established that EER in distance learning can be used both on a regular basis – in each class, and periodically – to explain new material or train skills; the quality of tasks performed by students can be monitored in the virtual office of the teacher and shape an individual trajectory of students' development. The teachers identified the following main problems of DLF implementation: internet interruptions; problems with providing new computer equipment to students and some teachers; lack of state aid in providing EER to all participants in the educational process; limited access to students' computers during complete isolation due to online work of parents. Despite the outlined problems, the quality of distance learning of primary school students during the pandemic using EER was positively and highly assessed by teachers.

Keywords

Distance Learning; Elementary School; Electronic Educational Resources; Virtual Teacher's Office; ICT in Education; Teacher Development

1. Introduction

During 2020, throughout a prolonged quarantine caused by the COVID 19 pandemic, primary school teachers had significant difficulties in organizing distance communication with students. Firstly, they did not have sufficient skills to apply the distance learning form (DLF), it was a shock for them, and, secondly, despite the fact that students of the XXI century are aborigines of digital technologies, they have not been taught to study by means of distance learning.

In general, research on the implementation of DLF reveals the process of using various digital technologies to training students in higher education. Organizational issues and psychological and pedagogical aspects of the implementation of DLF in general secondary education institutions are being constantly conducted by researchers. Thus, back in 2004, scientists R. M. Bernard, P. C. Abrami, Y. Lou and others conducted a comparative analysis of scientific articles on DLF between 1985 and 2002.

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Scientists analyzed more than 232 studies that contained 688 independent results on achievements in the process of DLF implementation; the attitude of participants in the educational process to this form of education; evaluation and preservation of learning outcomes. The authors note that a significant number of DLF programs exceed the results of fulltime learning in the classroom, but there are a significant number of those that do not give significant learning outcomes. The distribution of scientific results by synchronous and asynchronous forms of education showed other results. Asynchronous learning was preferred by students who had significant achievements during full-time study in the classroom, and synchronous – by those who had significant results during DLF. But scientists noted that the overall results showed that the magnitude of the positive effect of the introduction of DLF is essentially zero for all three indicators mentioned above, as there was significant variability in the organization of the learning process, training students and teachers [1].

2. Analysis of latest research and publications

With the development of Internet technologies, increasing the overall level of IC-competence of participants in the educational process, areas of research have focused on the study of psychological and pedagogical conditions that impact the effectiveness of learning; study of the components of DLF that affect students' perception of educational material; management aspects, such as decision-making on the use of technology in educational institutions, access to ICT, the ability of users to employ ICT tools in learning [2].

National scholars have made a significant contribution to the study of this problem. Various aspects of DLF are discussed in a number of works, namely by: V. Yu. Bykova (2009), V. M. Kukharenko (2007), K. R. Kolos (2011), V. I. Ko-valchuk (2017), L. M. Lavrynenko (2020), A. F. Manako (2009), N. V. Morze (2010), T. O. Oliynyk (2007), O. M. Pavlenko (2019), S. O. Sysoeva (2009), O. M. Spirina (2007), S. V. Sharova (2019), K. P. Osadcha (2009) at al.

In our opinion, DLF research in general secondary education institutions does not cover all educational aspects – the results of students' learning in DLF are represented by a small number of scientific publications.

Let us note the substantial work, carried out by such researchers as Yu. M. Bohachkov and O. P. Pinchuk (2013) [6]. The authors highlight the problem of building a network of resource centers for distance education to meet the needs of general secondary education institutions; they considered the main tasks of functioning of distance education resource centers and performed a review of possible models of DLF implementation for students of general secondary education institutions.

However, in recent years, the systematic introduction of DLF in the educational practice of general secondary education institutions has not been observed. Educational policies did not encourage general secondary education institutions to introduce distance learning technologies. But in the context of the COVID-19 pandemic DLF has acquired a new meaning in general secondary education institutions and needs additional attention and new research by scientists.

3. Problem Statement

In the course of 2020, a number of surveys were conducted concerning the definition of the status of the introduction of DLF, in particular the data of the State Service of Education Quality of Ukraine "Analytical Report on the organization of DLF in general secondary education institutions under quarantine" which analyzed aspects of DLF classes, procedures of getting homework tasks by students and provided recommendations to participants in the educational process (https://cutt.ly/fxm4UEb).

The real state of the problem of using digital tools by teachers during long-term quarantines is substantiated by researchers O. V. Ovcharuk and I. V. Ivanyuk, which is reflected in the work "The state of readiness of general secondary education institutions teachers to use information and educational environment for distance learning during quarantine caused by COVID-19" (https://lib.iitta.gov.ua/719908/) [10].

The monitoring studies of the process of DLF implementation in general secondary education institutions during 2020 identified the following main problems: lack of effective interaction of participants in the educational process; insufficient technical support of students and teachers; inefficient organization of distance learning; weak control of students' academic achievements; poor methodical training of teachers and heads of general secondary education institutions.

The technical and technological component remains the most difficult problem in starting DLF, namely: low speed and quality of Internet connection or its absence; lack of educational digital resources that can fully ensure the formation of students' knowledge of academic subjects; online platform overload; many teachers and students lack modern mobile devices, computers and other gadgets (especially in rural areas); some elementary students cannot work with computers on their own without parental help; limited access of some students to computer equipment was common, too (there may be two to three students and parents working online in a family), etc. [9].

As we can see, the issue of teaching primary school students is a separate item, as the organizational and psychological and pedagogical aspects of teaching primary school students by applying DLF are not fully explored. In addition, during the weakening of quarantine measures period, it was decided that primary school students should study full-time in the classroom in most regions of Ukraine. However, this situation does not solve the problem of organizing DLF for primary school students, and postponing the problem only deepens it.

4. Methods of Research

The study presents the results of the introduction of a distance form of education for elementary school students within the framework of realizing the experiment of the All-Ukrainian level named "Smart Kids technology of teaching primary school students", which has been realized in Ukraine since 2017. During 2020, a survey of 94 primary school teachers – participants in the project was conducted on the effectiveness of the use of electronic educational resources during long-term quarantine and distance learning of primary school children. 2454 students and 94 teachers from 12 regions of Ukraine took part in the experiment.

5. Research Results

5.1. Organization of Distance Learning

In 2017-2020 Ukraine witnessed the implementation of the project "Smart Kids technology of teaching primary school students" (order of the Ministry of Education and Science of Ukraine, 30.08.2017, No.1234), which is based on the method of using electronic educational resources and virtual teacher's office that can fully ensure the effective implementation of DLF in primary school.

Let us consider the model of DLF organization in primary school using electronic educational resources and a virtual teacher's office (Figure 1).

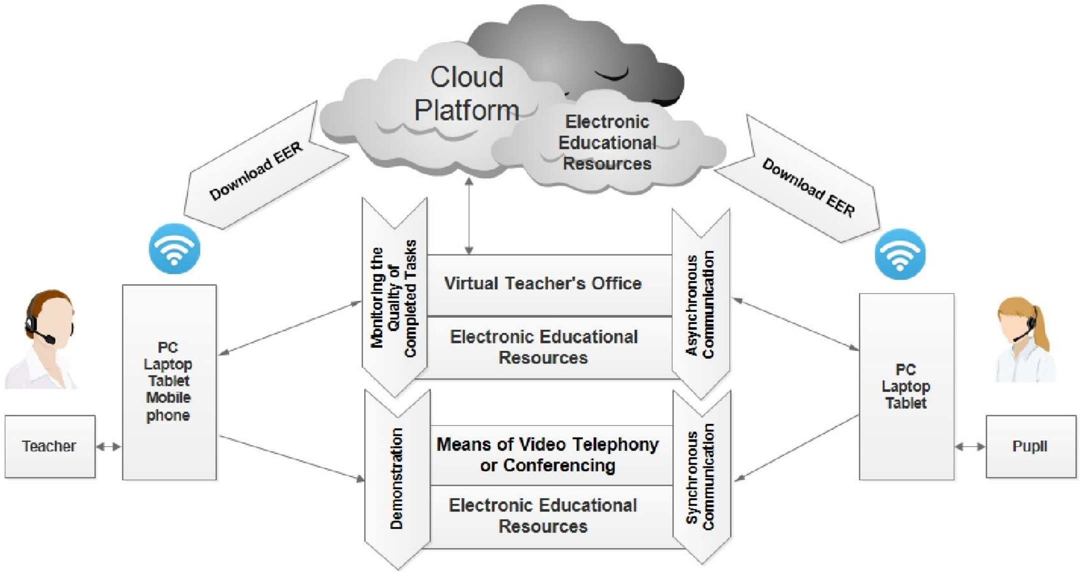

Figure 1: Model for the organization of distance learning in primary schools

The introduction of distance learning in primary school is based on the availability of electronic educational resources (EER) for grades 1-4 in Ukrainian language and mathematics of the "Smart Kids" company. Currently, the number of such resources is more than 52 units (http://edugames.rozumniki.ua/catalog/). Teachers and students download electronic educational resources to their gadgets one time at the beginning of the school year. The use of such resources does not require constant access to the Internet.

Distance form of learning, based on the use of EER, includes three main components: the organization of training, conducting online class (explaining new material or practicing skills by students) and monitoring the quality of independent performance of tasks by students. We will further detail all the components.

Organization of teaching process.

The main organizational components of distance learning in primary school include the presence of electronic mailboxes of participants in the educational process, means of video telephony or conferencing, electronic educational resources, electronic calendar, access to the Internet (Figure 2).

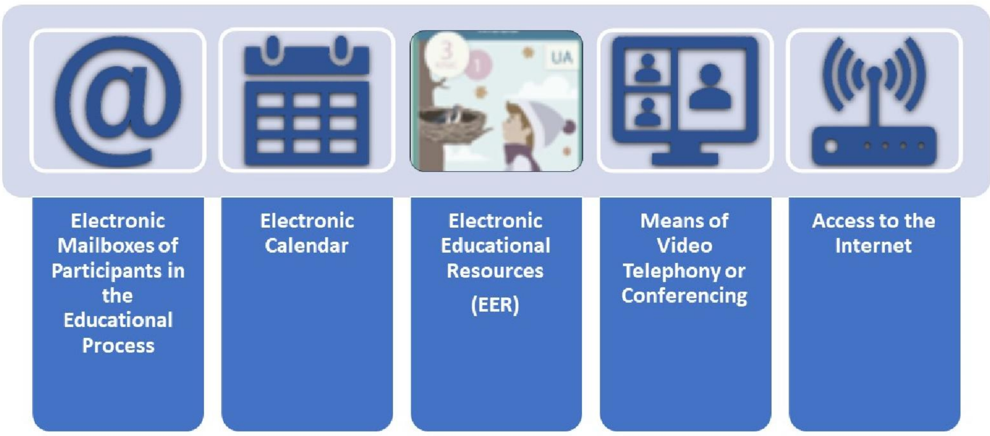

Figure 2: Organizational components of distance learning in primary school

All participants in the educational process must be provided with access to the Internet: students – at home, and teachers both at home and in the institution. For online communication, teachers and students need to have the technical means: laptops, personal computers, or tablets. Teachers can use modern mobile phones.

The implementation of online educational communication requires that the teacher be competent to use conference or video telephony, namely: Zoom, Skype, Google Meet, Teams, etc. Training should be provided for students and their parents on the use of online communication tools.

At the beginning of the school year, the teacher needs to form a database of e-mail boxes for students to generate invitations to online classes. Please note that the e-mail box for students in grades 1-4 should be created by parents in order to meet the requirements for the safety of children on the Internet. For example, in the "Age limits on Google accounts" section, Google sets the age limit for creating an email account – 13 years[2].

Organizational aspects include creating a schedule of online meetings with students. Teachers and students need to systematically enter meeting dates into Google Calendar, Outlook Calendar, or Teams Calendar. An effective way is to provide the access of students to the teacher's educational calendar, which will give constant access to current announcements and planned events.

Online classes.

According to the requirements of the Sanitary Regulations for schools' online class should last no more than 10 minutes for 1st graders and no more than 15 minutes for 2nd and 4th graders (https://cutt.ly/5cPeWZH). Therefore, a teacher should consider the following organizational aspects of the online classes:

- Rollcall of the students – for this purpose students can write their name in the chat, or the teacher can quickly view the video images of students; the best option – parents inform the teacher about the absence of the child for a good or bad reason, using means of communication, such as a group Viber.
- Explanation of a new material – for this purpose it is necessary to choose in advance those electronic resources which correspond to the object of the class, to think over logical transitions from explanation of a material to demonstration of examples and performance of exercises with students.
- Consolidation of the studied material – the educator should think over the procedure for summarizing the class, organizing feedback with students, announcing homework and the procedure for their assessment (for 3-4 grades).

Monitoring the quality of student performance.

Despite the fact that under the Order of the Ministry of Health of Ukraine as of September 25, 2020, No.2205 "On approval of the Sanitary Regulations for general secondary educational institutions" students of grades 1-2 are not recommended to be set mandatory tasks for self-preparation in extracurricular activities, in period of long-term quarantine, the quality of education can be ensured only through a system of homework. An effective way out of this situation is the use of electronic educational resources, which was implemented in the "Smart Kids" All-Ukrainian project.

The quality of the tasks performed by the students was assessed by three indicators: the task was performed correctly, the task was performed with one error, and the task was performed with more than one error. The pupil had the opportunity to redo the task – the motivation was the number of correctly performed tasks (Figure 3).

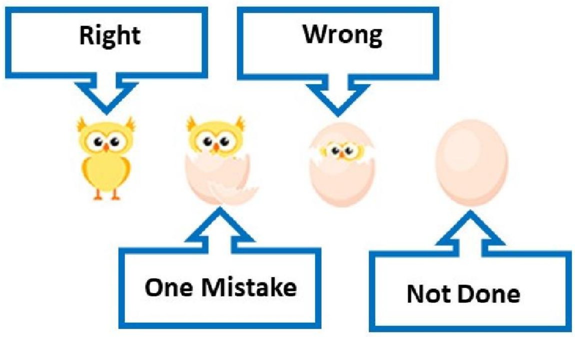

Figure 3: Motivational assessment of completed tasks by primary school students

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[2] https://support.google.com/accounts/answer/1350409?hl=uk

The teacher was able to monitor the quality of the completed tasks in the virtual teacher's office and, if necessary – to assign an additional task to practice the necessary skills (Figure 4).

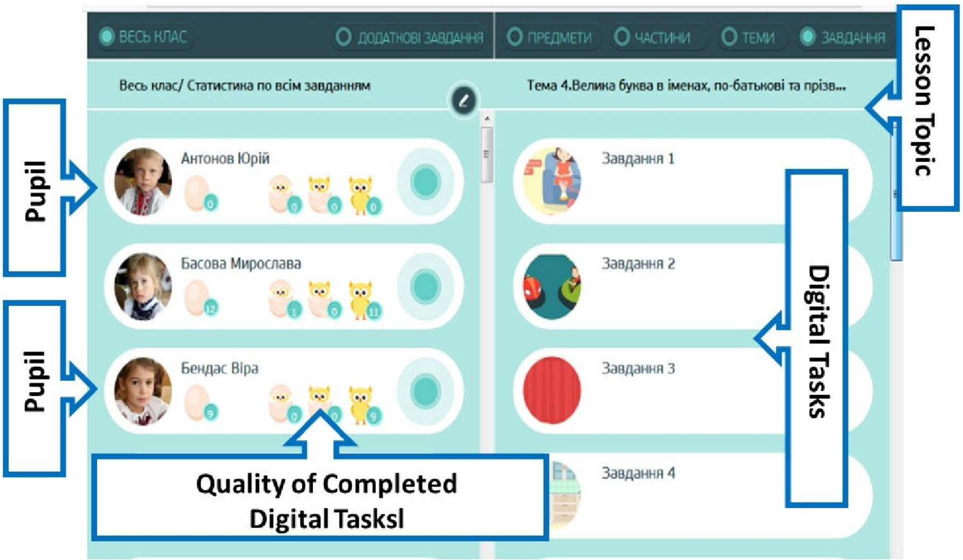

Figure 4: Virtual teacher's office – monitoring the quality of tasks performed by students

The procedure for providing an additional task through the virtual teacher's office is quite simple. The task selected by the teacher was marked with a red house, which was displayed on the student's personal computer while working with EER. Thus, while monitoring the students' academic achievements, the teacher was able to shape an individual trajectory of the student's development and provide for the development and consolidation of those tasks that the student encountered difficulties to complete.

5.2. Results of the "SMART KIDS" Experiment

At the time of the large-scale COVID-19 pandemic, 94 primary school teachers took part in the experiment to introduce distance education in 12 regions of Ukraine, namely: 1 grade – 27.7%, 2 grade – 22.3%, 3 grade – 17%, 4 grade – 32%. A total of 2454 students took part in the experiment; the distribution of students by grades can be seen in Figure 5.

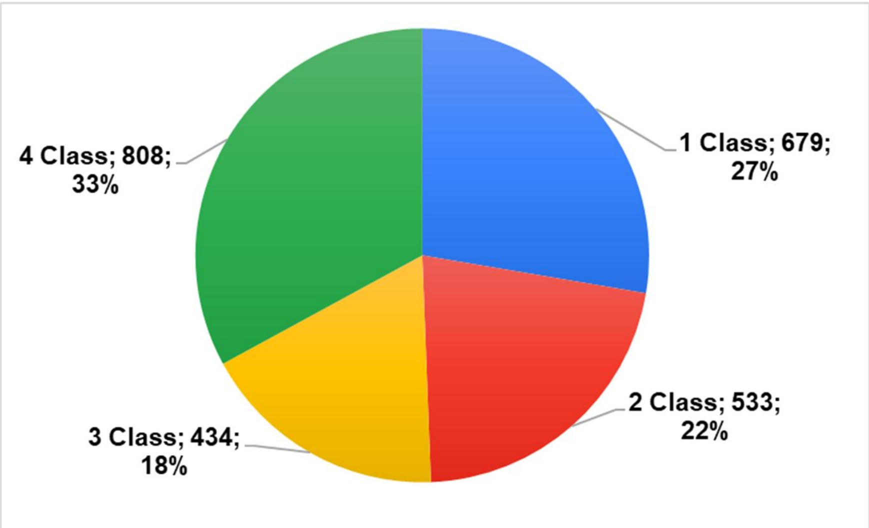

Figure 5: Distribution of students by grades with DLF learning process

In the process of organizing the education of primary school students by distance learning, teachers used the following technical means: school and home computers, they also identified a mobile phone and an additional means of instant communication (Figure 6).

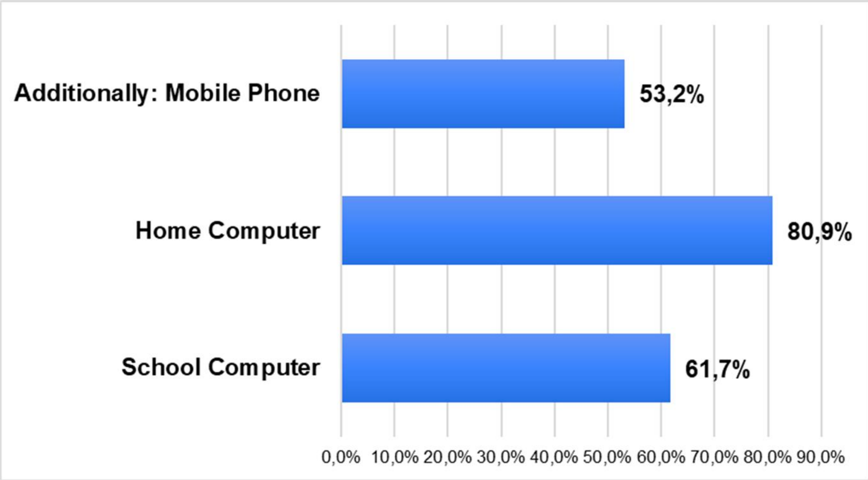

Figure 6: Means for organizing distance learning

An important aspect of any form of student learning is assessment. Under the normative documents of the Ministry of Education and Science of Ukraine, assessment in grades 1-2 is not recommended, but teachers – participants of the project carried out constant monitoring of students' academic achievements through a virtual teacher's office [9]. Moreover, they used additional services such as Kahoot, Viber, Microsoft Forms, Learning Apps, and Google Forms to evaluate students in grades 3-4 (Figure 7).

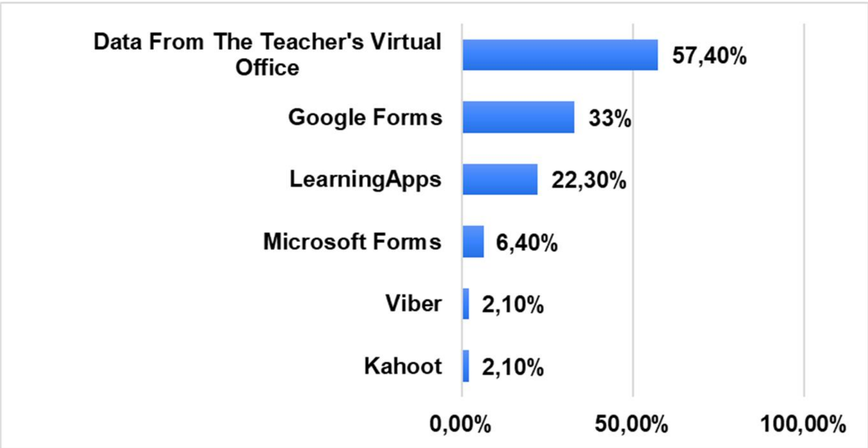

Figure 7: Services for assessing the academic achievements of primary school students

As teachers were provided with electronic educational resources, it was important to find out the frequency of using EER during distance learning (Figure 8).

Analyzing the results, we found out that 90.3% of teachers used EER for teaching both continuously and periodically, and only 10% failed to apply EER due to problems with the Internet.

During the pandemic, 64.9% used EER to explain new material, 50% – to test the learning material, 74.5% – gave students additional tasks to practice skills.

To ensure online communication with students, almost 28% of teachers used additional services, such as ZOOM, Google Meet, Teams, and Skype.

The authors also studied the role of EER in teaching primary school students. According to teachers, these were resources for practicing skills – 76.6%, for explaining new material – 64.9%, for monitoring the quality of completed tasks – 50%; 28.8% said that they managed to establish online learning communication and ask the students to speak in front of the class while performing EER tasks.

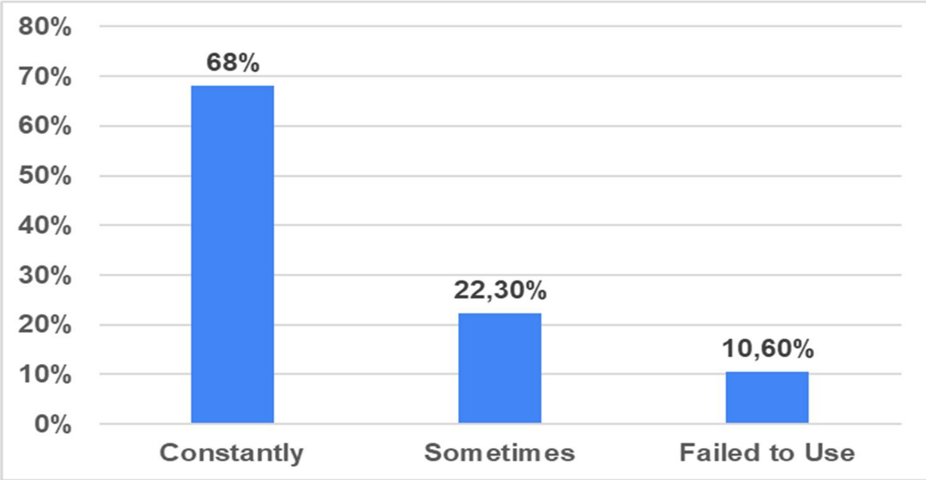

Figure 8: Frequency of using Smart Kids EER during the distance learning

Teachers who, in the extreme conditions of transition to distance learning, took the opportunity to use EER to ensure the continuity of student learning, rated the quality of their own work as quite high (Figure 9).

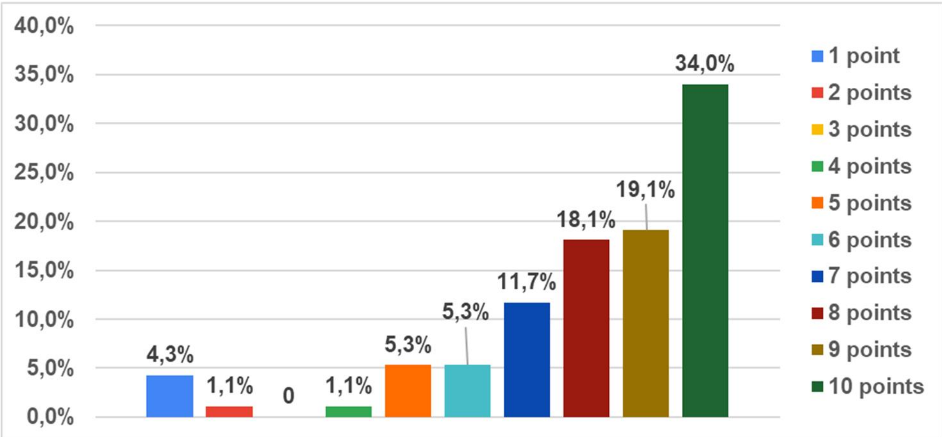

Figure 9: Teachers' self-assessment of the use of EER during the distance learning

To evaluate the results of the experiment, it was also important to summarize the teachers' opinions on the need to use EER in primary school in the pandemic event (Figure 10).

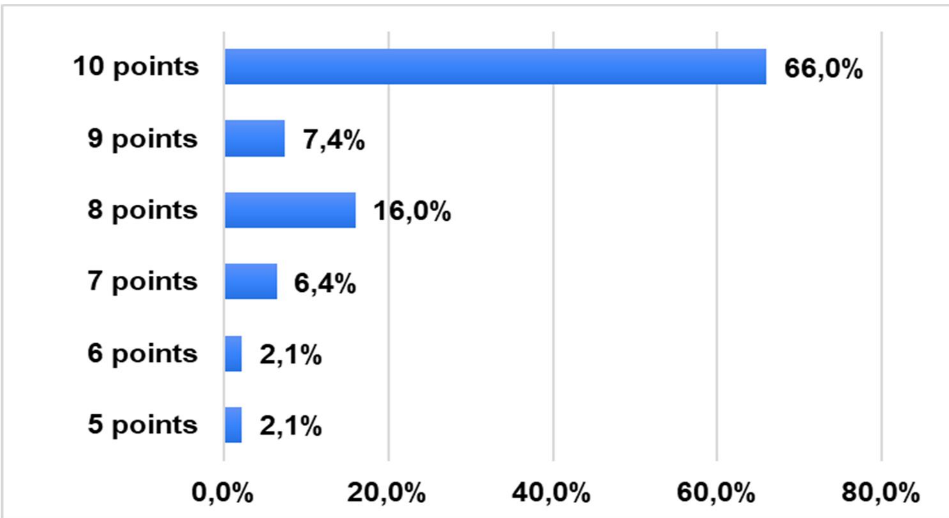

Figure 10: Assessing the need to use EER in primary school

Thus, 66% of teachers estimated the need for such resources for primary school at 10 points, 7.4% – at 9 points, 16% – at 8 points and 6.4% – at 7 points. On average, teachers rated the importance of EER at 8.5 out of 10, which is an important indicator in the implementation of Smart Kids technology in educational practice, being an effective means of teaching primary school students.

6. Discussion

During the discussion of the situation with COVID-19 and the transition to distance learning, teachers outlined three main problems that hindered the effective use of "Smart Kids" electronic educational resources, namely:

- 27% of teachers acknowledged significant problems with the use of the Internet. They noted unexpected disconnections and disruptions during online classes with students.
- 24% teachers identified the problem of providing computers to students and some teachers. The provision of computer equipment has become prohibitively expensive for low-income families.
- 20% teachers acknowledged the lack of government assistance in providing EER to all students in the classroom.
- Teachers raised the common problem – limited access to students' computers during complete isolation due to parents' online work.

7. Conclusions and recommendations for further research

At the moment the primary school system is not only in the process of completing the reform, but also in the process of benchmarking – finding a reference, cost-effective solution to effectively implement distance learning, adopting best practices and implementing best pedagogical practices that will lay the foundations for primary school to provide quality education.

Since EER can be used both in full-time and distance learning, the global experiment on the introduction of distance learning in the pedagogical practice of primary school teachers within the framework of the "Smart Kids technology of teaching primary school students" experiment is a positive example of providing continuous and high-quality student learning.

The developed methods of transition to distance learning in primary school at any time with continuity of education is a significant achievement of cooperation between scientists of the Institute of Information Technologies and Learning Tools of the National Academy of Educational Sciences of Ukraine, "Smart Kids" Holding company and teachers-innovators of primary school in Ukraine.

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A Self-Assessment Tool of the Level of Digital Competence of Ukrainian Teachers in the Context of Lifelong Learning: The Results of an Online Survey 2021

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Abstract

Reforms in education today are due to many factors, including globalization, the transition to a digital economy and citizenship, the formation of a knowledge society. That is why human digital competencies are becoming increasingly important in the development of education and affect the quality of life of every person. Modern teachers must not only possess his professional knowledge and skills but must also be able to learn throughout life. And in this context, their digital competencies play a crucial role. An important role in clarifying the state of possession of strong digital skills of teachers is played by the need for distance learning, which took place during the COVID-19 pandemic around the world, as well as in Ukraine. In order to clarify the level of digital competence of teachers in Ukraine, the Comparative Studies Department for Information and Education Innovations of the Institute of Information Technologies and Learning Tools of the National Academy of Educational Sciences of Ukraine conducted an all-Ukrainian online survey in January 2021 [[1]]. 1463 educators took part in the online survey, they answered five blocks of questions about their competence in the use of digital tools and instruments for distance learning and self-education: information and digital literacy, communication and cooperation, digital content creation, security and problem solving. The purpose of the article is to present the survey results and provide proposals regarding the development of teachers' digital competence and professional development.

Keywords

Digital Competence, Teacher, Professional development, ICT, Online Survey, COVID-19 Pandemic, Distance Teaching and Learning, Lifelong Learning.

1. Introduction

Today, Ukrainian teachers and schools are in a situation where distance learning has become a necessity. These circumstances are closely related to the introduction of quarantine measures in all countries of the world in connection with the COVID-19 pandemic. That is why the digital competencies of teachers and school administrators are on the agenda in the education system. What matters today is how teachers and schools develop digital learning environments, what tools they use, what digital skills they can apply for these purposes. The education system, for its part, should support teachers, provide them with lifelong learning, quality training and retraining given a person-centered approach. To determine the prospects for such support, it is important to find out what level

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of digital competence teachers have, how they assess it, and whether they can develop their digital skills on their own.

An online survey was aimed at implementing the following tasks: identifying public opinion of general secondary school teachers and school administrators about the problems, needs, and challenges that arise during distance and blended learning in quarantine; determining the degree of readiness of teachers to use online tools and online resources during distance and blended learning in quarantine; comparison of the results of the 2021 survey on the use of online tools and online resources with the results of the first survey in the spring of 2020 [[2]]; determining the level of digital competence of teachers through self-assessment based on the DigComp 2.0, 2.1 [[2]] and the international practice [[5]]; providing appropriate recommendations to stakeholders based on an assessment of the situation during the quarantine. An online survey revealed the level of development of teachers' digital competence, their ability to carry out self-assessment. The obtained results of the research allowed formulating recommendations for institutions that conduct trainings for teachers and their professional development, as well as for school principals on the use of ICT for the organization of distance learning.

2. Literature Review

The problems of using ICT for distance learning by teachers in educational institutions are covered in the works of researchers V.Yu. Bykov, O. Yu. Burov, O.M. Spirin, V.I. Lugovy, V.V. Oliynyk, N.P Morse, M.P Shyshkina, S.H. Lytvynova and others [[6]; [7]; [12]]. These researchers raise questions about the methodology of using digital tools, creating a digital environment for teachers and students. The main issue, researchers consider the creation of the necessary educational and methodological support of the process of creating a digital environment of the educational institution, determining the structure of such an environment and its main components.Issues of formation of digital competence of teachers are covered in the works of M.P.Leshchenko, I.V. Ivaniuk, O.O. Gritsenchuk, N.V. Soroko, O.V. Ovcharuk and others [[1]; [2];[4];[6];[8]; [9]; [10]]. The focus of researchers is on international approaches, as well as on the components of the teacher's digital competence. In their works, scientists emphasize the need to harmonize the framework for the development of digital competence of students and teachers with international approaches and the need to create effective mechanisms for assessing the level of digital literacy of educators in Ukraine.

2.1. Research Method

A phenomenon study of the development of teachers' digital competence; a systematic approach to information retrieval; the data gathering about the readiness of teachers towards the use of ICT tools and their problems were applied. An online questionnaire was based on European documents, including the DigComp 2.0 and 2.1 (2017) [[2]]. Importance was given to the analysis, synthesis of information based on common scientific methods of analysis and synthesis. In addition, computational methods of information processing were applied during the data processing online survey.

2.1.1. Research results

The study was conducted in the period from 10.01.2021 to 10.03.2021.The empirical data of the online survey was collected from 12.01.2021 to 28.02.2021.Teachers from the following regions took part in the online survey: Vinnytsia, Volyn, Dnipropetrovsk, Donetsk, Zakarpattia, Zaporizhia, Zhytomyr, Ivano-Frankivsk, Kyiv, Kirovohrad, Luhansk, Lviv, Mykolaiv, Odesa, Poltava, Rivne, Sumy, Ternopil,Kharkiv, Kherson, Khmelnytsky, Cherkasy, Chernivtsi, and Kyiv.Thus, geographically the online survey covered East, West, South, North and Center of Ukraine. The study covers a non-representative sample of the target group. A random type of sample was used to conduct an online survey of teachers. The number of respondents is 1463 people, including 1298 women and 149 men. The survey identified three main age categories: 40-55 years - 42.6%; 26-40 years - 32.9%; 55 and older - 20.5%. By type of educational institutions among the respondents - the most representatives of such institutions are secondary school - 67.2%, lyceum - 13.9%; educational complex - 10.3%; gymnasium - 3.4%. Distribution of respondents by type of settlements is the following: 46.8% - city; 36.7% - village; 16.5% is an urban-type settlement.

The form of the online questionnaire was filled in only at one's own request.The survey was anonymous. The questionnaire was published on the websites of the IITLT of the NAES of Ukraine, the website of the Presidium of the National Academy of Educational Sciences of Ukraine, the in-service teacher training institutes mailing list, and through the Facebooksocial network.All study participants were informed about the objectives of the study.

The analysis and interpretation of quantitative data was carried out using the methods of descriptive and mathematical statistics, the results are presented in the form of diagrams and their interpretations, which are arranged in the relevant thematic blocks. The general scientific approaches to the analysis of the results are outlined in the “Regulations on the Procedure for Forming, Conducting and Controlling the Performance of Scientific Research and Scientific and Technical (Experimental) Developments at the National Academy of Pedagogical Sciences of Ukraine” from December 20, 2018). These approaches are the followings: novelty and relevance; compliance with the priorities of state policy and thematic areas of research and scientific and technical development; practical usefulness, possibility of implementation of the given recommendations and conclusions; availability of previous experience and achievements of scientists in performing scientific research.

As was stated above, all questions are based on international approaches, including the Digital Competence Framework for Citizens: Eight Skills with Examples of Use (DigComp 2.1: Digital Competence Framework for Citizens) [[2]], and adapted to the current version of the online questionnaire [[1]]. The DigComp 2.1 includes the following levels: basic user, independent user, professional user. It outlines five areas of this competence: information and digital literacy, communication and collaboration, digital content creation, security, and problem solving. The study was constructed according these areas and levels.

In the area of "*Information and digital literacy*" when asked about the ability to search for information, 33.9% of respondents said that they can do search for information in the Internet using a search engine that corresponds to the basic level of the user; 44.6% of respondents said that they can use different search engines to find information that corresponds to the level of an independent user; 21.5% of respondents said that they can use advanced search strategies to find reliable information in the Internet, for example, using web channels that corresponds to the level of a professional user(see Fig.1).

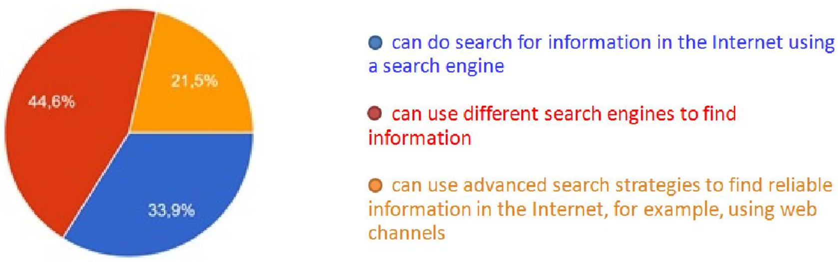

Figure 1: The sample of the answers of the respondents about the area of "Information and digital literacy".

When asked about the ability to assess the accuracy of information during a search 30.5% of respondents stated that they know that not all information on the network is reliable, which corresponds to the basic level of the user; 22.3% of respondents stated that they use some filters when searching to compare and evaluate the reliability of information they find that corresponds to the level of an independent user; 47.1% of respondents said they could assess the accuracy of the information using a number of criteria that meet the level of a professional user.

When asked about the ability to store the information found, 23.7% of respondents said that they can save files or content and receive them after saving, which corresponds to the basic level of the user; 28% of respondents stated that they classify information methodically using folders; back up information or files that store that corresponds to the level of the independent user; 48.3% of respondents stated that they can store information found on the Internet in various formats; can use cloud storage services that correspond to the level of a professional user.

In the field of "*Communication and Cooperation*" on the question of the ability to communicate using various means of communication 21.8% of respondents said that they can communicate with other users via Skype or chat - using basic functions (eg, voice messages, SMS, text exchange), which corresponds to the basic level of the user; 11.5% of respondents said that they could use the advanced features of several means of communication (for example, using Skype and file sharing), which corresponds to the level of an independent user; 66.7% of respondents said that they actively use a wide range of means of communication (e-mail, chat, SMS, instant messaging, blogs, micro-blogs, social networks) for online communication, which corresponds to the level of a professional user(see Fig.2).

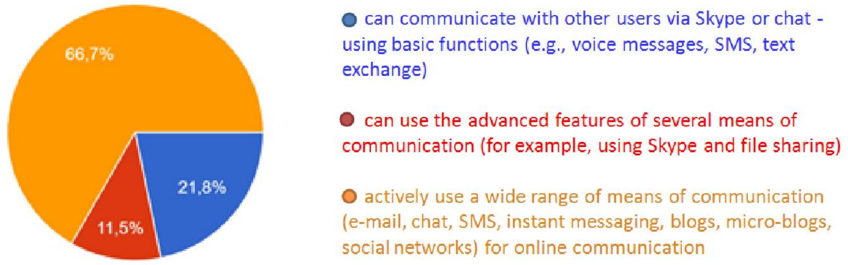

Fig.2. The sample of the answers of the respondents about the area of "Communication and Cooperation".

When asked about the ability to create and manage content using collaboration tools, 27.1% of respondents said that they can share files and content using simple tools that correspond to the basic level of the user; 50.1% of respondents indicated that they could use collaboration tools and distribute, for example, shared documents / files created by other people, which corresponds to the level of an independent user; 22.8% of respondents said that they can create and manage content using tools for collaboration (eg, project management systems, spreadsheets on the Internet), which corresponds to the level of a professional user.

When asked about the ability to use online services 22.1% of respondents stated that they can use online services (e.g. e-banks, e-governments, e-hospitals, etc.), which corresponds to the basic level of the user; 44% of respondents stated that they use the functions of online services (e.g., public services, e-banking, online stores, etc.), which corresponds to the level of an independent user; 34% of respondents said that they take an active part in online spaces and use several online services (eg, public services, e-banking, online store, etc.), which corresponds to the level of a professional user.

When asked about the available knowledge and ability to use online tools for collaboration 30.3% of respondents stated that they know social networking sites and online collaboration tools, which corresponds to the basic level of the user; 23% of respondents stated that they pass on knowledge to other users on the Internet (for example, through social networking tools or in online communities), which corresponds to the level of an independent user; 46.7% of respondents stated that they can use additional functions of communication means (e.g. video conferencing, data exchange, sharing), which corresponds to the level of a professional user.

In the field of "*Digital content creation*" when asked about the ability to create multimedia content in different formats using various digital tools and environments, 55.6% of respondents said that they can create simple digital content (eg text, tables, images, audio files) in at least one format using digital tools that corresponds to the basic level of the user; 38.1% of respondents said that they can create complex digital content in various formats (eg text, tables, images, audio files) and use tools to create web pages or blogs that correspond to the level of an independent user; 6.3% of respondents said that they can produce complex multimedia content in different formats, using a variety of digital tools and environments, can create a website using a programming language that corresponds to the level of a professional user(see Fig.3).

Fig.3. The sample of the answers of the respondents about the area of "Digital Content creation".

When asked about the ability to use the formatting features of content and various tools, 27.6% of respondents said that they can make basic editing of content created by other users (for example, add and remove), which corresponds to the basic level of the user; 63.4% of respondents stated that they can apply basic formatting (for example, insert links, charts, tables) to content created by themselves or other users that corresponds to the level of an independent user; 8.8% of respondents said that they can use the functions of advanced formatting of various tools (eg, merging e-mail, merging documents of different formats, using advanced formulas, macros), which corresponds to the level of a professional user.

When asked about the knowledge regarding the rules of using content in accordance with copyright protection, 44.7% of respondents said that they know that content can be protected by copyright, which corresponds to the basic level of the user; 42.9% of respondents stated that they know how to refer to and use copyrighted content that corresponds to the level of an independent user; 12.4% of respondents said that they know how and when to apply for licenses and copyrights, which corresponds to the level of a professional user.

When asked about programming skills 67.7% of respondents said that they can change simple software functions by changing the default settings, which corresponds to the basic level of the user; 25.3% of respondents stated that they know the basics - the principles of one programming language, which corresponds to the level of an independent user; 7% of respondents said that they can use several programming languages. I know how to design, create and modify databases with a computer tool that matches the level of a professional user.

In the area of *Safety*, when asked about the ability to protect the system of devices and programs, 54.7% of respondents said that they can take basic steps to protect their devices (eg, use of antivirus and password), which corresponds to the basic level of the user; 32.5% of respondents stated that they can install security programs on devices that use to access the Internet (eg, antivirus, firewall), which corresponds to the level of an independent user; 12.8% of respondents said that they often check the security configuration and systems of devices and / or programs that they regularly use to access the Internet, which corresponds to the level of a professional user(see Fig.4).

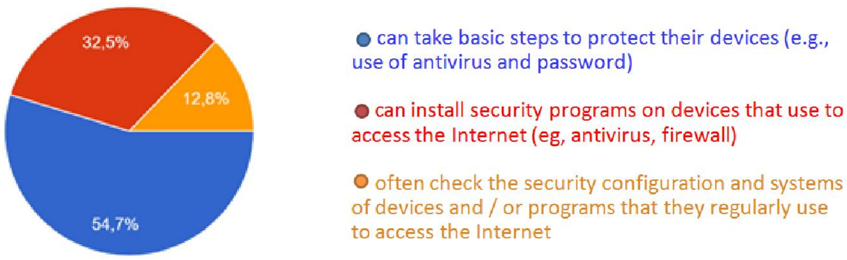

Fig.4. The sample of the answers of the respondents about the area of "Safety".

When asked about the ability to protect personal information on their digital devices, 47.3% of respondents said they knew that credentials (username and password) could be stolen and that they should not disclose personal information on the Internet, which corresponds to the basic user level; 34.9% of respondents stated that they use different passwords to access equipment, devices and digital services, periodically changing them to match the level of the independent user; 17.9% of respondents said they know how to react if a computer is infected with a virus, can configure or change the antivirus and configure the security of their digital devices, which corresponds to the level of a professional user.

When asked about the ability to use ICT safely for their own health, 22.1% of respondents said that they know that the use of digital technologies has too much impact on their health, which corresponds to the basic level of the user; 34% of respondents stated that they understand the health risks associated with the use of digital technologies (for example, the risk of dependence), which corresponds to the level of the independent user; 43.9% of respondents said that they can use ICT in such a way as to avoid health problems (physical and psychological), which corresponds to the level of a professional user.

When asked about knowledge about the impact of digital technologies on everyday life and the environment, 12.5% of respondents said that they take basic measures to save energy, which corresponds to the basic level of the user; 44% of respondents said that they understand the positive and negative impact of technology on the environment, which corresponds to the level of the independent user; 43.5% of respondents stated that they have an informed view on the impact of digital technologies on everyday life and the environment, which corresponds to the level of a professional user.

In the area of “*Problem Solving*”, when asked about the ability to solve problems that arise when using digital technologies, 56.5% of respondents said that they find support when a technical problem arises or when a new program is used that meets the basic level of the user; 37.3% of respondents said that they can solve most of the problems that most often arise when using digital technology, which corresponds to the level of independent user; 6.2% of respondents said that they can solve almost all the problems that arise when using digital technologies, which corresponds to the level of a professional user(see Fig.5). When asked about the ability to choose and use an appropriate digital tool or service to solve non-technical problems, 42.6% of respondents know that digital tools can help solve problems that correspond to the basic level of the user; 36.9% of respondents stated that they can use digital technologies to solve non-technical problems, which corresponds to the level of an independent user; 20.6% of respondents said that they can often choose the right tool, device, application, software or service to solve non-technical problems that corresponds to the level of a professional user.

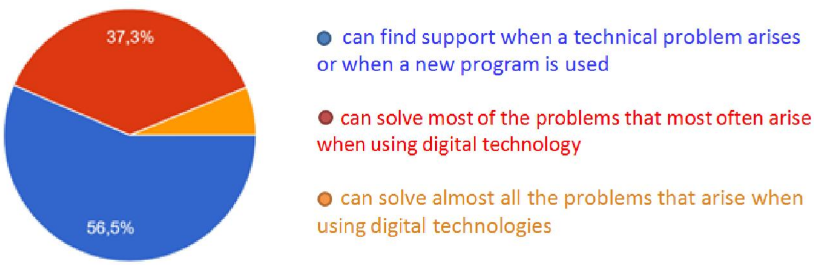

Fig.5. The sample of the answers of the respondents about the area of "Problem solving".

When asked about the ability to choose and use an appropriate digital tool to solve technological problems, 54.7% of respondents said that they can use familiar tools to solve a technological problem that corresponds to the basic level of the user; 38.6% of respondents said that they can solve technological problems by studying the settings of programs or tools that correspond to the level of an independent user; 6.7% of respondents said that they know about new technological developments and understand how new tools work, which corresponds to the level of a professional user.

On the question of awareness of the need to update skills in the field of digital technologies 36.6% of respondents said that they are aware of the need to regularly update their skills in the field of digital technology, which corresponds to the basic level of the user; 47.5% of respondents said that they regularly update their skills in the field of digital technology, know their limitations and try to fill the gaps that correspond to the level of an independent user; 15.9% of respondents said that they often update their skills in the field of digital technology to reduce their limitations and increase knowledge in this area, which corresponds to the level of a professional user.

The results obtained by teachers' self-assessment of the level of digital competence indicate the following.

A positive trend is observed in the field of "Information and digital literacy". The vast majority of teachers are able to search for information at the level of independent (44.6%) and professional (21.5%) users; assess the reliability of information at the level of professional (47.1%) and independent (22.3%) user; store the found information at the level of professional (48.3%) and independent (28%) user. Approximately 29% of respondents have a basic user level and need advanced training.

In the field of "Communication and Cooperation" teachers also have high levels. The vast majority of respondents are able to communicate using various means of communication at the level of professional (66.7%) and independent (11.5%) user; create and manage content at the level of independent (50.1%) and professional (22.8%) users; use online services at the level of independent (44%) and professional (34%) users; know and are able to use online tools for cooperation at the level of professional (46.7%) and independent (23%) user. Approximately 25% of respondents have a basic user level and need advanced training.

In the field of "Digital Content Creation" the situation with the existing levels of digital competence of teachers is changing. The vast majority of respondents are able to create multimedia content in different formats, using a variety of digital tools and environments at the level of basic (55.6%) and independent (38.1%) user; use the formatting functions of content and various tools at the level of independent (63.4%) and basic (27.6%) user, know the rules of using content in accordance with the protection of copyright legal levels of basic (44.7%) and independent (42.9%)) user; have programming skills at the level of basic (67.7%) and independent (25.3%) users. On average, only 8% of respondents have the level of a professional user. It is in this area that problems arise that affect the formation of a culture of academic integrity in society.

In the area of "Safety", the issues concerned two areas (ensuring the safety of their digital devices and safety related to their own health and the environment) and each of them has different indicators on the levels of digital competence of teachers. The first direction involved the ability to protect the system of devices and programs (baseline - 54.7%, independent level - 32.55) and protect personal information on their digital devices (baseline - 47.3%, independent level - 34.9). The second area included the ability to use ICT safely for one's own health (professional level - 43.9%, independent level - 34%) and knowledge about the impact of digital technologies on everyday life and the environment (independent level - 44%, professional level - On average, 15% of respondents have the level of a professional user to ensure the security of their digital devices and personal data, so this issue should be given more attention.

In the field of "Problem Solving", the professional level of the user is on average 12% of respondents, which indicates certain gaps in the system of professional development of teachers in need of refinement. Half of the respondents have a basic level of user in this area, as evidenced by the following data: the ability to solve problems arising from the use of digital technologies (basic level - 56.5%, independent level - 37.3%); ability to choose and use an appropriate digital tool or service to solve non-technical problems (basic level - 42.6, independent level - 36.9); ability to choose and use the appropriate digital tool to solve technological problems (basic level - 54.7, independent level - 38.6); awareness of the need to update skills in the field of digital technologies (independent level - 47.5, basic level - 47.5).

3. Conclusions and Recommendations

The conducted survey allowed the authors to use the tool of self-assessment of digital competence of teachers based on the Digital Competence Framework for Citizens (DigComp 2.0 and 2.1) and the Digital Competence Framework for educators (DigCompEdu) for the first time in Ukrainian context. Based on the results of the assessment of the current state of the level of teachers' digital competence, the recommendations were developed and presented to stakeholders, in particular, for the network of the in-service teacher training institutions [[8]; [11]]. For these institutions we recommend to introduce the already tested self-assessment tool as a part of the regular and voluntary instruments to help teachers to identify needs and gaps into their level of digital competence. This instrument can be used also as a source of the information about possible topics and modules for the in-service teacher training programs and future trainings.

Researchers expect that by the end of the 2020/2021 school year, regional ITTIs will assess the level of digital competence of teachers, using the proposed tool for self-assessment, which will determine the real situation in each area. By the beginning of the 2021/2022 school year, each regional in-service teacher training institute will be informed on how to develop appropriate in-service training programs for teachers in the region based on the results of the current study. A group of researchers plans to conduct an All-Ukrainian online survey at the end of the 2021/2022 school year and compare how much the situation has changed regarding the development of digital competence levels of teachers.

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Actual Areas of Development of Digital Competence of Officers of The Armed Forces of Ukraine

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Abstract

The purpose of the study is to find ways to solve the current problem of improving the military education system. The needs in the formation and development of digital competencies of military management officers in different competence areas were studied: information and data literacy, communication and collaboration, digital content creation, safety and problem solving are studied. Possession of a high level of competence in these areas, according to the authors, significantly affects the professional development of officers during their military careers. The attention is focused on the possibility of implementing transdisciplinary integration in the system of advanced training of officers of the Armed Forces of Ukraine. The subject of the study, among other things, was the formation of readiness to use STEM-technologies in professional activities. The study reviewed modern STEM-approaches in the educational process and analyzed the experience of countries such as the United States, Australia, China, Britain, Israel, Korea, Singapore. The results of the survey among the students of advanced training courses at The National Defence University of Ukraine named after Ivan Cherniakhovskyi are highlighted. In particular, the attitude and needs of military management officers to training and professional development were clarified; identified their educational interests. In particular, the need for effective ownership of tools for planning and organizing project work, analysis and evaluation of achieved results is identified.

Keywords

STEM-education, STEM-technologies, digital competence, digital tools, the Armed Forces of Ukraine, military management, military education, transdisciplinary integration, ICT, lifelong learning, professional development during a military career.

1. Introduction

Information and communication technologies (ICT) have become drivers of innovative economic development of the leading countries of the world and the EU. Studies of various aspects of the impact of ICT on motivation and academic progress indicate the recognition of ICT as a multi-purpose tool for solving educational problems [1, 2, 3, 4, 5, etc.]. In the field of ICT that we most clearly observe the development of new elements of innovation ecosystems, which are aimed at supporting the interaction of all aspects of innovation processes: government, business, education, science and civil society, including military management. Information and data literacy, Communication and collaboration, Digital content creation, Safety and Problem solving should be areas of high digital competence of officers. The use of information and communication and network

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technologies is a decisive factor in fulfilling conceptual social demands to solve problems: reduced resilience of human ecosystems, extremely high rates of social processes, low probability of predicting natural, social, economic, technical and technological processes and phenomena, lack of available information for decision-making. Digital transformation covers all areas and spheres of human life, because, first of all, it is a social transformation, which has a sign of maximum use of digital technologies such as: Internet of Things, Industry 4.0, artificial intelligence, robotics, big data processing, cloud computing, electronic communications, as well as nano- and biotechnology, genetic engineering, etc. There are significant changes in the system and structure of social relations as a whole in society and in its individual segments. Our research interests focus on the lifelong education of servicemen, or more precisely, the education of officers during advanced training. This thematic direction is an integral formation, which on the one hand is the direction of development of digital humanistic pedagogy in general [1], and on the other – has characteristic properties inherent only in the field of national defense and military management (state policy on professional growth, the concept of training Armed Forces of Ukraine (AFU), development of the security and defense sector of Ukraine [6,7].

It should be noted that the European Commission has been quite active in focusing on digital education. A Digital Education Action Plan (2021–2027) has now been developed to promote a highly efficient digital education ecosystem and enhance digital skills and competences for digital transformation [8]. What and how should change in education systems to meet today's digital challenges? Among the tasks in this document are: updating the European Digital Competence Framework (DigComp 2.0, DigComp 2.1) by including position on artificial intelligence (AI) and data-related skills; development of ethical standards for the use of artificial intelligence and data about students and teachers in the learning process; further development of computing education (including confidentiality, security, information ethics, software engineering, etc.) as a basic digital skill; promoting women's participation in STEM with The European Institute of Innovation and Technology (EIT) and the EUSTEM Coalition.

Under modern conditions, to ensure the competitiveness of Ukraine among the countries of the European Union, it is important to introduce pedagogical technologies that help improve the quality of training in the field of high technology. However, the acquisition of a high level of professionalism in various fields increasingly requires awareness and appropriate practical training of specialists in various fields of knowledge in areas covering STEM education, in particular, engineering, nano- and IR technologies. The introduction of ICT is aimed at improving the quality of military education. Does the training and advanced training of UAF officers fall within the scope of such modern educational trends? In our opinion, definitely so. Therefore, it is important to explore the relevance and necessity of the formation and development of relevant digital competencies of such a target audience, to take into account different competency areas: Information and data literacy, Communication and collaboration, Digital content creation, Safety and Problem solving [9].

2. Related works and recent research

Tibor Navracsics European Commissioner for Education, Culture, Youth and Sport said: "*Knowledge related to science, technology, engineering and maths (STEM) is crucial in responding to the challenges we are facing as a society*" (in office 2014 – 2019). The Strategy for the Development of Innovation until 2030 identifies the following key factors of high priority to STEM during last time: the first is related to overcoming the global economic crisis that has affected each country in recent decades; the second - a significant need for professionals who have comprehensive knowledge and flexible skills that meet the requirements of the XXI century; third – the social demand for STEM literacy, necessary to solve technological and environmental problems of society [10].

The acronym STEM came into general use after a meeting of the interagency meeting on scientific education (2001), held at the US National Science Foundation, chaired by NSF Director Rita Colwell. STEM is used to denote a popular field in education, covers the natural sciences, technology, engineering and mathematics. This direction in education often strengthens the natural science and technological components in educational programs. It should be noted that the emphasis on these two components has recently been criticized by scientists and educators. For example, Lyn D. English [11] after a careful analysis of the materials of the STEM conference (http://stem2014.ubc.ca/presentations/) statistically proved that mathematics and engineering are given much less attention. In our opinion, it is not appropriate to use STEM to refer to only one or two disciplines, this is a disadvantage that does not allow full implementation of integration approaches. It is the inter / multidisciplinary approach that is the basis of STEM. The essence is as follows: on the one hand, students master the basic concepts and use the acquired skills separately for each discipline, but in the learning process they are presented within a certain generalized topic. On the other hand, as a result of the integrated use of combined concepts and skills from several disciplines, students have the opportunity to deepen their understanding of each separately. Last but not least, closely related disciplines are used to solve real problems and implement educational projects and to form a common learning experience.

In [11] the author distinguishes four levels of integration processes: disciplinary, multidisciplinary, interdisciplinary, transdisciplinary. Although, in our opinion, the ideology of STEM corresponds to the latter, that in the author's vision is "… knowledge and skills from two or more disciplines are applied to real-world problems and projects with the aim of shaping the total learning experience."

At present, *the development of STEM-oriented curriculum and projects without focusing on the skills of the twenty-first century, including researches, problem solving, critical thinking, creativity and innovation, is impractical.*

Many foreign scholars, namely M. Harrison [12], Derek Riley, Colleen McCann, Yvonne Woods [13], N. More [14], Elaine J.Hom [15] note that the introduction of STEM education involves interdisciplinary and project-based approaches. The main place in STEM is given to practice, which combines different scientific knowledge into a single whole.

Training through the engineering design process is also being introduced. This is the basis of STEM pedagogy. Students learn in practice, they are encouraged to develop a new understanding, clarifying their ideas [16, 17].

The introduction of STEM-education in educational institutions of various specialties was studied by such domestic scientists as O. Hrybiuk [18], Y. Botuzova [19], L. Gryzun [20], I. Chernetsky [21, 22], N. Polikhun. [21,22], I. Savchenko, V. Sipiy, O. Strizhak [21], N. Morse [23], L. Klimenko [24] and others. Regarding the implementation of STEM at the level of higher education A. Kolomiets and V. Kobisya. Main support of STEM-education implements state policy taking into account the new requirements of the Law of Ukraine on Education on the following: strengthening the development of scientific and technical direction in teaching and methodological activities; creation of scientific and methodical base for increase of creative potential of youth; development of professional competence of teachers, mathematical literacy, competence in natural sciences and technologies, information and digital literacy [25, 26].

The implementation of the ideas of STEM-education in Ukraine involves the implementation of a number of measures to update the material and technical base of educational institutions, research laboratories. Also, STEM-education aims to introduce innovative technologies in higher education in order to improve the training of future professionals by improving curriculum through the digitalization of education, which is a modern stage of its informatization and depends on objective conditions and current trends in the information society, including:

- development of artificial intelligence, machine learning, artificial neural networks;
- ensuring the mobility of information and communication activities of users in the information space, further development of mobile-oriented tools and ICT access to electronic data;
- development of cloud computing and virtualization technology, corporate, public and hybrid ICT infrastructures and introduction of fog computing technology;
- development of new functions of added reality and availability of equipment for virtual reality and devices of mixed reality;
- introduction of chat bots and virtual assistants;
- formation of the Internet of Things (IoT);
- development of robotics, robotic systems, in particular, 3D printers and 3D scanners;
- development of data security and counteraction of cyber criminality) [15, 27].

Current trends in the development of the information society are causing changes in the field of military management. Given the topic of our study, we pay special attention to the following areas:

development of artificial intelligence, machine learning, mobility of information and communication activities of users in the information space, development of mobile tools and ICT access to digital data, accumulation and processing of large amounts of data; formation and use of electronic information databases and systems, ensuring the compatibility of ICT tools and ICT applications, development of data protection systems in information systems and combating cybercrime.

Different teaching methods should be used in the implementation of STEM education, but we agree with the vast majority of researchers that problem-based learning and project-oriented learning methods have a special place because they involve students in actively acquiring special subject knowledge and skills and experience of scientific activity. Such activities should be based on complex real technical problems and accurately worked out tasks.

New professions will appear in the future. It is expected that bio- and nano-technology specialists will be especially in demand, the most popular and promising specialists will be engineers, high-tech professionals, etc. All of them will be related to technologies and high-tech production, which are at the intersection of the natural sciences.

It is important to create a positive motivational guideline for a non-traditional approach in the learning process [28]. At present, STEM education is the basis for training in the field of high technology. Currently, in countries such as Australia, China, Great Britain, Israel, Korea, Singapore, and the United States, government programs in the field of STEM education are being actively implemented, combining a project and interdisciplinary approach. The most actively promoted STEM approach in education of the United States of America, the list of these specialties is very large - more than four hundred. For example, the number of STEM majors at Oregon State University is 169.

STEM specialties include the most complex areas that are currently in high demand in the United States. STEM specialists are in demand in various fields: computer programming, information technology, bioengineering, biomedicine, electromechanics, molecular biology, pharmacology and toxicology, psychology, social anthropology, etc. Among the most in demand today are: information security analysts, cartographers who use digital geographic information systems, and architects with skills of digital design, 3D modeling. Such specialists with a high and expert level of digital competencies [9], which allows to effectively analyze and interpret data for practical purposes, in demand in the military field.

In our opinion, these specialties require a high and expert level of digital competencies [5], which will effectively analyze and interpret data for practical purposes.

In the field of military management, the officer is expected to be aware of readiness, competence in implementing innovative ideas, making effective management decisions, productive actions in situations with a high percentage of uncertainty, and therefore must have some technical experience, knowledge and skills in information technology and software, be able to use digital tools for planning and analytics. Knowledge of digital means of communication, web applications, understanding of design principles, development of analytical abilities, development of abilities to non-standard thinking are actual for officers. It is known that every project is driven by a certain framework. The risk of losing control over project management is critical. To plan and conduct project activities, we offer to use specialized programs and platforms: Asana, Todoist, Slack, Trello, Planner, GanttProject, which we consider as modern effective digital tools. Mastering them during advanced training is necessary for officers-future project managers and participants in project activities. The list contains both relatively simple programs and programs that can be used to professionally create Gantt charts for complex tasks and to analyze performance. The convenience of these programs is that all information is stored in cloud storage, which is widely available. Consequently, the relevance of the development of digital competence of officers of the Armed Forces of Ukraine in the system of advanced training is growing.

Ukraine is a party that has ratified a number of documents through the instruments of the Council of Europe and the EU in the field of education and has adopted at the legislative level provisions for the harmonization of Ukrainian standards and mechanisms of harmonization processes in digital transformation. It is also planned to restructure the military education system in accordance with NATO standards. This should improve the quality of education and promote the interoperability of the Ukrainian Army with NATO forces.

This article is the result of analytical study of modern educational, industrial and technological trends, scientific publications and documents, regulations in the area of military management and analysis of own experience in researching the most relevant areas and fields of formation and development of digital competence of UAF officers.

3. Results and Discussion

Digitalization as a modern stage of informatization of society is manifested in the saturated physical world with electronic and digital devices, means of activity in various fields and systems (networks) for communication, actually creates cyberspace and puts forward new requirements for training officers in the armed forces of developed countries.

Nowadays, the military profession requires a much larger range of competencies than 20-30 years ago. Informatization of society, education, economy and industry makes new demands on the training of officers of the armed forces of developed countries. Formation of readiness for the application of STEM-technologies in the professional activity of an officer is a little-studied problem by domestic scientists. The readiness of officers of the Armed Forces of Ukraine (AFU) to use STEM-technologies in professional activities is a set of tools, methods and processes built on the integration of science, technology, engineering and mathematics, as well as logical thinking, leadership, cooperation and research, which provides effective professional activity [29]. The readiness of an officer can be characterized as the ability to interact and interact between all parts of the control system, operation and combat use of weapons and military equipment. and reading sign systems. Readiness is the basis for the formation of competencies of military specialists of the Armed Forces of Ukraine, provided by the professional standard. The competence of a military command officer is seen as the ability to solve complex problems and practical problems in the field of military sciences, in the management of military units of the armed forces and other military formations and law enforcement agencies in everyday activities and during joint tasks in group operations. troops (forces) and while working as part of interspecific bodies of military management using the theory and methods of military science, which involves research and / or innovation and is characterized by uncertainty of conditions and requirements. ICTs have the potential to provide military management specialists not only with tools for planning and organizing work, but also to provide an opportunity to conduct research on various processes and evaluate the results achieved. From the officer of military management, the state requires the ability to think abstractly, plan and manage time, developed the ability to analyze and synthesize, to make independent informed decisions [28]. These requirements, in our opinion, correlate with the descriptors of competencies information and data literacy, problem solving, as defined by the DigComp 2.1.

We studied the requirements for the military in other countries. For example, the United States Department of Defense believes that military personnel play an important role in improving the well-being and prosperity of the entire state. In order to achieve the outlined tasks, the concept of STEM education is being actively implemented in postgraduate training of military specialists in order for the US Army to remain a leader in the fields of science and technology. STEM education is of key importance during advanced training. It is worth noting that in the US Armed Forces, professional development is seen as one of the defining conditions for the realization of their personal, military, professional and professional prospects for career advancement. Today, the United States has created and operates a modern system that is organically integrated into the system of phased training of military specialists, consistent with their career advancement, allows them to improve their professional and professional levels throughout the service. Its operation is coordinated by the Office of the Assistant Secretary of Defense for Personnel through the US Armed Forces Command, which generally ensures its successful operation.

In view of the above, following the basic provisions of STEM education will increase the motivation of officers to develop their professional competence, career growth, and as a consequence - to increase the level of defense capabilities of the state as a whole.

Actualization of the need for application of STEM-technologies in professional activities by AFU officers provides purposeful modeling and development of situations in which it is necessary to acquire new knowledge, develop skills, solve professionally important tasks that will require them to show professionally significant and personal qualities, including high and expert level of digital competencies.

Project activities, as we have already mentioned, have great potential for the implementation of STEM-education tasks. Acquisition of digital competencies in the use of ICT, development of creative thinking, willingness to interact productively and work responsibly in a team are no exception. All of the above creates extremely favorable conditions for the development of the competence of officers of the military administration of the Armed Forces. Implementation of STEM-education in the system of advanced training of military management officers can provide: increase the interest of servicemen in engineering, motivate them to master modern technical developments, participate in the development of technological solutions. In our opinion, this can be facilitated by the creation of an appropriate digital training and methodological resource for the coordination and development of STEM, the development of officers' own STEM projects during training and advanced training. The introduction of advanced pedagogical technologies, including the project-based learning , naturally increases the level of motivation and cognitive interest.

We share the opinion of researchers who consider the degree of motivation to be one of the criteria for the effectiveness of vocational education. Motivation characterizes the orientation of the individual [30].

Various aspects of the formation of sustainable motivation of servicemen are revealed in the works [31; 32; 33].

Contrary to the exceptional potential of the STEM phenomenon for the formation and development of professional competencies of military management specialists, our analysis of scientific sources revealed a lack of work on the introduction of STEM technologies in the training of military officers of the Armed Forces of Ukraine. At present, this indicates that military education does not fully take into account current social trends.

We also studied the specifics of the professional activities of military officers in planning and resource management in the field of defense, project management in the field of informatization and project management in the Armed Forces of Ukraine, as well as in the organization of intelligence activities. These categories of servicemen must possess and be able to apply the basic provisions of the concept of IT project management. In particular, to know the procedure for formulating the purpose of the IT project, determining the timing of its implementation, effective methods of launching, planning, implementation, control and closure of IT projects.

In March-April 2021, at The National Defence University of Ukraine named after Ivan Cherniakhovskyi, we conducted a survey of advanced training students to address the following tasks: to investigate the attitudes and needs of military officers to train and improve their professional level; identify needs to improve the professional level of military officers in the use of digital teaching aids and ICT, identify current issues. The answers to the questionnaire will help to provide more accurate recommendations to stakeholders on the use of digital tools for professional activities; improved the organization and content of advanced training courses; to choose for studying and improvement of skills of listeners those means and methods which will help them to carry out official duties effectively; determine the need of students for additional knowledge and skills in the field of digital technologies.

The survey was anonymous, conducted online using Google Forms, covered 116 respondents, the vast majority (percentage) aged 40 to 45 years. Among them are 99 men and 17 women.

We found that in terms of basic education, the majority of respondents have a technical education of 39% and a general military education of 27%. Figure 1.

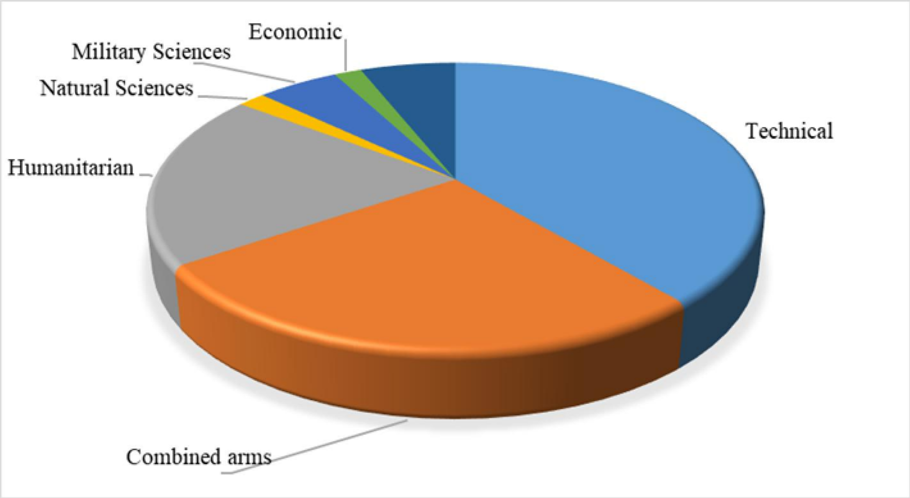

Figure 1. Basic education of students of advanced training courses

This makes it possible to use STEM approaches during training. The fact that 62% of respondents pursue their educational goal to maintain / improve their skills, and 36% - before appointment to a higher position, Figure 2 suggests that the content of training should be directly related to the development of leadership and management competencies inherent in managers level of military management. Capable of solving complex tasks and problems involving research and / or innovation and characterized by uncertainty of conditions and requirements in the field of management of military units, planning and conducting operations of interspecific groups of troops by military authorities, as well as maximum implementation of operational (combat) capabilities of groups of troops (forces). Students are required to think critically, explore complex processes and phenomena, prepare and present the results of individual and collective work. Therefore, each officer must have certain competencies and have the necessary case of theoretical knowledge, skills and abilities, with which he can effectively and safely use modern digital technologies in work and in the learning process every day. Therefore, the relevance of the use of ICT tools for the development of digital competence in the areas of Information and data literacy, Safety and Problem solving - is extremely high.

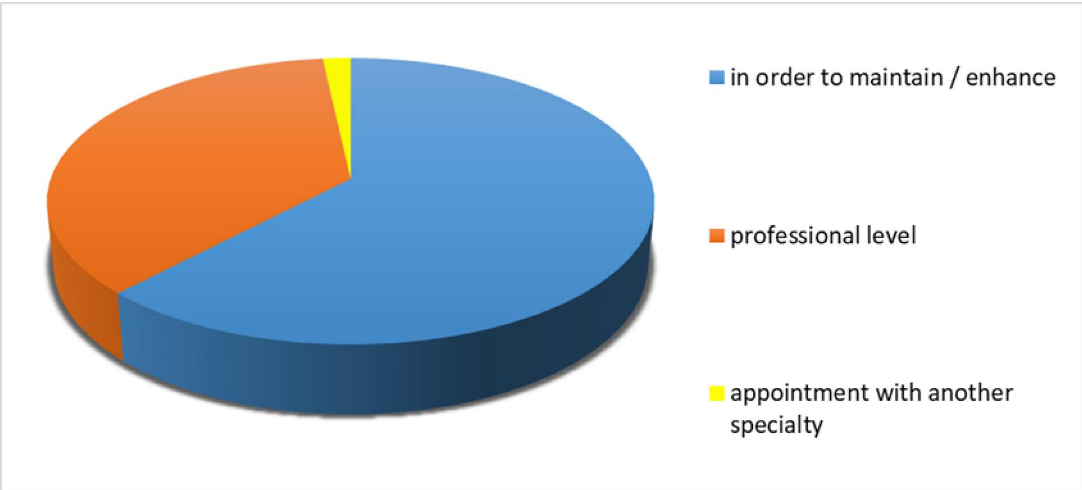

Figure 2. The purpose of realization of educational interests of participants of advanced training courses

77% of respondents said that the use of tools to search, process and analyze information from various sources will contribute to their effectiveness in the performance of official duties. 57% of respondents preferred tools for compiling official documents and analytical reports Figure 3.

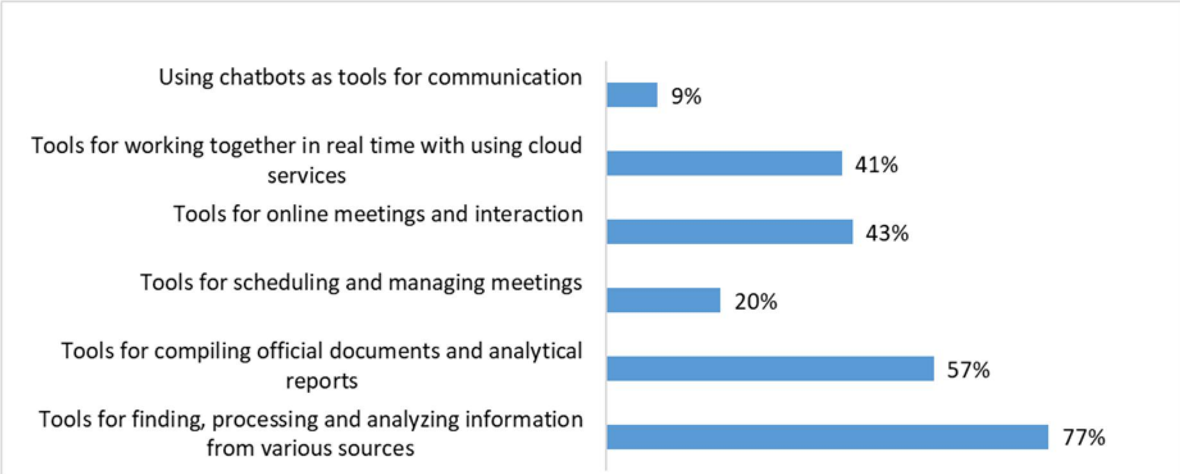

Figure 3. Current needs of participants in digital tools

The information in Table 1 clearly illustrates the need of officers for the formation and development of digital competencies in various areas: Information and data literacy, Communication and collaboration, Digital content creation, Safety and Problem solving.

Table 1
Current needs of participants in digital tools

Which digital tools do you think will help you be more effective in performance of official duties?	%
Tools for finding, processing and analyzing information from various sources	77
Tools for compiling official documents and analytical reports	57
Tools for scheduling and managing meetings	20
Tools for online meetings and interaction	43
Tools for working together in real time with using cloud services	41
Using chatbots as tools for communication	9

The results of the survey showed that 48% lacked skills in working with services to create infographics, 36% said they would like to have security and privacy settings, 31% preferred planning services, and 48% expressed a desire to have chat skills bots Figure 4. The results show that officers are interested in developing digital competencies in well-defined areas.

Respondents' answers to questions about ways to gain new knowledge in the field of digital technologies determined the advantage of training in advanced training courses.

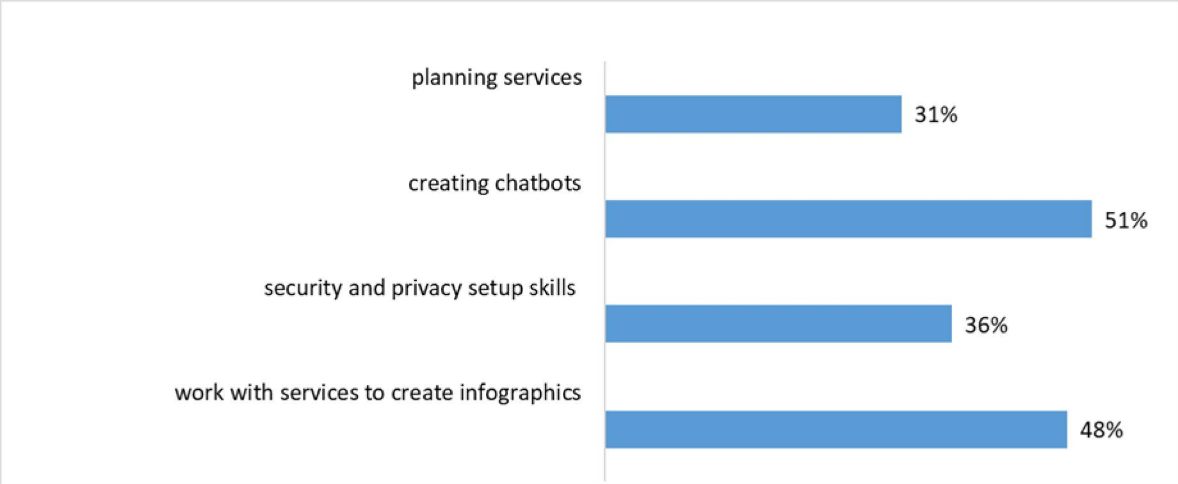

Figure 4. The need for digital skills of students of advanced training courses

For us, the result of a relatively large proportion of respondents who feel the need to have the skills to create such a software product as a chat bot was unexpected. However, to create such digital content you need to have certain programming skills. And for this - to increase competence in the relevant field.

During the study we also found out which digital tools respondents use in the line of duty, how much time they spend working with computers without the Internet, and how much time they spend with free access to the Internet.

The results of our study indicate that modern officers are aware of the need for continuous development of digital competencies, which is an important component of the professional competence of a modern military management specialist. Digital competence implies knowledge, skills and conscious willingness to use digital technologies for the effective organization of official activities, to critically evaluate information resources and apply technological innovations.

In the world, digital competence is recognized as one of the key competencies for a full life and activity of citizens. Digital competence is key in the context of the fourth industrial revolution. The creation of digital content (including programming), security (including the protection of personal data in the digital environment and cybersecurity), as well as the ability to solve professional problems and learn throughout life using ICT - all this was a well-known need for military officers. The results of our study fully confirm the exceptional need for the development of digital competence in officers of the Armed Forces of Ukraine, as they believe that possession of digital tools at a high level is a guarantee of professional and personal development. The internal motivation of the respondents, which is aimed at increasing professional competence, is revealed.

As military management officers consider the most effective forms of professional development to be training in higher military education institutions, we consider it necessary to modernize the training system in accordance with NATO standard Bi-SCD 075-007 "Education and Training", which, on the one hand, improve the quality of education, on the other hand, promote the interoperability of our forces with NATO forces. Since 2012, the Armed Forces of Ukraine have been participants in the Defense Education Enhancement Program (DEEP). This is a program to improve military education. The program brings together experts from NATO's educational and research institutions, such as the J. Marshall Center for European Security Studies, the NATO Defense College, the NATO School in Oberammergau and others.

4. Conclusions and prospects for further research

The National Economic Strategy of Ukraine for the period up to 2030 identifies European and Euro-Atlantic integration, as well as the development of the digital economy as one of the drivers of Ukraine's economic growth. It is generally recognized that underdeveloped digital skills in citizens hinder the full transition to the digital economy. The overall assessment of digital literacy of citizens in Ukraine shows that 53 percent of citizens are below the "basic level" [34]. A major barrier to achieving national strategic goals is poor coordination between the IT sector and the education sector; lack of specialists in such promising areas as Big data, IoT, artificial intelligence; lack of quality educational STEM-programs [35].

Improving the level of professional and specialized digital skills of citizens in various fields of activity is an unconditional priority of the digital economy and a reliable way to achieve its strategic goals. The Concept of Development of Digital Competences approved by the Cabinet of Ministers of Ukraine in March 2021 [2] establishes the conceptual foundations of state policy in the field of development of digital competencies of citizens, which will ensure the development of all spheres of public life in accordance with modern requirements.

It follows that during retraining and advanced training, military management officers should be able to increase the level of their competence comprehensively: researches, application of ICT, management technologies, project organization and implementation, and so on. Training should be properly equipped with modern hardware and software. In our opinion, the use of STEM-technologies will allow to take a comprehensive approach to solving the problem of developing the competence of officers of the military command of the Armed Forces.

In our opinion, the US experience in actively implementing the concept of STEM education in postgraduate training of military specialists in order to create favorable conditions for the realization of their personal, military, professional and professional prospects, as well as achievement by the armed forces of the position of a leader in the field of science and technology.

The implementation of STEM education in the system of advanced training of military officers can provide: increase the interest of servicemen in engineering, motivate them to master modern technical developments, participate in the development of technological solutions to solve professional problems. This, in our opinion, can be facilitated by the creation of an appropriate digital training resource for officers to develop their own STEM projects during their study and advanced training.

The analysis of scientific sources revealed the lack of work on the introduction of STEM-technologies in the process of professional training of military officers in Ukraine. At present, this indicates that military education does not fully take into account current social trends.

The training of highly qualified officers of the military administration of the Armed Forces in modern military education has its own specifics, as these specialists must be competent in specific issues of military management, have highly organized thinking skills and be able to effectively perform tasks. We propose to apply an interdisciplinary approach to the training of officers, which is implemented in STEM-education, combining such components as robotics, IT and programming. The application of such an approach, in our opinion, will have positive consequences: improving the quality of students' understanding of disciplines related to the field of science, technology, engineering and mathematics; increasing the level of their digital competence, strengthening the research and scientific and technological potential of students, developing skills of critical, innovative and creative thinking, the ability to solve problems.

During the study of the specifics of the professional activities of military management officers identified the needs of this category of servicemen in the knowledge of IT project management. The results of the survey, analysis of current research on the issue allow us to conclude that there is a need for the formation and development of digital competencies of military officers, taking into account different areas: information and data literacy, communication and collaboration, digital content creation, safety and problem solving. The use of STEM technologies in the practical training of military officers will contribute to their personal and professional development and career growth. In our opinion, the professional development of officers of the Armed Forces should be carried out in the following areas: artificial intelligence; machine learning; ensuring the mobility of information and communication activities of users in the information space; formation of skills of using mobile and cloud-oriented means of access to information, digital tools for planning and organizing project work, data processing and performance evaluation; formation and use of electronic information databases and systems; data protection in information systems and combating cybercrime.

We see prospects for further research in the development and implementation of methods for the formation of digital competence of military officers, to ensure their continuous professional development. Also, in clarifying the conditions for the introduction of educational robotics in higher military education.

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Formation and Self-Development of the Students' Digital Competencies Within the Lifelong Learning System

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Abstract

The impetuous development of digital technologies is changing the requirements for specialists. In the modern world, a competitive analyst working in the field of economics must have not only professional competence, but also digital competence, which includes not only digital skills, but also a set of knowledge and views on the nature and role of information technologies and opportunities, as well as relevant legal and ethical principles.

The article deals with the analyzes of the modern theoretical foundations and approaches to the development of digital literacy within the lifelong learning processes: namely, one of the tools for determining the level of formation of digital competence using Tsifrogram test (which is based on the conceptual model of digital competence of citizens DigComp - The Digital Competence Framework for Citizens) is described and analyzed in detail.

The research was carried out in line with the competence-based, personality-activity and communicative approaches. The training program for economic analysts used active and interactive teaching methods and practices.

The results of the level of digital competence formation among students of economic specialties of the university are presented. The main recommendations for increasing the level of the students' digital competence are analyzed, identified, and highlighted. In the future, it is planned to develop a roadmap for increasing the level of students' digital competence during their studies at the university.

Keywords

Digital competence, DigComp, constituents of digital competence, self-diagnosis test, digital profile results

1. Introduction

The rapid pace of development of information technologies, the emergence of new devices, the growth in the number of Internet users are markers of the modern information society. Scientists [1] note that the key technologies that will influence the development of society are: robotics, artificial intelligence, the Internet of Things, cloud computing, Big data, 3D printing, digital payment systems, interoperable technological systems and platforms.

The European Commission has for several years expressed concern about the slow adoption of digitalization processes in education and training. In order to study the state of the current level of implementation of e-learning in educational institutions of the EU, the European Commission conducted a survey of citizens' opinions and published it in the framework of the Eurobarometer [2].

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In recent decades, a unique situation of dialectical contradiction unfolds: a generation is growing that from an early age knows how to handle various gadgets, and this generation is taught by those who grew up in the system of classical education without constant access to the Internet and without social networks. The Eurobarometer data confirms these provisions: only 20-25% of students in European universities are studied by teachers who are confident users of new technological advances, 43% of Europeans do not have basic digital skills, and 71 million students in European countries lack skills for a digital society. Considering the need to take decisive action in the field of education, the European Commission adopted the main provisions of the Digital Education Action Plan in 2021-2027 years. [3].

Now in Ukraine, a large number of teachers are motivated to use digital technologies in the teaching process, however, more resources are needed to support the development of sound digital practices, since it is obvious that the digital environment and infrastructure of domestic higher education institutions require investment.

The EU wishes to raise awareness of the European lifelong learning space through Internet platforms (e-learning) to support the modernization of education and training systems.

The Council of the European Union adopted on 22 May 2018 a revised recommendation on core competencies for lifelong learning [4], which emphasizes the need to support the development of core competencies, with a particular focus on improving the achievement of basic digital skills and participation in society in a lifelong perspective, increasing and improving the level of digital competencies at all stages of education and training for all segments of the population.

The education system is forced to constantly improve, since the prospects for the functioning of the state depend on how the level of education develops.

The modern space of higher education in Ukraine sets a new educational paradigm focused on students and lifelong learning. This includes changes in professional competence since the training must be adapted to the requirements of the new context.

The Concept for the Development of the Digital Economy and Society of Ukraine for 2018-2020 [5] defines the creation and implementation of the national training program for general and professional digital competencies and knowledge as one of the priority tasks on the way to the accelerated development of the digital economy.

The Concept for the Development of Digital Competences [6] also notes the need to improve the quality of training of workers to create the possibility of modernizing the country's economy in accordance with modern requirements.

2. Research methodology

Today, the pace of computerization is well ahead of the skills of the vast majority of users.

According to the results of the first all-Ukrainian study of digital literacy of Ukrainians (December 2019), 53% of the population of Ukraine is below the "basic level" mark. At the same time, 37.9% of Ukrainians aged 18-70 have digital skills at a level below the basic level, and 15.1% do not have them at all. However, only 47% of Ukrainians aged 18-70 (mostly young people) believe that digital skills training is relevant for them [7].

Interpretations of the essence of the concepts of "digital literacy", "digital competence", "digital culture", "digital technologies", the definition of their structure and features are considered in many works of foreign and domestic scientists, in particular J. Stommel [8], C. Scott [9], S. Carretero, R. Vuorikari , Y. Punie, [10], L. Havrilova, Y. Topolnik [11], V. Bykov, O. Spirin, O. Pinchuk [12] and others.

Currently, the concept of "digital literacy" as a person's ability to navigate the digital environment is widely used by the international educational communities. Digital competence is seen as the conscious, confident, responsible, and critical use of Information Society Technology (IST) for work, social activities, free time, and communication [13].

Digital competencies include information literacy, communication and collaboration, digital content creation (including programming), and security (including digital well-being and cybersecurity competencies). According to Henseruk [14], digital technologies actively influence the learning process, since they change the scheme of knowledge transfer and teaching methods; their application in the educational process stimulates interest in learning, contributes to the formation of logical and creative thinking, which mainly leads to the formation of the information culture among the students.

The purpose of the article is to research the competencies determined by educational and professional programs and the levels of formation of digital competencies of students of the "bachelor" educational level (future specialists in economics of an analytical profile).

Research methods: analysis (dividing the general concept of "digital competence" into its constituent elements), synthesis (combining the separated and explored parts), induction (generalized consideration of digital technologies and digital competencies), deduction (transition from the general perception of digital technologies and digital competencies to the determination of properties and characteristics of individual competencies and skills), abstraction (determination of the features inherent in digital competencies), and concretization (study of the features of individual digital competencies).

The main objectives of the study are: first, to clarify the concepts of information literacy and digital literacy; secondly, in defining the components of digital literacy; thirdly, in identifying the educational opportunities of the university in creating a digital environment that contributes to the development of digital literacy of students within the framework of special disciplines for future specialists-economists of an analytical profile.

3. Results and discussion

Digital literacy is a broad and holistic concept that encompasses much more than the functional digital skills that students must use in a digital society. Despite the fact that many students are well-versed in the use of modern digital technologies, they often do not have all the necessary digital competencies to successfully study in a higher education institution.

University studies should develop digital literacy skills both over time and in aspects related to professional development and gaining professional experience.

In order to train the qualified specialists-analysts of economic profile, one of the competencies that must be formed is precisely “digital competence”.

The analyst must have key skills, namely industry knowledge (specifics of the industry, business processes, standards, and trends), effective communication with customers (methods of structured problem solving and facilitation, brainstorming for generating ideas with their subsequent visualization, as well as experiments and research), work with processes and data (strategic analysis, business process management and optimization, data modeling), learning skills, and writing business cases.

To clarify the place and role of digital competence in the general structure of professional competence of future specialists in economic specialties, an analysis of educational and professional programs (EPP) was carried out and the mapping of digital competencies in the content of professional training of students of specialties 051 "Economics" and 075 "Marketing", which are implemented in Taras Shevchenko National University of Kyiv, was conducted [15-18].

As a result, the general and special competencies listed in the EPP were identified, which can be classified as digital, i.e., please, check

Table 1.

A quantitative and qualitative analysis of the identified competencies made it possible to determine the following: in these educational and professional programs and at different levels of training, there is a slight difference in the content and number of competencies that can be classified as digital.

The authors consider that there is some contradiction between the real requirements of society and the labor market for the content and quantity of digital competencies and the normative requirements for the content of professional training of future analytic economists.

To solve the above problem of the formation of digital literacy, taking into account the peculiarities of thinking of modern students, there are two approaches. The first is to conduct additional courses aimed at building digital competencies. The second approach involves the parallel development of digital skills and competencies during hands-on training. Since digital skills are integrated in the educational process with professional knowledge, it is likely that the student will use them in their professional activities. Despite the fact that there is no generally accepted didactic theory of digital literacy, many disciplines from the EPP at Taras Shevchenko National University of Kyiv have the potential to solve this problem.

Table 1
Digital competencies in educational and professional programs of the economic profile at Taras Shevchenko National University of Kyiv

Specialty, EPP	The first (bachelor's) level of higher education			The second (master's) level of higher education		
	General competencies	Special (professional) competencies	Program learning outcomes	General competencies	Special (professional) competencies	Program learning outcomes
051 Economics, "Economic Analytics and Statistics"	GC5. Skills in the use of information and communication technologies. GC6. Ability to search, process and analyze information from various sources.	PC7. Ability to use computer data processing technologies to solve economic problems, analyze information and prepare analytical reports	PLO20. To use the information and communication technologies to solve socio-economic problems, prepare and submit analytical reports. PLO23. To demonstrate flexibility and adaptability in new situations, in working with new objects, and in uncertain conditions.	-	PC4. Ability to use modern information technologies, methods, and techniques of research of economic and social processes, adequate to the established needs of research.	PLO10. To apply modern information technologies and specialized software in socio-economic research and in the management of socio-economic systems.
075 Marketing, “Marketing”	GC9. Skills in the use of information and communication technologies.	SC10. Ability to use marketing information systems in marketing decisions and develop recommendations to improve their effectiveness	PLO7. To use the digital information and communication technologies, as well as software products necessary for the proper conduct of marketing activities and practical application of marketing tools	GC6. Ability to search, process and analyze information from various sources.	-	PLO15. To collect the necessary data from various sources, processes and analyze their effectiveness using modern methods and specialized software

Currently, the educational process is being provided with modular courses aimed at developing digital literacy; building an educational process based on blended learning technology; the use of active, interactive, problem-based teaching methods taking into account the individual characteristics of the modern generation of students. It carried out a constant update of the content of regulations that dictate the requirements for the training of specialists and focus on improving the education system, aimed at training personnel with the competencies of the digital economy at the average world level.

In the training of future specialists in economics at Taras Shevchenko National University of Kyiv, a special place is occupied by innovative didactic teaching aids based on the use of digital technologies covering a wide range of educational software. Among such software, one should highlight electronic training courses, software tools, electronic educational and methodological complexes, network programs, and control and diagnostic systems. Most of the tasks using digital technologies that students perform are creative. They stimulate motivation, activate the cognitive activity of students, contribute to the effective development of skills in working with electronic documents and cloud services, the ability to analyze, draw generalizations and conclusions, as well as obtain practical results of the work performed.

It should be noted that digital literacy is of particular importance in the process of training specialists. Students use the full range of Internet resources to prepare for practical, laboratory, seminars, colloquia, project tasks, and the like. The quality of his work and the assessment of progress depends on how a student is able to work with information.

To determine the level of formation of digital competence of future analytic economists, the classification developed in 2017 by the European Joint Research Center is used, which includes a number of levels of proficiency and examples of knowledge, skills, and abilities in each of the areas of competence (DigComp 2.1 The Digital Competence Framework for Citizens 2017) [19].

The digital literacy of higher education applicants within the European approach includes the personal, technical, and intellectual (digital) skills that are necessary to live in a digital world (see Fig. 1).

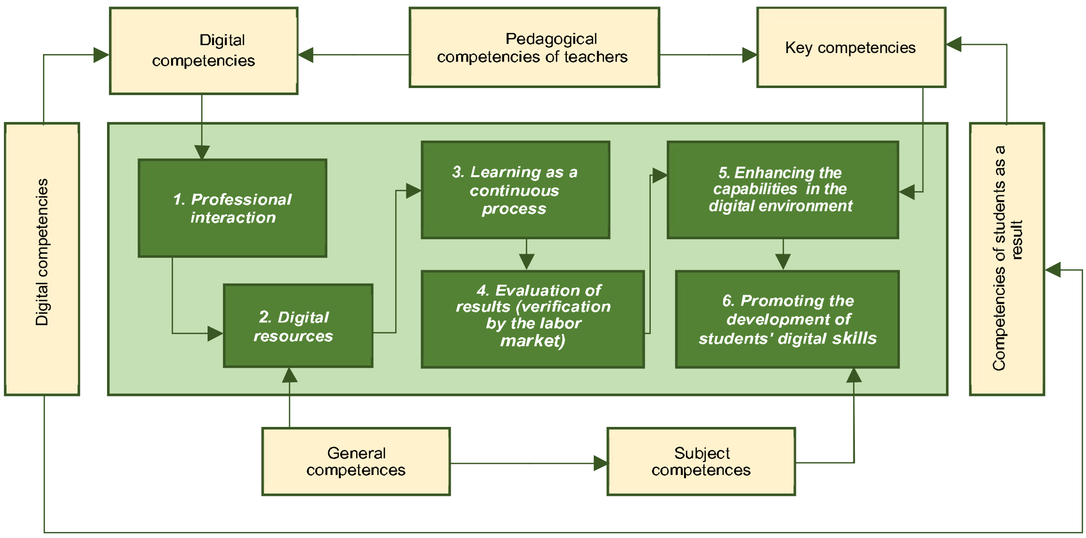

Figure 1: Plan-diagram of a model of digital competencies in education in the interpretation of the European Union "DigComp 2.1: The Digital Competence Framework for Citizens with eight proficiency levels and examples of use", 2017 [20]

Of particular importance in the above model is the central block, which can be characterized as the integration of resources, platforms, and results. The outer contour is a new format of requirements for the quality of teaching and characteristics of competencies, as fundamentally new in relation to traditional models and technologies of teaching.

In the process of research to identify the level of formation of digital competence, the authors used the national test for digital literacy (project Tsifrogram implemented by the Ministry of Digital

Transformation of Ukraine together with USAID and the Eastern Europe Foundation on the online platform "Action. Digital Education" [21]), which determines the main components of digital competence in terms of knowledge, skills and abilities required in a digital society. After filling it out and calculating the number of points, the respondents receive an assessment of their level of digital competence formation.

The Ministry of Digital Transformation of Ukraine in 2021 proposed the project Digital Competence Framework for Citizens of Ukraine (DigComp UA for Citizens). The "DigComp UA for Citizens" is based on the conceptual reference model DigComp 2.0 and the updated European framework DigComp 2.1, which are adapted to the national, cultural, educational, and economic features of Ukraine.

The results of testing the level of formation of digital competence of applicants for higher education can be assessed by the areas of the components given in Table 2. Each of these areas of knowledge covers 5 competences. The Tsifrogram offers testing participants to answer 90 questions.

Table 2
Features of digital competence assessment using the adapted model DigComp UA for Citizens and Tsifrogram

Adapted model DigComp UA for Citizens		Competencies and descriptors of Tsifrogram national test		
Competence areas (CA)	Competences (C)	Competence areas (CA)	Competences' names	Evaluation points
CA0. Basic digital skills	C0.1 Use of digital devices; C0.2 Using basic digital device software.	Basics of computer literacy	1) Use of computer and mobile devices; 2) Use of basic software; 3) Use of applications and application software; 4) Use of the Internet and online applications; 5) Digital identity management	0-15
CA1. Information and data literacy	C1.1 Viewing, searching, and filtering data, information and digital content; C1.2 Evaluation and interpretation of data, information and digital content; C1.3 Management of data, information and digital content; C1.4 Meeting own needs with the help of digital technologies	Information and data literacy	1) Viewing, searching, and filtering data, information and digital content; 2) Critical assessment and interpretation of data, information and digital content, verification of the reliability of sources and information; 3) Management of data, information and digital content; 4) Implementation of your own requests and needs using digital technologies; 5) Self-realization and personal development in a digital society	0-15
CA2. Communication and collaboration	C2.1 Digital engagement; C2.2 Digital exchange; C2.3 Realization of civic position using	3.Communication and collaboration in the digital society	1) Digital engagement; 2) Dissemination and exchange of data using digital technologies; 3) Collaboration using digital technologies;	0-15

	digital technologies; C2.4 Digital collaboration; C2.5 Netiquette; C2.6 Digital Identity Management		4) Implementation of civic position using digital technologies, digital citizenship. Use of E-services, E-signature; 5) Responsibility. Legal and ethical standards. Netiquette.	
CA3. Digital content creation	C3.1 Development of digital content; C3.2 Integration and processing of digital content; C3.3 Copyright and licenses; C3.4 Programming	4. Digital content creation	1) Development of digital content; 2) Editing and integration of digital content; 3) Copyright and licenses; 4) Primary programming skills; 5) Creative use of digital technologies	0-21
CA4. Safety	C4.1 Device protection; C4.2 Protection of personal data and privacy; C4.3 Protection of health and well-being; C4.4 Protection of consumer's personal rights against fraud and abuse; C4.5 Environmental protection	5. Safety in the digital environment	1) Device protection and secure Internet connection; 2) Protection of personal data and privacy. Internet security; 3) Protection of consumer's personal rights against fraud and abuse; 4) Protection of health and well-being; 5) Environmental protection	0-24
CA5. Problem solving and further training	C5.1 Solving technical problems; C5.2 Identification of needs and technological response measures; C5.3 Creative use of digital technologies; C5.4 Identifying gaps in digital competence	6. Problem solving in the digital environment and lifelong learning	1) Solving technical problems; 2) Identification of needs and their technological solution; 3) Self-assessment of the level of own digital competence. Identification and elimination of gaps; 4) Solving life problems with the help of digital technologies; 5) Lifelong learning. Professional self-development in the digital environment	0-21
Total (maximum score)				111

When assessing the formation of digital competencies, there are three levels of mastery: high - characterized by the ability to use digital and information and communication technologies in full (including creating a digital product); medium - can be described as knowledge of the availability of all digital competencies, but only partial application; basic - differs in the presence of knowledge about digital components, but is characterized by the inability to correlate the components of knowledge with professional tasks.

In the 2020/2021 academic year, 91 applicants for the first level of higher education in Economics and Marketing specialties took the National Digital Literacy Test; of these, 7.7% passed Tsifrogram test at the B1 level, and 90.1% - at the B2 level, 2.2% - at the C1 level (see Fig. 2). Analyzing the results obtained, one can conclude that digital competencies are developed at the average level for most students.

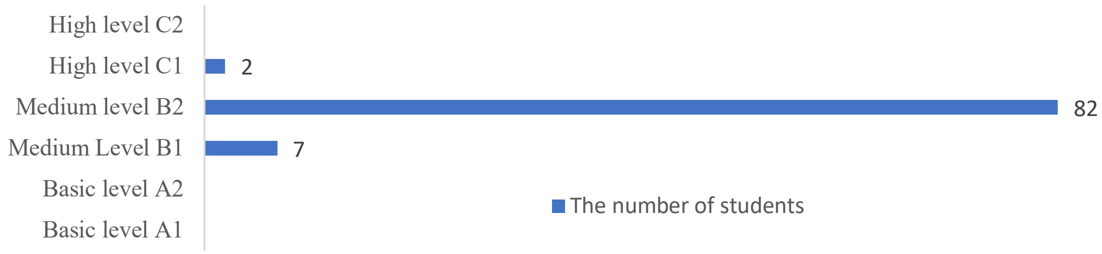

Figure 2: Level of digital competence of students of the analytical profile of economic specialties at Taras Shevchenko National University of Kyiv in 2020/2021 academic year

The level of knowledge and skills of students in the field of digital competence turned out to be different, depending on the level of their self-development, self-motivation, and other factors. Using the Internet for communication, searching, downloading and creating content, solving technical problems, shopping and payments are the different possibilities and, accordingly, different resources are needed to implement them. Both the average level in digital development and the high one can be both general (in many areas of activity) and partial (in certain areas). Therefore, when researching digital competence, it is important to study its components and cells in which each of the components can receive specific development and implementation.

The detailed analysis of the questionnaire shows that the development of digital competence components is not equally developed among students (see Fig. 3). Components such as fundamentals of computer literacy, information literacy, data skills and communication and interaction in a digital society are best developed.

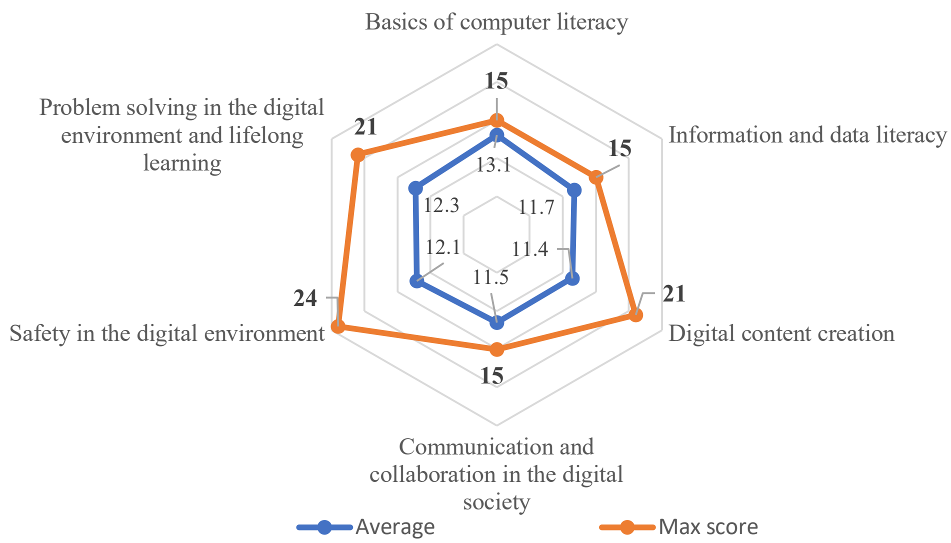

Figure 3: Distribution of the scores received by the students of the analytical profile of economic specialties at Taras Shevchenko National University of Kyiv in the 2020/2021 academic year by components.

Students of the analytical profile of economic specialties showed the highest results in the “basics of computer literacy” competency (in particular, use of basic software, applications, and applied software): 89% of students received a high level of knowledge C1 and C2 (see Fig. 4). This means that they actively respond to the emergence of new types of computer and mobile devices, can use (including installing, updating and configuring the system software) the main common computers and mobile devices of medium complexity, easily master new applications and new application software, independently install, configure and use the software, create online services of medium complexity, learn the basics of web design, and know different ways to protect their reputation on the Internet.

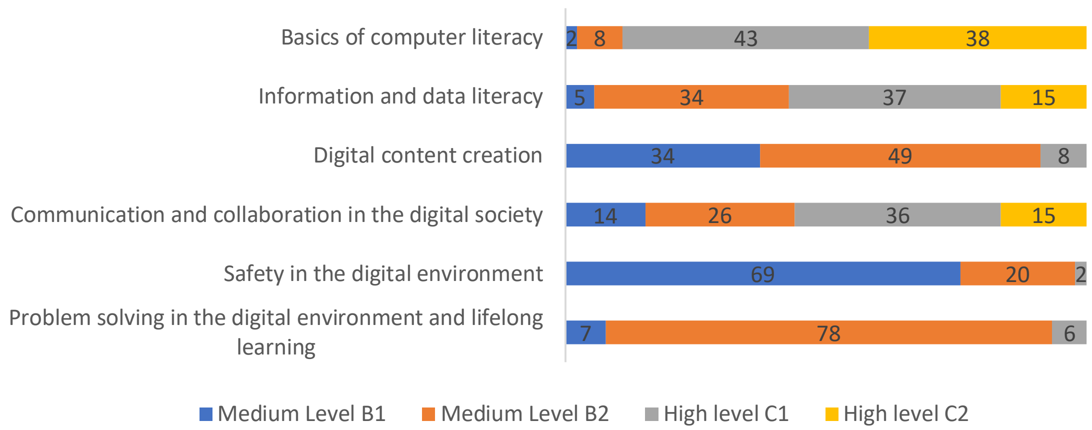

Figure 4: Distribution of the scores received by the students of the analytical profile of economic specialties at Taras Shevchenko National University of Kyiv in the 2020/2021 academic year by competency levels.

Good results were obtained by students in the “information and data literacy” and “communication and collaboration in the digital society “competencies: respectively 57% and 56% of students received a high level of knowledge C1 and C2.

Lower knowledge was found by students in the “safety in the digital environment” competence (in particular, on the Protection of consumer's personal rights against fraud and abuse and device protection and secure Internet connection): 76% of students received an average level of B1, and only 2 students out of 91 high level of C1.

Owing to Tsifrogram National Digital Literacy Test, the bachelors of analytical profile of economic specialties received recommendations to improve the level of digital competence in these areas, which will allow in the future to acquire the necessary knowledge, improve their skills and be successful professionals in modern society. In the future, it is planned to develop a model of digital competence formation for the training of competitive analytical specialists with a high level of digital competence.

4. Conclusions

Based on the results of the research, it can be concluded that the digital competence is an important component of the professional competence of future specialists-economists of analytical profile. This competence combines knowledge and skills to use the digital technologies when working with modern business processes, their optimization, and data modeling.

Despite the large number of studies devoted to the concept of digital competence, the issue of its interpretation (namely, for future specialists-economists of analytical profile), definition of the structure and content requires further research.

The authors consider it extremely important to further research the approaches to creating a digital model of competencies, determining the conditions for its formation and prospects for the implementation of the developed model to ensure the lifelong development of the specialists-economists of analytical profile.

Achieving the maximum degree of mastery of information and communication competence by a future specialist is possible only with systematic work on all components of the competence. Without information literacy and knowledge of the laws of information security, communication, and interaction, it is difficult today to create adequate digital content and solve technological problems. The ability for reflection and self-esteem is, of course, the path to self-development. Confident, conscious, and creative use of information technology for education, work, leisure time and social activity is the key competence of an individual in the 21st century.

The challenge for research and teaching staff is to move beyond thinking about information technology as a tool or " information technology support platform." An integrated approach to solving the problem of the formation of digital competence in the process of training specialists at the university within the framework of any academic discipline is required.

The development and implementation of a pedagogical system for the formation of students' digital competence in the learning process, as well as the ways of delivering, should include targeted, active, informative, and effective components.

The use of project-based or inquiry-based learning as a tool to increase students' interest is the key to developing a range of competencies. Project-based learning is really at the heart of learning new digital skills right now. Traditional learning models are too passive to create such skills. The competency model is the basis for key changes in education training for the digital economy.

The analysis performed makes it possible to draw the following conclusions and generalizations.

1. In the light of modern trends in social development, digital competence of specialists, which provides an individual's opportunity for successful interaction, accumulation, and exchange of experience with subjects of the surrounding world and professional activity, is of particular importance. For future specialists in economic specialties, digital competence is also necessary, since it ensures the effective implementation of professional functions, personal success, and readiness for further professional development.

2. It seems advisable to use the systems based on DigComp 2.1 for a diagnostic test of the competence of applicants for education, advanced training of scientific and pedagogical personnel, and the introducing digital literacy into educational programs.

3. It is necessary to ensure the consistency and systematic way of the formation of digital competencies of future specialists in economic specialties at different levels of higher education.

In further research, it is proposed to carry out a deeper analysis of the content and technologies for the formation of digital competencies of future economists at different levels of education.

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Modeling of the adaptive system of individualization and personalization of future specialists' professional training in the conditions of blended learning

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Abstract

The model of adaptive system of individualization and personalization of future specialists' professional training in the conditions of blended learning is offered. It includes the contextual, pedagogical and instrumental subsystems. In the system, the adaptability is planned to be implemented through the adaptation of educational materials, monitoring, devices, face-to-face classes; individualization involves the study of students' individual features, support and assistance of student's individual syllabus, individualization of the learning process, development of student's individual features and formation of new characteristics according to student's educational needs, monitoring of student's individual progress; personalization involves the organization of the educational environment, including the electronic one.

Keywords

model of adaptive system, adaptive learning system, individualization, personalization, professional training, blended learning.

1. Introduction

Various aspects of the issue of improving the future specialists' training have been studied by many scientists and educators. As a result of pedagogical research, scientists [1], [2], [3], [4], [5] are increasingly inclined to believe that in the context of a great variety of educational content and individual preferences of students, the educational process can be carried out through the introduction of adaptive learning systems in higher education institutions. Many scientists have devoted their research works to the modeling of such systems. In particular, Siadaty M. and Taghiyareh F. [3] proposed a pedagogically adaptive learning system based on learning styles. An adaptive learning system, focused on learning style and cognitive state, was designed by Chen S. and Zhang J. [6]. Huang S. L. and Shiu J. H. [7] developed a model of the user-centric adaptive learning system, which uses sequential pattern mining to construct adaptive learning paths based on users' collective intelligence and employs Item Response Theory (IRT) with collaborative voting approach to estimate learners' abilities for recommending adaptive materials. Huang H.C., Wang N.Y. and Hsieh F.M. [20] introduced a model of the adaptive mobile learning system that provides learners with the content adapted to their knowledge levels, learning styles, and heterogeneous learning devices. However, the need for modeling and development of a system in which the adaptation technologies, approaches to individualization and personification of education for the purpose of future specialists' professional training in the conditions of blended learning in a higher education institution remains relevant.

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2. Analysis of subject domains

In the process of modeling of the adaptive system of individualization and personalization of future specialists' professional training in the conditions of blended learning (ASIPT), we relied on scientific works on the methodology of research and pedagogy [8], [9], [10] as well as on the modeling of pedagogical systems and environments [11], [12], [13]. We analyzed studies representing the development of adaptive systems (platforms) of learning in higher education institutions [14], [15].

In pedagogical science in order to accurately reflect the characteristic features of the phenomenon under study modeling is used, the result of which is a model of this phenomenon. The model is a project of the educational process, which will later be put into practice and its construction will allow choosing the most effective ways to achieve the aims of specialists' training [16]. Thus, the development of the ASIPT model facilitates the study and provides new knowledge about the original object (pedagogical process in the adaptive system of individualization and personalization of future specialists' professional training in the conditions of blended learning).

In this aspect, modeling of the pedagogical process in ASIPT is needed in order to learn how to manage this process; to identify the best ways to manage it under certain organizational and pedagogical conditions, aims and criteria; to anticipate the direct and indirect consequences of realization of the set ways and forms of influence on the subject (students of higher education institution); to achieve the desirable outcomes (professional competence); to provide the process of future specialists' professional training in higher education institutions with technologies; to monitor the efficiency and quality of future specialists' professional training in higher education institutions.

As a methodological basis for the construction of ASIPT model, we used a polyparadigmatic approach [17], which involves the use of an open cluster of approaches to learning that do not interfere with each other and their integrated application has a synergistic effect. The leading role in this cluster is given to the systematic approach, which provides the basis for the subsystems (contextual, pedagogical, instrumental). The structures of these subsystems were identified. Let's describe each of the ASIPT subsystems in detail.

3. ASIPT subsystems

3.1. Contextual subsystem

The basis of ASIPT contextual subsystem is a general idea of the developed adaptive system, i.e. how the concept and idea of its development will be implemented. Given the fact that ASIPT model is used a blended learning environment, some aspects of the implementation of adaptation, individualization and personalization of learning in the process of distance and traditional (face-to-face) learning were identified (Fig. 1).

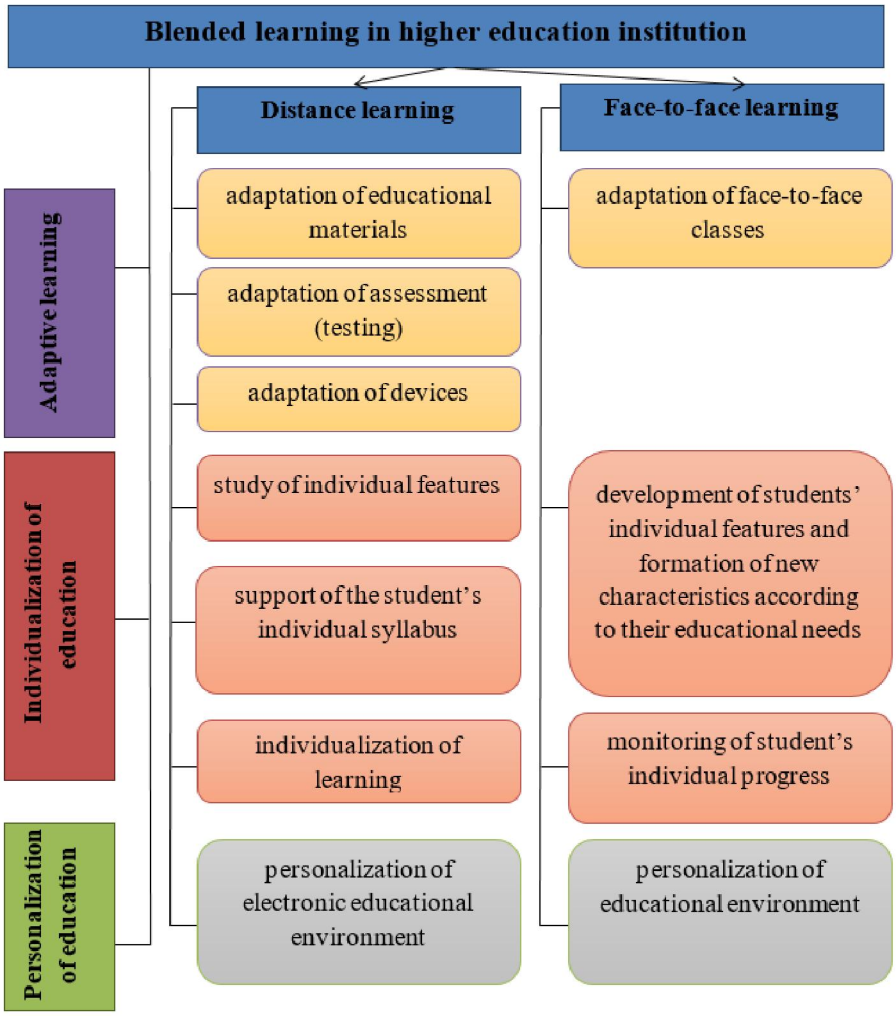

Figure 1: ASIPT contextual subsystem

In ASIPT the adaptive learning is carried out by means of:

1) adaptation of educational materials (content of educational materials) – organization of algorithms for educational materials adaptation in a three-stage system: "introductory adaptation" (adaptation of the content of introductory educational materials of the discipline based on the initial level of students); "current adaptation" (adaptation of educational materials on the basis of current effective actions of students in the adaptive electronic environment (SDL)); "assessment-corrective adaptation" (adaptation of normative parameters of the level of materials acquisition taking into account the learning outcomes achieved by students) [18];

2) adaptation of assessment (testing) – specific ways are used to regulate the complexity and number of the proposed tasks, depending on the students' results, including different testing options: pyramidal: everyone is given a task of medium level of complexity and then, depending on the result, everyone is given a more difficult task), flexible testing (starts with the level of complexity, chosen by the test taker, with a gradual approach to the real level of knowledge), stratified (conducted using a bank of tasks divided by levels of complexity: in case of the correct answer the next task is taken from the top level, in case of incorrect one – from the bottom level) [19];

3) adaptation of devices – adaptation of educational resources (portals, SDL, sites, etc.) to various computer devices (PCs, mobile phones, smartphones, tablets) [20];

4) adaptation of face-to-face classes – when having face-to-face classes new structures of courses are created; the variation of learning (content, forms, methods, means) and adaptation of educational process to students' individual features thanks to considerable increase in time allotted to the students' individual work take place; pair and group work; individual pace of students' work depending on the level of knowledge, skills, innate anilities, and working capacity, etc.; creation of multilevel tasks for

individual work; giving students a choice of the level of complexity of the tasks performed; wide use of generalizations and reference schemes in the learning process; management of educational process by means of the network plan; continuous monitoring of the individual work outcomes [21].

In ASIPT the individualization of learning gives an opportunity to individually plan content, pace and time of study using the list of educational resources. This plan is focused on the student's learning preferences and the opportunity to work according to the individual syllabus. In order to implement this option the following ways of individualization are planned in ASIPT:

1) study of students' individual features – at the beginning of learning a number of psychological and pedagogical activities are carried out; it provides the basis for the identification of student's individual learning path and for the analysis of the outcomes in order to take them into account in the learning process (for example, identification and proposal of the study time depending on the psychological features of the students);

2) support of the student's individual syllabus – considering the fact that individualization provides the organization of system of interaction between participants of educational process in which individual features of everyone [22] are most fully taken into account, the system has the option of the digitization of communication acts (their protocolling, algorithmization, timing, archiving) and monitoring of competencies, including educational and professional self-identification and self-presentation (professional portfolio) [23];

3) individualization of learning process – when implementing an individual educational route the students are provided with an opportunity to learn when it is convenient for them (morning, day time, evening) and at their own pace (faster, slower, flexibility of reporting time);

4) development of students' individual characteristic features and formation of new characteristics according to their educational – needs involve the implementation of "subject-subject" learning based on student's individualization, when such necessary qualities as independence, initiative, creativity, confidence, enthusiasm, research style, culture of search and work are forming and developing; these qualities are necessary for the future specialist who will act in the new social conditions [22];

5) monitoring of student's individual progress – gradual compilation of the student's own professional portfolio, which reflects the outcomes achieved by him or her in the process of learning in a particular specialty without comparison with the achievements of other students.

In ASIPT personalization of learning facilitates a growing demand of users (learners) to meet their learning needs as well as their natural desire for greater productivity and comfort of mastering new competencies [24]. Teachers turn to personalization in order to intensify and increase the efficiency of the future specialists' training process.

Personalization of learning in ASIPT is carried out in two ways: 1) personalization of the electronic learning environment (PELE); 2) personalization of the learning environment (PLE).

PELE includes the creation of conditions for the consolidation of various Internet services, electronic resources and ICT tools in their relationships, through which the student builds his or her own learning process, including personalization of the SDL interface (depending on the results of individual features testing, the color frame of the student's personal page is offered). Access to learning turns into an access to resources and services and it allows students not only to use learning resources, but, most importantly, to create them. So, learning is transformed from a simple transfer of information and knowledge to their creation [25]. Personal e-learning environment is formed by means of a set of open educational resources, web services and software applications that have to perform certain tasks or functions in the educational process. It is described in more detail in the instrumental subsystem.

Personalization of the learning environment means providing students with conditions for having their own set of educational resources (teaching aids) in the laboratories of higher education institutions. It becomes possible under the condition of the creation of STEAM-laboratory in higher education institution. The laboratory space is organized in the format of Makerspace – a global format of creative spaces-workshops – as a place to brainstorm ideas, conduct experiments, study, put ideas into practice and improve student's new skills [26]. Teachers and students have the opportunity to come to the laboratory in order to use the special equipment available in it, which is expensive or quite specific in its characteristics. The space of the laboratory is specially planned for the purpose of appropriate and comfortable accommodation and work of its visitors, providing mobility, flexibility and the ability to use technical aids when learning. Equipment of the STEAM-laboratory allows users to create optimal conditions for the realization of each student's potential in order to organize his or her personal learning environment in higher education institution.

3.2. Pedagogical subsystem

One of the main features of ASIPT is its structuring, which provides for the possibility of identifying its components, as any system has a structure that is a set of connections between parts of the whole [27]. Pedagogical subsystem of ASIPT model includes an understanding and presentation of aspects related to the process of future specialists' professional training. This subsystem, like the majority of pedagogical models of education which represent a unity of process and result, contains five components: target, theoretical-methodological, content, activistic, and resultative. We have added a creative component to the traditional structure of the pedagogical model, because in our opinion, learning systems should develop the creativity of future specialists, which contributes to more effective development of students' professional competencies (Fig. 2).

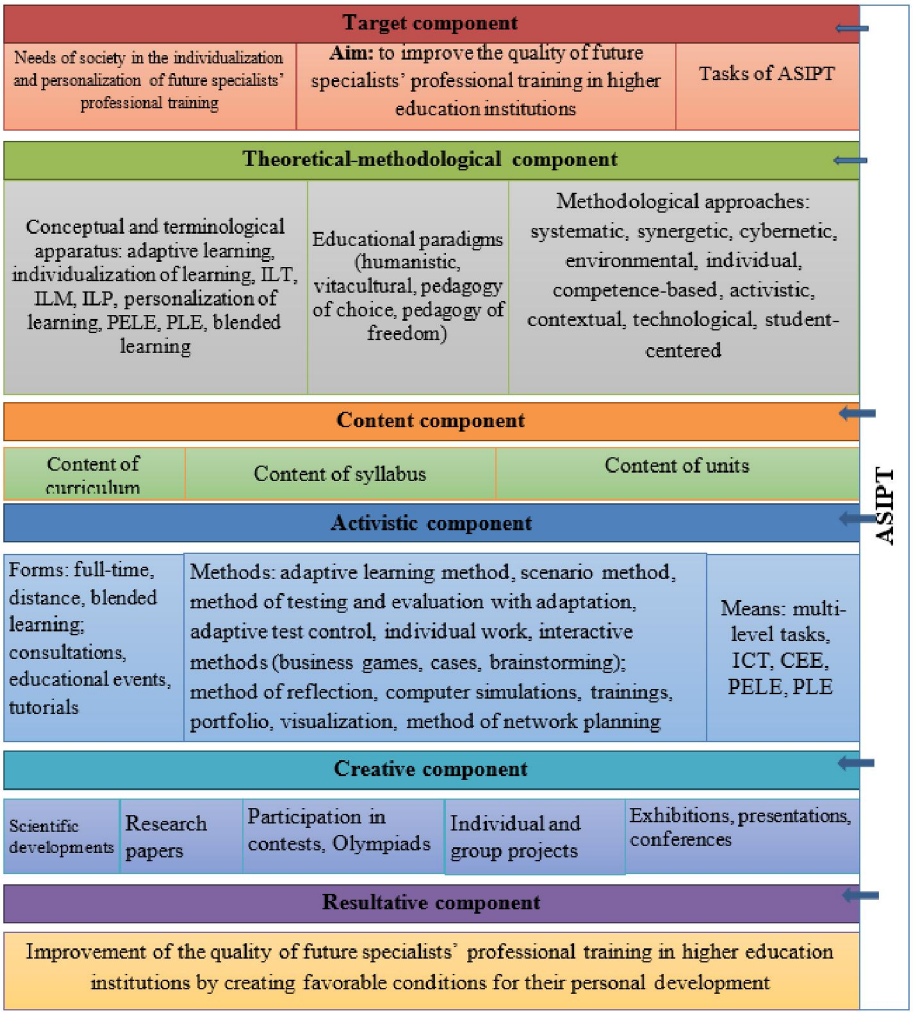

Figure 2: Pedagogical subsystem of ASIPT

The target component identifies the needs of society in the individualization and personalization of future specialists' professional training; the aim is to improve the quality of future specialists' professional training in higher education institutions by creating favorable conditions for their personal development; tasks of ASIPT.

The theoretical-methodological component reveals the conceptual and terminological apparatus, educational paradigms and methodological approaches (systematic, synergetic, cybernetic, environmental, individual, competence-based, activistic, contextual, technological, and student-centered) according to which ASIPT model is constructed.

The content component reflects the content of future specialists' professional training in the form of a syllabus, designed on the basis of the standard of higher education for Bachelors and Masters; content of courses, which is organized in accordance with the requirements of adaptive learning, including the distribution of didactic units in each discipline.

The activistic component includes a system of forms, methods, means, organizational and pedagogical conditions that contribute to the improvement of the quality of professional education by developing the future specialists' competence necessary for successful future professional activity.

The creative component involves the development of students' creativity in the innovative pedagogical activities, their involvement in the development of new projects, writing research papers, participation in contests, Olympiads, exhibitions, presentations, conferences, etc.

The resultative component shows the improvement of the quality of future specialists' professional training in higher education institutions by creating favorable conditions for their personal development.

All components are interconnected in ASIPT model.

3.3. Instrumental subsystem

To implement the adaptation, individualization and personalization of learning, this environment is created through the use of various tools: information and communication technologies, modern technical means of learning, hardware and software. These tools form the Instrumental subsystem of ASIPT model. Its schematic representation is shown in Fig. 3.

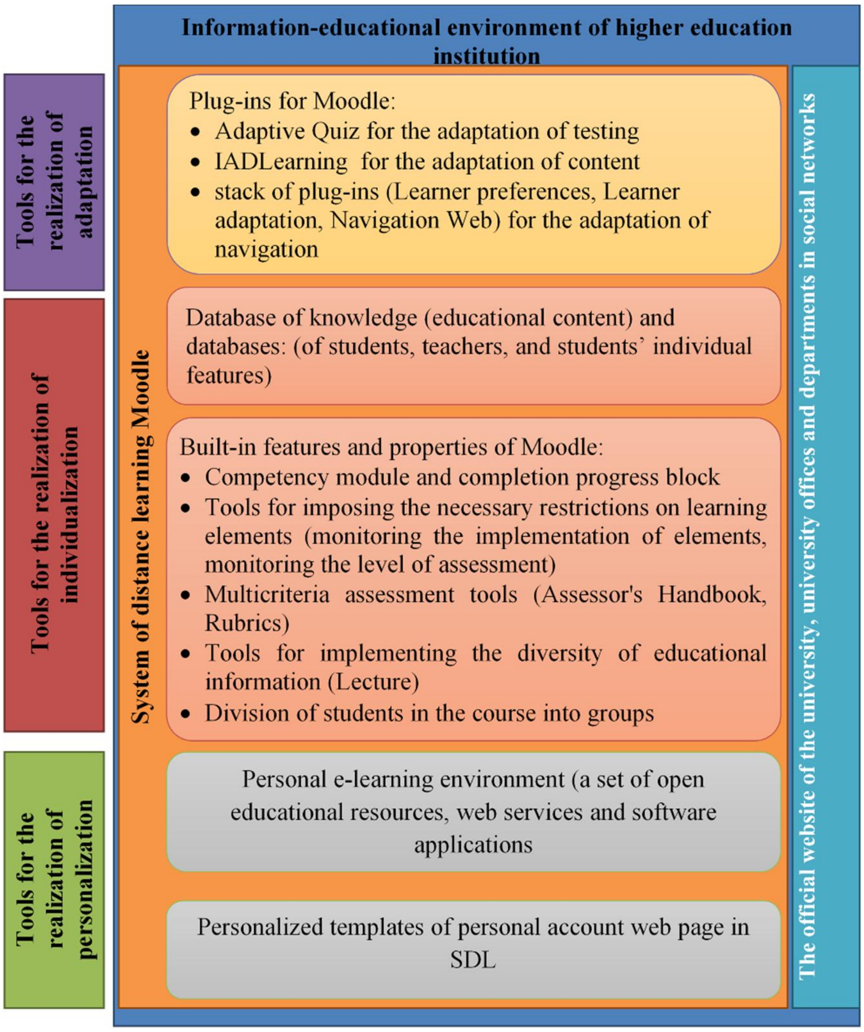

Figure 3: Instrumental subsystem of the adaptive system of individualization and personalization of future specialists' professional training in the conditions of blended learning

The basis for this subsystem is the distance learning system Moodle. It is not positioned by developers as an adaptive learning system. However, the growing popularity of adaptive learning technology has prompted Moodle developers and other programmers to improve the system. Therefore, to implement an adaptive approach, Moodle has developed appropriate plug-ins. Among the analyzed plug-ins, we singled out Adaptive Quiz for adaptation of testing, IADLearning for adaptation of content and stack of plug-ins (Learner preferences, Learner adaptation, Navigation Web) for navigation adaptation [28].

To support the individualization of learning in SDL Moodle, there are the following advantages: creation of a course in SDL in the form of a modular structure; formation of modules with the accessibility of materials based on the results of studying previous modules and passing mid-course tests; creation of educational materials in SDL of a branched structure according to a pre-created pedagogical scenario (lecture with feedback); creation of resources with additional opportunities for material processing for students with insufficient level; creation of multilevel tests; creation and placement of individual tasks in the course of SDL [29].

The easiest way to individualize the course is to create mini-groups in SDL to optimize the path of their learning process. Creation of tasks and educational materials for groups depends on their initial level, educational needs and tasks oriented for the achievement of outcomes. It is also possible to add some additional materials that help to master the content of the course. In addition, in SDL Moodle it is convenient to support the development and implementation of project activities.

It is possible to integrate SDL Moodle with various information systems, which allows users to create and store an electronic portfolio. In the student’s portfolio all the works submitted by him or her, grades and comments of the teacher, messages in the forum are saved. SDL Moodle offers the following tools for implementing an individual approach:

1. Tools for the formation of the learning route by imposing the necessary restrictions on the learning elements (tracking the execution (review), tracking the level of assessment).
2. Multicriteria assessment tools (Assessor's Handbook, Rubrics), which take into account the complexity of the material.
3. Tools that allow implementing a variety of educational information within the framework of a single distance course.
4. Compilation of the profile of learning material representation for each group of students.

Individualization of the learning process using Moodle can be expanded through the use of mobile learning technologies [30]. This is the way how mobile learning can be adopted and developed as a supplementary line in higher education institutions [31]. It is achieved through various mobile technologies. In particular, for the implementation of individual learning, in addition to access to Moodle via a mobile phone browser, there is a mobile application Moodle in the App Store and Google Play. The SDL Moodle mobile application has a user-friendly interface and full functionality for students learning distantly.

For the organization of a personal electronic learning environment (PELE) it is advisable to use appropriate tools. It should be noted that some tools from Internet service providers can be used as examples of tools in PELE. Based on our expert experience of long-term work with ICT we have outlined only some examples (Table 1).

Table 1
Tools for organizing a personal electronic learning environment in ASIPT

Tasks, function of tools	Type of tools	Sample tools
Organization of a single entry point	Educational portal	Official site of higher education institution,
Google Apps for Education		
Organization of learning	System of learning management	Moodle, Google Classroom,
Publication of educational materials	Services for e-courses creation	Edmodo, Eliademy
	Video hosting	YouTube
	Services of online presentations	Prezi
	Google Slides	
	Photo hosting	Google Photos, Imgbb
	Services for materials publication	Google Docs
Development of practical skills	Virtual stimulators	Codecademy, GeoGebra, STAR, Classmaster, PhET
Cooperation	Services of joint work with documents	Google Docs
	Online boards	Twiddla, Miro, IDroo
	Online mind maps Services for the organization of teamwork	MindMeister Trello, Asana
	Services for project management	CRM Bitrix24 Wrike, Basecamp
Communication	Messengers	Viber, Telegram
	Applications for group calls	Discord
	Video conference services	Skype, Google Meet, Zoom,
Systematization and storing data and information	Cloud storage	Google Drive, Dropbox,
	Notes storage services Services for collecting and systematizing information	Evernote, Netboard Pinterest
Presentation of learning outcomes	Services for sites development	Google Site, Wordpress.com
	Portfolio services	Behance.net, Clippings.me
Search for educational resources	Search services	Google Search, Google Scholar, Google Maps
Information about the events in the university	Social networking pages	Facebook, Instagram, Twitter, TikTok, LinkedIn

4. Model of adaptive system of individualization and personalization of future specialists' professional training in the conditions of blended learning

Three presented ASIPT subsystems can be generalized in one ASIPT model (Fig. 4)

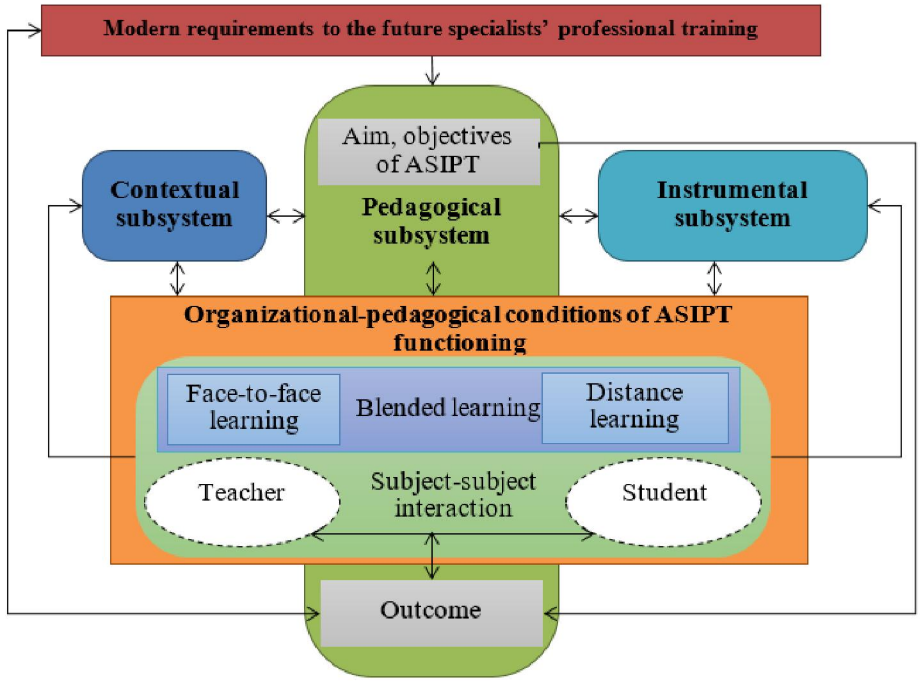

Figure 4: Model of adaptive system of individualization and personalization of future specialists' professional training in the conditions of blended learning

The developed model of ASIPT which includes three subsystems (contextual, pedagogical, instrumental) takes into account modern requirements to future specialists' professional training which agree with the aim and outcome of its implementation. All subsystems are interconnected and are determined by the organizational and pedagogical conditions of ASIPT, the leading of which are the conditions of blended learning and subject-subject interaction between the main participants of the educational process (teacher, student).

5. Conclusion

In the model of the adaptive system of individualization and personalization of future specialists' professional training in the conditions of blended learning, adaptability is planned to be realized through the adaptation of educational materials (content of learning), assessment (testing), devices, face-to-face classes; individualization includes the study of students' individual features, support and assistance of student's individual syllabus, individualization of the learning process, development of student's individual features and formation of new characteristics according to student's educational needs, monitoring of student's individual progress; personification involves the organization of learning environment, including electronic one. A further perspective of the research is the development of a working prototype of an adaptive system based on the stack of educational and information and communication technologies implemented in the structure of higher education institutions.

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Experience of use of electronic educational resources by Ukrainian teachers during the distance learning due to the COVID-19 pandemic (March-May 2020)

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Abstract

The introduction of distance learning in Ukrainian schools during quarantine due to the COVID-19 pandemic has updated the study of use of different types of electronic educational resources by teachers to ensure qualitative distance learning. The online survey of 576 teachers in March–May 2020 determined that the introduction of quarantine due to the COVID-19 pandemic was a catalyst and motivated 12% of the surveyed teachers to start using electronic educational resources to provide the distance learning for students during the lockdown. The analysis of electronic educational resources recommended by the Ministry of Education and Science of Ukraine for use in all schools of Ukraine made it possible to identify areas of educational activity that are insufficiently provided with electronic textbooks and electronic training manuals that have passed the state examination. The results showed that in 2016–2019, electronic textbooks were developed only in some subjects of the 1st, 2nd grades of primary school and 5th, 6th grades of middle school. None of the 5 electronic textbooks developed for high school has passed the examination of the commissions. The electronic manuals that have passed the examination of the commissions also cover only certain subjects, mainly for primary and middle schools. The lack of certified educational and demonstration, control electronic educational resources, which teachers actively used during distance learning, is compensated by teachers with the help of electronic educational resources, developed by other teachers and posted on the YouTube channel or platform Na urok and also self-developed electronic educational resources: presentations, video lessons, tests and interactive exercises.

The effective ways to overcome the problem of providing teachers with qualitative electronic educational resources can be: 1) resumption of the program of development at the expense of the state of high-quality electronic textbooks for different classes and subjects in accordance with the gaps identified in the study in providing students with educational electronic educational resources, which have passed the state examination;

2) creation of a state register of self-developed by teachers open electronic educational resources and the development of criteria for assessing their quality;

3) development of a national platform of electronic educational resources, which would place e-textbooks and manuals that have passed the state examination, and independently developed by teachers demonstration, game, control or other types of electronic educational resources, which meet the quality criteria for content and technical implementation.

Keywords

distance learning due to the COVID-19 pandemic, electronic educational resources, electronic textbook, electronic manual, informatization of education.

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Introduction

The introduction of electronic educational resources (EERs) in the educational process allows to implement models of distance and blended learning, lifelong learning, enrich forms and methods of learning, expand its content, automate the management of educational institutions, develop subject, scientific, information and digital competencies of participants of educational process, to modernize the education sector in the context of the development of the digital economy of Ukraine.

The current Regulations on electronic educational resources determines EERs as "learning tools on digital media of any type or placed in information and telecommunications systems that reproduce using electronic technical means and used in the educational process" and emphasizes that EERs "are created to ensure the modernization of the educational process, providing equal access to participants in the educational process, regardless of place of residence and form of education" [1].

EER can exist as an "indivisible educational object" [2, p. 9], but mainly it is a set of educational objects. In the works of foreign scholars, "there is a growing recognition that educational resources are not discrete "learning objects", but amalgams from several resources, each with its own characteristics, interconnected by complex relationships" [3, p. 14].

According to the Ukrainian legislation, some types of EERs must be examined and considered by the relevant commissions (subject and technical) to get a conclusion "Approved for use in the educational process" or "Recommended by the Ministry of education and science of Ukraine", which gives the right to use them outside of one educational institution. Subject commissions consider the content of EERs, the technical one examines the compliance of EERs with design and ergonomic, technical requirements and the quality of their functioning.

Ukrainian scientists have studied various aspects of development, evaluation and implementation of EERs in school education of Ukraine, in particular: effectiveness of education with electronic educational game resources in primary school (V. Bykov, S. Lytvynova, O. Melnyk); evaluation criteria of EERs (S. Lytvynova), experience of using EERs in secondary school within the framework of general education digitalization in Ukraine (I. Vorotnykova); practices of information and communication technologies application and use of EERs in primary school (O. Melnyk); statistics, functionality and quality problems of electronic textbooks developed for the state order in 2018–2019 (A. Antokhova, L. Iliychuk, M. Zhenchenko, O. Melnyk, V. Miroshnychenko, I. Zhenchenko); structural and organizational procedural characteristics of EERs design (O. Balalaieva), etc. All these studies concerned the use of EERs as an element of blended learning.

The transition to distance learning during quarantine through the pandemic COVID-19 actualizes the study of practices of the use of different types of EERs by Ukrainian teachers to ensure quality distance learning.

Foreign researchers have actively studied the opinion of teachers, students, parents on the organization and quality of distance learning during the COVID-19 pandemic in schools around the world: Canada [4], Chinese [5], Indonesia [6], Italia [7] et all. Among the "results of e-learning implementation barriers" the problems of providing students with EERs were also indirectly mentioned. Thus, "Descriptive results of e-learning implementation barriers" in Indonesia among "School Level Barrier" defines "Textbooks are not in line with e-learning use" and "Because of workload, I do not have enough time to prepare e-learning materials." [6, p. 5].

The scientists of the Institute of Information Technologies and Learning Tools of the National Academy of Pedagogical Sciences of Ukraine conducted an online survey on March 27 – April 4, 2020 on the needs of teachers to improve their professional skills in the use of digital tools and ICT in the quarantine due to the COVID-19 pandemic. The survey was all-Ukrainian, anonymous, with 430 teachers. The results of this survey are published in the article of I. Ivaniuk and O. Ovcharuk "The response of Ukrainian teachers to Covid-19: challenges and needs in the use of digital tools for distance learning" [8]. This study focused on electronic platforms and means of communication.

Therefore, the objectives of our study were fourfold:

1. Analyze of the use of EERs by Ukrainian teachers and the impact of the introduction of distance learning through the COVID-19 pandemic on this process (March–May 2020).
2. Identify the types of functional EERs that are most often used by teachers during distance learning due to the COVID-19 pandemic.

3. Investigate the level of providing teachers with EERs that have passed the state examination and were approved (or recommended) for use in the educational process in all schools of Ukraine.
4. Identify which types of EERs teachers have developed independently to ensure qualitative distance learning during the pandemic through COVID-19.

The study is limited to March-May 2020, as in Ukraine the national lockdown was announced in general secondary education institutions only twice: from March 12 to May 22, 2020 and from January 8 to January 24, 2021. The article was prepared in January 2021, so teachers' survey on use of EERs during the second nationwide lockdown is a part of our plans for further research.

Research methodology

The study was realized in several stages. In the *first stage* of the research the literature on the topic was analyzed, the range of scientific works, which covered the results of all-Ukrainian or local surveys of teachers on the introduction of ICT in the education system and indirectly addressed the problem of Ukrainian teachers using different types of EERs, was determined. Based on the analysis, a range of topical research questions was identified and the questionnaire to interview teachers was developed.

In the *second stage*, a survey of Ukrainian teachers was conducted to find out their opinion on the specifics of the use of EERs to organize effective distance learning during the quarantine due to the COVID-19 pandemic (March–May 2020). The study involved 576 teachers (393 middle and high school teachers and 183 primary school teachers) from 22 regions of Ukraine and Kyiv, with 73% of surveyed teachers living in cities, 17.7% in villages, and 9.3% in towns. The method of "convenience sampling" was used to form the sample; the initial group of respondents was selected randomly by posting the questionnaire on the thematic pages of teachers in the social network Facebook, in groups of teachers in Viber, etc.

The *third stage* involved the collection of data on EERs, which passed the state examination, developed for Ukrainian schoolchildren. The main sources of data were the minutes of the Commission on informatization of educational institutions for 2016–2019, prepared by the staff of the Digital Education and ICT Department of the Institute of Educational Content Modernization (IECM) and materials of the Electronic register on the provision of stamps and certificates of the Ministry of Education and Science of Ukraine (MESU), posted on the official website of IECM. The 2016–2019 years have been chosen for analysis, as the authorization is granted for five years, which is why the analyzed EERs are currently used in the educational process during the quarantine in March–May 2020. This made it possible to get an answer to the question identified in the analysis of the results of the survey why Ukrainian teachers use EERs which have passed the state examination not very often.

In the *fourth stage* the collected empirical data were generalized and systematized with the help of general scientific methods of analysis, synthesis, generalization, comparison. Mathematical methods were used to process empirical data. Graphic methods were used to build diagrams, charts and tables. The descriptive method was useful at the stage of describing the research results. The comparative method made it possible to see the results in the context of research conducted by other scientists.

Results

Impact of the quarantine due to the COVID-19 pandemic (March–May 2020) on use of EERs by Ukrainian teachers

The results of our online survey of Ukrainian teachers conducted in March–May 2020 showed that the number of teachers who use EERs in the educational process is gradually increasing: 38% of surveyed teachers have systematically used EERs in the last 5 years, 18.2% – in the last 2–3 years and 2.7% – in the last year. Slightly more than a quarter of respondents (28.6%) used EERs occasionally as needed, and only 0.5% said they did not use EERs because they did not have the appropriate skills to work with them (Figure 1).

The introduction of the quarantine during the COVID-19 pandemic has been a catalyst and motivated teachers to use EERs more actively. Thus, 12% of teachers surveyed did not use EERs in working with students at all before the quarantine and only after the introduction of the quarantine during the COVID-19 pandemic they began to use EERs for distance learning (Figure 1).

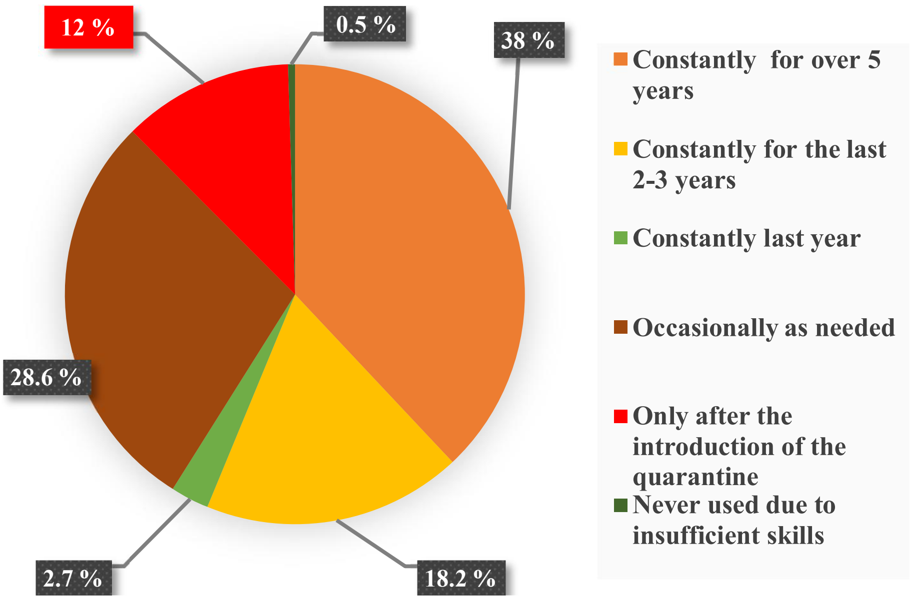

Figure 1: Use of EERs by the Ukrainian teachers before and during the quarantine due to the COVID-19 pandemic.

Types of EERs by functional purpose used by the teachers during the distance learning

According to the functions in the educational process EERs for educational purpose can be divided into:

1. Educational (electronic copy of a printed textbook, electronic textbook (e-textbook), electronic training manual (e-manual).
2. Educational and methodical (electronic educational and methodical manual, electronic methodical recommendations, etc.).
3. Educational and practical (electronic workshop, electronic simulator, collection of virtual laboratory works, electronic workbook).
4. Educational and game (electronic educational games, electronic educational game resources);
5. Educational and demonstration (electronic visual aids, audio-visual works, electronic didactic demonstration materials, etc.).
6. Control (electronic tests, electronic banks of control questions).
7. Reference (electronic directory, electronic dictionary, electronic encyclopedia);
8. Supporting (electronic chrestomathy, electronic collection of normative documents, electronic bibliographic indexes of scientific and educational literature, electronic scientific publications, electronic diary, electronic register, etc.) [9, p. 132–133].

The most popular among teachers are educational and demonstration EERs (electronic visual aids, presentations, video lessons, etc.). They were chosen by 85.4% of surveyed teachers in response to the question "*What types of EERs (by functional purpose) do you use in your professional activities during distance learning due to the COVID-19 pandemic most often?*" In second place there are control EERs (71.4%), followed by educational and game (66.7%), educational (61.5%), educational and practical (49.5%), reference (44.3%), educational and methodical (37.5%), supporting (32.3%) (Figure 2). The total number of answers exceeds 100%, as teachers could choose several answers at once.

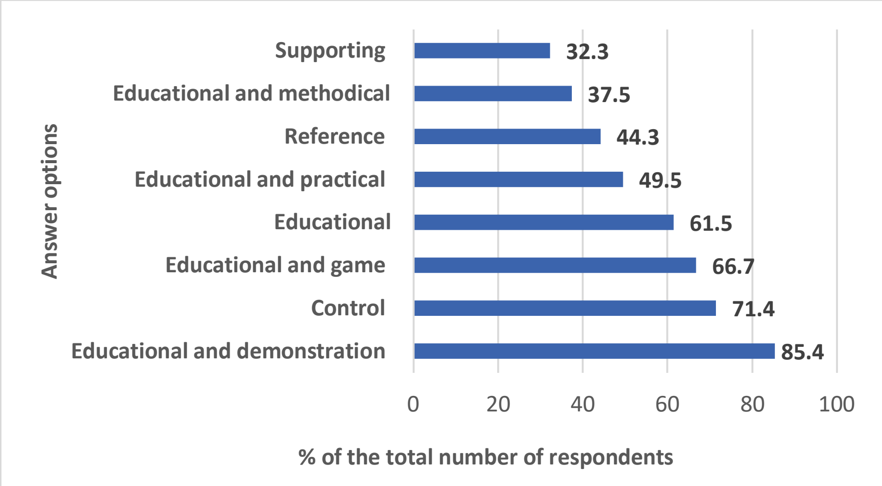

Figure 2: Answers to the question "What types of EERs (by functional purpose) do you use in your professional activities during the distance learning due to the COVID-19 pandemic most often?"

Ukrainian teachers' use of qualitative EERs that have passed the state examination

To the question, "*Which EERs do you use the most often in your professional work during the distance learning due to the COVID-19 pandemic?*" only 29.3% of the surveyed teachers chose the answer "more often those which have passed the state examination of MESU", 46.9% of teachers use EERs developed by other teachers and posted on the Internet, 20.8% – EERs developed on their own. However, 3% of respondents stated that they use different EERs: EERs approved by MESU, developed on their own, created by colleagues and presented for free access (Figure 3).

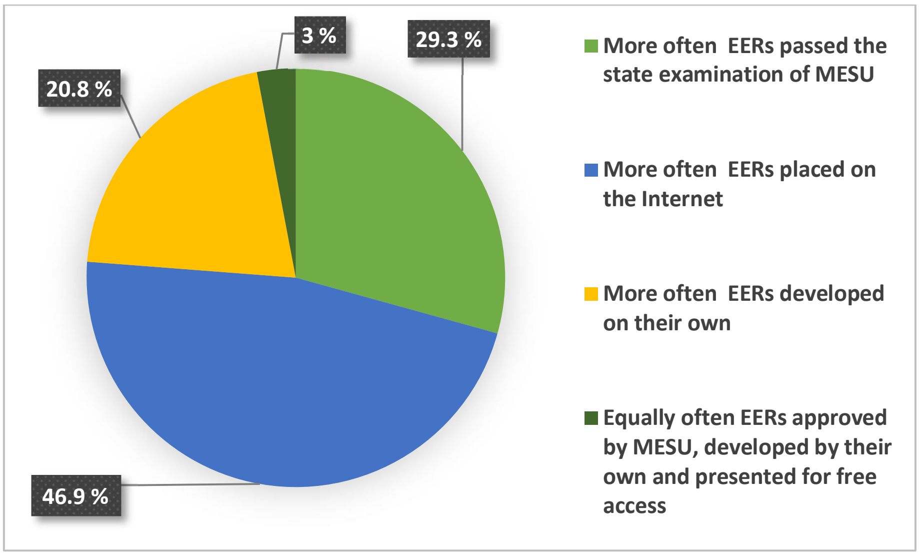

Figure 3: Answers to the question "Which EERs do you use in your professional work during the distance learning due to the COVID-19 pandemic most often?"

The obtained data showed the low level of use of EERs, which passed the state examination, and caused necessity of the study of the level of teachers' provision with qualitative EERs that were approved (or recommended) for use in the educational process in all schools of Ukraine.

In order to determine the number and types of EERs that have passed the state examination, the materials of the Electronic register of educational literature and equipment approved or recommended by MESU posted on the official website of IECM and the minutes of the Commission on informatization of educational institutions for 2016–2019, prepared by the staff of the Digital Education and ICT Department of IECM were analyzed. The analysis showed that in 2016–2019 the developers submitted for examination only 137 EERs for educational purposes, among which were approved or recommended for use in the educational process a little less than a half – 64 EERs (47%). As shown in Table 1, mainly educational EERs (e-textbooks and e-manuals) were submitted for the state examination.

Table 1

Number of EERs approved or recommended of MESU for use in the educational process

Types of EERs	Years 2016	2017	2018	2019	Totally
Educational	5	10	7	22	44
Educational and methodical	1	6	1	1	9
Educational and practical	-	-	-	1	1
Educational and game	-	1	1	-	2
Educational and demonstration	1	1	2	1	5
Control	-	-	-	-	-
Reference	-	-	-	-	-
Supporting	1	1	1	-	3
Totally	8	19	12	25	64

To identify the gaps in providing Ukrainian students with recommended and approved EERs, 23 e-textbooks and 21 e-manuals recommended and approved by MESU in 2016–2019 were analyzed. It was analyzed for which forms and in which subjects they were developed.

Among the 23 e-textbooks that received "Recommended for use in the educational process", 74% are e-textbooks for primary school (the 1st and 2nd grades) and only 26% – for middle school (the 5th and 6th grades), in particular:

- 12 e-textbooks for the 1st grade students: 5 e-textbooks "I explore the world", 3 e-textbooks "Art", 3 e-textbooks "Mathematics" for 1st grade, 1 e-textbooks "Ukrainian. Primer";
- 5 e-textbooks for the 2nd grade: 2 e-textbooks "I explore the world", 3 e-textbooks "Art";
- 2 e-textbooks for the 5th grade: 1 e-textbooks "Introduction to History", 1 e-textbooks "Labor";
- 4 e-textbooks for the 6th grade: 3 e-textbooks "Geography", 1 e-textbooks "World history. History of Ukraine" [10, p. 732, Fig 5].

None of the 5 e-textbooks developed for high school has passed the examination of the commissions [10, p. 732].

It should be noted that 23 e-textbooks that passed the state examination in 2019 are currently not available to teachers, as they have not been purchased from publishers at public expense.

The e-manuals passed the examination of the commissions also cover only certain subjects, mainly primary and middle schools, in particular, they have been developed for the 1st grade in music and mathematics, for the 2nd grade – in the course "I and Ukraine", for the 5th grade – in "Computer science", for the 6th grade – in "Ukrainian" and "History of the ancient world", for the 8th grade – in "Ukrainian literature" (Figure 4).

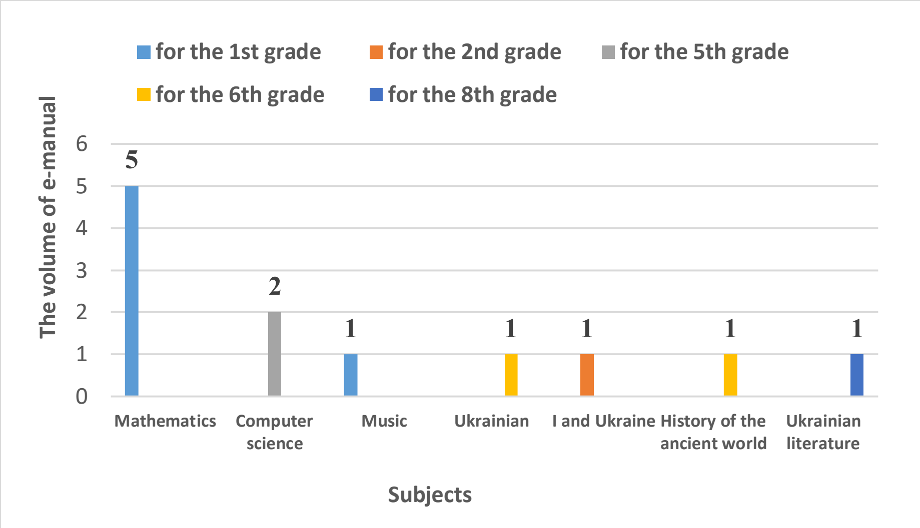

Figure 4: Number of e-manuals approved for use in all schools (based on the analysis of the Electronic register on the provision of stamps and certificates of MESU and the minutes of the Commission on informatization of educational institutions, 2016-2019)

Some e-manuals are designed for use within some years of study, for example: “Natural science” for grades 1–2, “English” for grades 1–6, “Computer science” for grades 8–9, “Computer science” for grades 9–10, “Computer science” for grades 10–11 (Figure 5).

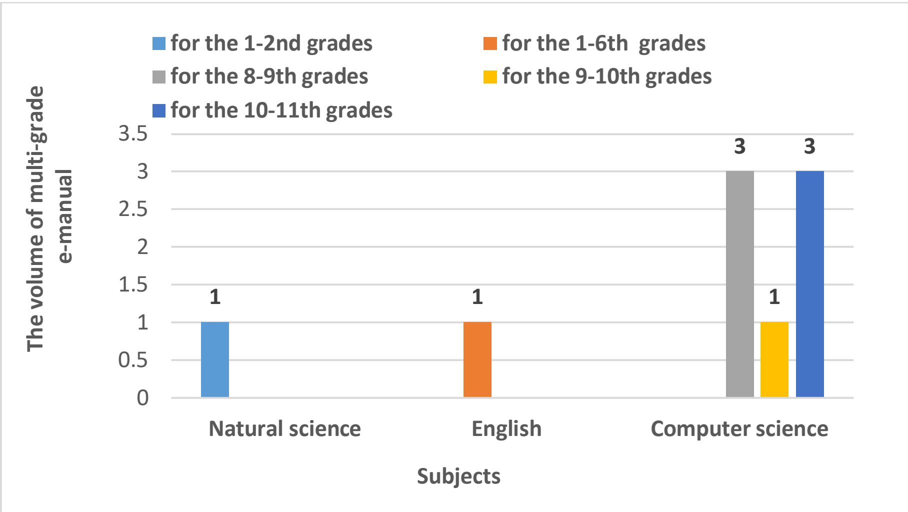

Figure 5: Number of electronic multi-grade e-manuals, which were approved for use in all schools (based on the analysis of the Electronic register on the provision of stamps and certificates of MESU and the minutes of the Commission on informatization of educational institutions, 2016-2019)

To solve the problem of providing teachers with e-textbooks and e-manuals, it is necessary to resume the program of developing at the expense of the state qualitative e-textbooks for different grades and subjects in accordance with the gaps identified in the study.

The first step in this direction and response to the problems that arose during the first national lockdown was the development and launch of the educational electronic platform All-Ukrainian School Online by MESU in December 2020. There are the video lessons, tests, materials for independent work in 18 basic school subjects for the 5–11th forms students on the platform. All educational content corresponds to the current state educational programs, and its quality is checked by the Ukrainian institute of quality of education. The list and topics of courses are proposed by the Ministry of Education and Science of Ukraine", stated in the description of the platform [11]. However, the quality and ease of use of EERs by teachers and students hosted on the All-Ukrainian School Online platform requires a separate all-Ukrainian study.

Use of EERs independently developed by teachers

The lack of recommended and approved educational and demonstration, control EERs (Table 1), which are especially popular among teachers (Figure 2), they compensate with EERs developed on their own. Thus, to the question, "*Do you develop your own EERs? If yes, which ones (you can choose several options)*" 86.5% of the interviewed teachers stated that they developed presentations, 77.6% – electronic tests, 61.5% – interactive exercises, 38.5% – video lessons and 28.6% – electronic crosswords, puzzles (Figure 6).

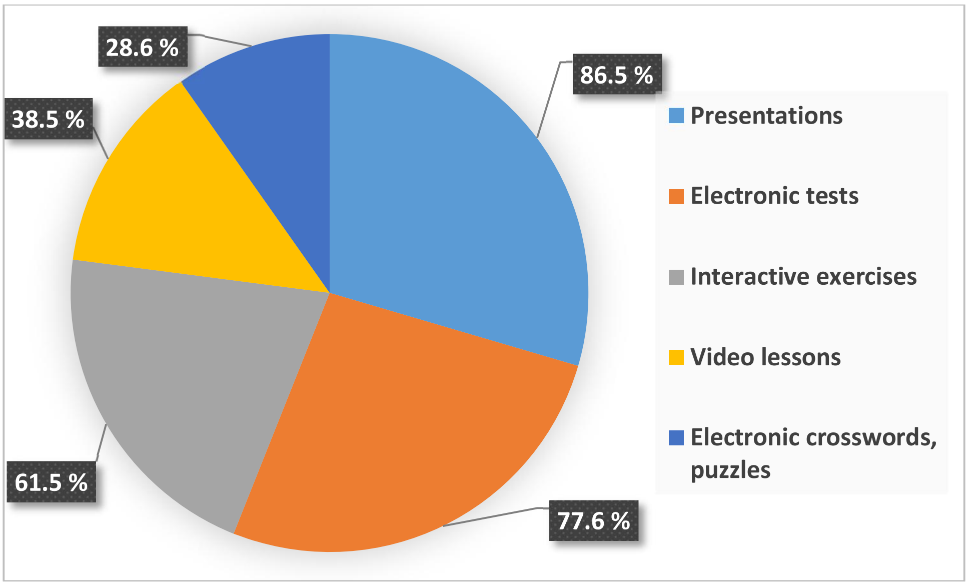

Figure 6: Answers to the question "Do you develop your own EERs? If yes, which ones (you can choose several options)"

The situation that there are no control EERs, which have passed the state examination, can be explained by the fact that data banks of control questions, electronic tests are mostly developed by teachers themselves using various platforms (Classtime, ClassMarker, Easy Test Maker, Google Forms, Kahoot, Moodle, Na urok, etc.). They are used locally within a certain educational institution that does not require experts' evaluation and obtaining the approval of MESU.

The teachers also actively use EERs developed by other teachers, published on YouTube or on specialized platforms created to share experiences between teachers (Vseosvita, Na urok). Thus, to the question "*Which EERs (developed by other teachers or placed on the Internet) do you use in your professional work during the distance learning due to the COVID-19? (you can choose several options)*" 76% of them said that used video lessons on the YouTube channel, 71.9% – EERs, posted on the educational platform *Na urok*, 3.5 % – EERs, posted on the educational platform *Vseosvita*.

The number and need for control EERs posted on the platform Na urok has increased significantly during the distance learning due to the COVID-19 pandemic. For example, the developers of the project Na urok in early June 2020 announced that during the quarantine in March–May, teachers asked students to perform 2,169,391 online tests created using the platform. At the beginning of April 2021, this number has increased to 4,260,575 tests [12].

It should be noted that, unlike multimedia interactive e-textbooks and e-manuals submitted for the state examination, EERs developed by teachers are mostly separate electronic objects (text files, presentations, video lessons, and exercises). The quality of such EERs is not checked by anyone, it is determined by the number of views and downloads by teachers, likes by users, and so on.

To overcome these problems it needs to *create a state register of qualitative of self-developed EERs, which would be systematized, available to teachers open EERs*. This will allow teachers to access all EERs from a single resource, and experts to develop criteria for assessing the quality of self-developed EERs. The criteria for assessing the quality of EERs can be based on the criteria developed within the EDCITE (Evaluating Digital Content for Instructional and Teaching Excellence) project and published in the article Kui Xie, Gennaro Di Tosto, Sheng-Bo Chen, Vanessa W. Vongkulluksn "A systematic review of design and technology components of educational digital resources" [13]. It should be taken into account the requirements for e-learning resources proposed in the "Handbook on Facilitating Flexible Learning During Educational Disruption: The Chinese Experience in Maintaining Undisrupted Learning in COVID-19 Outbreak" [5, p. 9, 21-22].

The first steps in this direction were taken in 2016, when in accordance with the Order of MESU of 12.01.2016 № 9 "On systematization of experience in the use of electronic educational resources" [14] a catalog of authors' educational resources of Zaporizhia region was developed [15], information on the use of own open electronic educational resources to provide distance learning in Kyiv schools was collected [16], however, the information received from different cities and regions has not been systematized and published as a single register of EERs.

Discussion

The article by Kalinina et al. [17] provides information on EERs, approved by the Commission on Informatization of Educational Institutions for use in the educational process in 2013–2017. However, this paper lists the approved EERs without their analysis, which does not allow identifying the features of providing Ukrainian teachers with certified EERs as elements of the system of distance school education.

Our results, compared to the results of the first all-Ukrainian study on the implementation of ICT and the use of EERs in education, conducted in 2014–2015 by the Institute of Innovative Technologies and Educational Content of MESU, and partially published in the article by O. Melnyk [18], demonstrate an increase in the number of teachers who use EERs and the trend of using EERs, which have not passed the state examination and were not approved by MESU over the last 5 years. Thus, in 2014–2015, as noted by O. Melnyk, "only 12% of primary school teachers used EERs systematically, more than half of respondents (65%) did so sporadically, almost 13% did not use EERs due to lack of experience, technical opportunities or desires, 8% said that the school was not provided them with such resources, 3% did not use EERs because they did not see their need. The study showed that 45% of the surveyed teachers used resources approved by MESU and almost 41% of respondents used resources taken from the Internet" [18, p. 98]. Such a comparison is quite conventional due to the difference in the quantity and quality of the respondents, as only primary school teachers (931 from rural areas and 358 from urban ones) took part in the 2014–2015 survey. To obtain more representative results, it is necessary to conduct similar surveys systematically and at the national level. This approach will allow us to see in the dynamics the problem of the use of EERs by Ukrainian teachers and respond quickly to the needs of teachers in EERs to provide quality blended and distance learning.

Conclusion

The results of our online survey of Ukrainian teachers conducted in March–May 2020 showed that almost 60% of teachers systematically used different types of EERs in their teaching activities in offline and blended learning. The introduction of quarantine during the COVID-19 pandemic became a kind of catalyst and motivated 12.5% of surveyed teachers to start using EERs for the first time to provide distance learning for students during the lockdown in March–May 2020.

To provide distance learning, teachers used mainly educational and demonstration EERs, control, educational and game, and educational EERs. Only 29.3% of the surveyed teachers used EERs, which have passed the state examination of MESU, 46.9% of the teachers used EERs developed by other teachers and posted on the Internet, 20.8% – EERs developed on their own. This situation is explained by the low level of provision of teachers by EERs that have passed the state examination. The analysis of electronic educational resources recommended by MESU for use in all schools of Ukraine showed that only 23 e-textbooks and 21 e-manuals were recommended or approved by MESU in 2016–2019. The e-textbooks were developed only in some subjects of the 1st, 2nd grades of primary school and 5th, 6th grades of middle school. Multi-grade e-textbooks in Computer science have been developed for high school. The e-manuals that have passed the examination of the commissions also cover only certain subjects, mainly for primary and middle schools.

The lack of certified educational and demonstration, control EERs, which teachers actively used during distance learning, is compensated by teachers with EERs, developed by other teachers and posted on the YouTube channel or on the platform Na urok and also self-developed EERs: presentations, video lessons, tests and interactive exercises.

In our opinion, the effective ways to solve the problems identified during the study of providing teachers with qualitative EERs are:

1. Development at the expense of the state of high-quality e-textbooks for various classes and subjects in accordance with the gaps identified in the study in providing students with educational EERs, which have passed the state examination.

2. Creation of a state register of open EERs self-developed by teachers and the development of criteria for their quality.

3. Development of a national platform of e-learning resources, which would include e-textbooks and e-manuals that have passed the state examination, and independently developed by teachers demonstration, game, control and other types of EERs, which meet the quality criteria for content and technical implementation.

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Adaptive Learning Environment Design in the System of Future Maritime Specialits' Training

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Abstract

In an environment of education reformation aimed at transition of higher education to competence based and individual approaches, we face the need to construct individual learning path for every future maritime professional. In this respect technology of adaptive learning based on modern ICT becomes of high importance. At the same time COVID-19 pandemic has changed system of education at all its levels, but the issue of quality and efficiency is still to be considered and studied by scientists and practitioners.

Under these conditions the issue of adaptive information environment creation becomes relevant for training modern and competitive specialists. This environment should be based on implementation of adaptive technologies for education and training of maritime students, therefore, article provides investigation of pedagogical problem of future navigators' professional culture building in training system of adaptive information environment of maritime educational establishment. Feasibility of adaptive learning technologies implementation is grounded as a tool for future navigators' professional culture building in the process of their fundamental education and training.

Example of higher mathematics adaptive learning implementation for future navigators at Kherson State Maritime Academy is considered. Higher mathematics adaptive learning was introduced through: adaptive feeding of educational content of the course; problems solving support based on examples and pre-created typical algorythms; adaptive testing; analysis of test tasks answers; system teacher support; constant support conditions for individual tasks completion; adaptive course navigation, etc. As the result of experiment there was found out that higher mathematics adaptive learning for future navigators presupposes: individual learning path designing; possibility to timely provide advising and objective control as well as evaluation; enhancement of learning activity and motivation of through improved degree of autonomy; promotion of students' research skills development; creation of cooperation, partnership and maritime brotherhood atmosphere.

Keywords

Adaptive learning environment, future marine navigators, higher mathematics, system of education and training.

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1. Introduction

Modern globalization of society conditioned great interest of scientists and practitioners to the problem of future maritime specialists' training and education both in Ukraine and in the world. Thus one of strategic tasks of modern Ukraine is the necessity to transform the system of future maritime specialists' education and training, in particular its professional constituent connected with Mathematics. It was defined in international and national standards namely in International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), Strategic Plan of Marine Transport Development till 2020, Strategy of Ukrainian Sea Ports Development till 2028, etc.[1]

Under this conditions the issue of maritime education quality improvement at all levels and all forms of implementation becomes particularly relevant. Solvation of this issue is first of all connected with improvement fundamental training quality, namely in Mathematics and Physics, which creates important ground for learning professional cycle courses. Mathematical basis is the platform for development and training of future navigators. Mathematical training, as a constituent of fundamental training, is of special concern of maritime educational establishment stakeholders. Main stakeholder of Kherson State Maritime Academy (KSMA) provides for the students tests in Mathematics and Physics developed by specialists from the industry. This testing is conducted on the platform LMS MOODLE using all its resources. The results of testing are immediately sent to the company by the system, the representatives of stakeholder check the tests and the Academy receives consolidated report on the result. Twice a year Academic Council of KSMA considers the results of this test and introduces changes to the programme of education and training [9-10, 19].

Government of Ukraine defined the year of 2020 as the year of Mathematics; besides the 40th session of General Conference of UNESCO on September 3, 2019 declared the 14th of March to be the International Mathematics Day. Session's resolution emphasizes that enhancement of global mathematic training has the key role for solving such modern actual issues as artificial intelligence (autonomous sea vessels), climate change (rise of World Ocean level), Energetics, improvement of humanity welfare; it also reveals applied nature of Mathematics and its importance for progress in all fields of Engineering, marine in particular. Thus improvement of methodics of future maritime specialist's education and training in mathematical, science and professional disciplines with wide implementation of digital technologies becomes an urgent issue.

The second half of 20th century became the period of transition of society to the state of information one. Introduction of modern information and communication technologies became the priority development direction for professional education of Ukraine. National Strategy of Education Development in Ukraine for 2012-2021 emphasizes that the main tasks for modernization of education include: digitalization of education; development of effective system of teaching in education; creation conditions for development of modern teaching tools industry. At the same time, the influence of innovation technologies development becomes greater both in maritime industry and maritime education.

In the conditions of constant development of digital technologies in technical equipment of sea vessels the conditions of work are being changed, and these changes cause shifts in the models and conditions in education and training. The above mentioned makes creation of adaptive information environment relevant; this environment should be based on introduction of adaptive technologies for education and training of future maritime specialists.

2. The theoretical basis of research

Adaptive learning s included to list of main trends of modern innovative education along with mobile and blended ones, micro-learning, gamification, VR, AR, critical thinking and others [2-11, 19-20]. The notion of adaptivity and adaptive learning system (ALS) is not new in science; a lot of researchers from different countries investigated classified and introduced it into their educational works. In 2015 Peter Froschl in the work "Adaptive e-Learning with Eye-Tracking" considers adaptivity as "possibility to change necessary to solve different situations" and defines five basic adaptive systems: macro-adaptive systems (they have a set of disadvantages, absence of consideration individual features among them); micro-adaptive systems; micro-adaptive systems of abilities' correlation and possibilities of their correction; intellectual learning systems (ILS) (supplemented with hypermedia potential); adaptive hypermedia systems (principal element of it is a student; it is impossible to design ALS without thorough information about the level of students' education and knowledge, as well as about the aim and requirements of future profession) [13].

From the point of view social and philosophical basis Maron, A. considers adaptation as two-track process of educational environment adjustment to the personality of a student. "Adaptation is adjustment, its function is to provide appropriate generally accepted behaviour and activity of a person corresponding to his internal structure (interests, value orientations, peculiarities of temperament)" [14]. The researcher points out main directions of adaptive learning: psychological and motivational adaptation, which presupposes transformation of person's actions due to his mental activity, understanding of importance of strategy and methods choice for achievement of predictive learning outcomes; organizational and objective focused adaptation aimed at maximal approximation of participants' objectives and system of educational process arrangement based on their individual peculiarities; content adaptation involving selection of targeted study material, variability of study plans and educational programmes; technological adaptation interpreted as possibility to adjust study programme to the peculiarities of specific educational process aiming at its streamlining.

The above mentioned leads to the conclusion that ALS structure incorporates one subject of adaptation with all its requirements and needs and a number of objects of adaptation containing different factors of adaptation.

The researchers Moscal, P., Carter, D. and Johnson, P. (2017) used a very definitive, to our mind, comparison of ALS and GPS. During learning educational discipline by a student there should be taken into account principles of personalization of education; they provide possibility to alter educational technologies (route in GPS) leading to the aim of the course. It is feasible due to the possibility to evaluate and assess the knowledge constantly and, depending on the result, to implement definite corrective actions in order to achieve progress in the results [15, 19-20].

As we can see there are a lot of researches proving advantages and opportunities of ALS introduction, but presently there is no well-defined concept of adaptive learning in electronic environment; therefore, design of ALS is an actual task. We shall define ALS here as educational resource developed in the context of competence-based approach, represented in digital form and containing technologies capable to adapt a subject of learning taking into account and on the basis of his personal features and characteristics. [16-17, 19].

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3. Experimental study

During the survey of first-year students of KSMA Navigation Faculty there were singled out a set of shortcomings in the arrangement of education and training process of the Academy. Following issues, according to the results of the survey, prevent the students from successful adaptation: overload with classroom lessons (35%), lack of basic knowledge (23%), challenges in adaptation due to students' life and drills (18%), low level of motivation to study (12%), insufficient awareness of students about the changes in KSMA programmes and about results of their studies (38%). Besides there was conducted a survey among the students/cadets connected with the nature of relationships in the frameworks "cadet-cadet" and "cadet-teacher". The results of this survey is depicted in figure 1.

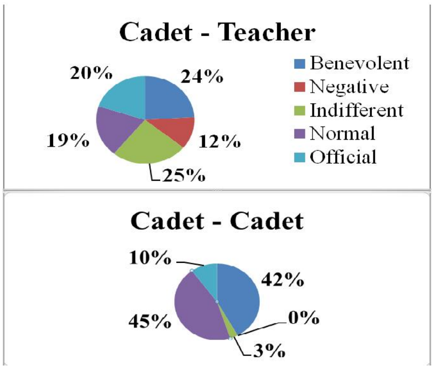


Fig. 1. Nature of relationships in the frameworks "cadet-cadet" and "cadet-teacher".

Figure 1 reveals that the majority of cadets/students (42%) regard their relationships with their mates to be benevolent; at the same time only 24% of them consider their relationships with teachers as benevolent, 12% see them as negative and 25% of cadets/students believe that teachers are indifferent to them. We suppose that the abovementioned issues will be coped when the personality of a cadet/student is in centre of the educational process arrangement. Meeting these challenges is seen as designing of adaptive learning environment, including higher mathematics learning system.

Information adaptive educational environment is understood here as an aggregate of conditions ensuring information interaction between the participants of the process and interactive learning tools aimed at well-timed an effective adaptive corrective actions based on personality oriented approach as well as implementation of modern pedagogical and information communication technologies at different stages of education and training process.

Principle of adaptivity in education and methodical aspects of adaptive learning in modern information system ia aimed at designing individual education programmes, at psychological corrections of student's actions stereotype, his thinking mode and implementation mechanisms. The concept of adaptive learning in modern information system is built on the basis of following principles: personalization (content of an educational discipline is divided into levels of complexity, which allows a cadet/student to choose his own learning path and to design individual environment of study materials; it envisages individualization of interaction between a teacher and a cadet/student); variability of learning content of a course (learning content of a course has different forms of delivery); cyclicity of learning (automatic return to learning material in order to refresh or improve knowledge and understanding); participation (students learn problem solving according to the proposed by a teacher algorithm of actions and individual creation of algorithms for new problems solving depending on the chosen complexity level); autonomy (students learn searching necessary materials individually, allocate principal information, think autonomously, design their own algorithms for problems solving as well as for learning new materials); systematicity and consistency (learning content of a course should be proposed for students/cadets in the form of logic sequence of developing knowledge, understandings and skills in a course module and logic interconnection between modules) [19-20].

In the conditions of adaptive information system, a teacher becomes a promoter, mentor and tutor providing advising, guidance and inspiration for achievement of the learning outcomes defined for the profession of marine navigator. Adaptive learning system utilizing modern information technologies activates the process of education and training through: providing possibility for cadets/students to design individual learning path (pace and rhythm of learning activity, schedule of work with training materials, choice of complexity level, etc.); introduction of differentiated approach to education and training (education and training is student-centered, it takes into account individual peculiarities and motive); optimization of control over the level of student's competences built (system of knowledge and skills monitoring introduces corrections to learning path according to individual features of a cadet/student); enhancement of evaluation and assessment process credibility (information system leaves human factor aside the process of evaluation and assessment); promotion of cadets'/students' autonomy, engagement and sociability during interaction with a teacher and mates in the information system); creation of partnership and cooperation environment between a teacher and cadets/students.

The aim of adaptive learning technology is development of autonomy, self-control, skills of research work in the conditions of maximum adaptation of education and training process to individual peculiarities of a cadet/student. In these conditions a teacher should provide monitoring and control of individual work of every cadet/student; ensure individual teaching actions for those stuck with their studies and for those having leading results in comparison to their mates); encourage cadets/students to learning; provide up-to-date information about novelties of the course. Under the conditions mentioned above, modern information system, operating the principles of adaptive learning, in our case it is the full course of Higher Mathematics (meaning classwork, individual distant work) should ensure learning process.

Analysis of information learning systems and algorithms of adaptive learning design available is given and summarized in the form of table (Table 1) [19].

Table 1.
Adaptive learning systems introduced in different countries of the world.

Learning System	Learning Algorithm in Interactive Adapted Learning System
AHA! (Adaptive Hypermedia Architecture)	System for creation of adaptive web-applications (aha.win.tue.nl). Adaptation is achieved through step-by-step analysis of baseline and interim information about user; based on this information user's model and the system itself are adjusted.
Brightspace	Virtual learning environment including a great number of training materials, resources and learning platforms; using all these it is possible to design individual learning paths for students. In the education and training process a student is actively involved in communication with teachers. This communication provides possibility for correction actions in terms of individual learning path.
Geekie	System provides access for students to following learning materials developed by the teacher: videolectures, digital materials for practical lessons, topical tests, individual practical classes etc. Students operating with these materials are made ready to the final assessment works. The programme monitors the whole process of education and training, summarizes and systemizes personal information of every student and provides it for the teacher. Every study course starts with a test with the results providing information about the level of necessary competences development of students. Based on the results of diagnostic test there can be chosen content of the course aiming at the learning outcomes. All learning materials are of multi-level character, therefore every student can individually design own learning path for the course (level of complexity, types of activities, pace, timing etc.).
Knewton (MyLab & Mastering series)	Platform for designing programmes with adaptive function. MyLab & Mastering series project is the system providing answers for following questions: what student knows; why he made mistake in the task completion; what learning material is more important; what student's prognostic performance can be reached at every stage of education and training.
DreamBox Learning Math	Adaptive online-maths programme based on Intelligent Adaptive Learning technology monitors the results of learning activity of a student, analyses methods and algorithms used during tasks completion. Based on the information collected the system introduces changes into the content of the course (level of tasks complexity, number of prompts, information to be learned, pace of learning etc.).
InterBook	A tool intended for electronic textbooks and manuals designing. The server of InterBook creates individual learning path for every user registered; it ensures adaptive guidance, adaptive navigation support and adaptive help tips and prompts for students.

Smart Sparrow	Open learning platform allowing creation of interactive adaptive courses. Learning is based on “small data” approach using algorithms, which allow to analyse previous answers of a student in order to choose next question or task. There is a possibility to arrange teacher’s feedback to students for learning process support in the form of prompts (links and references to the source, video or audio materials, charts, pictures, figures, basic diagrams etc.) right in the moment when a student meets difficulties in doing task or answering question.
Aero	The system defines objectives of the course, topics, tasks for individual work and topical tests. The system stores information about results of tasks completion, number of attempts, number of consulting with theoretical part of course. Thanks to adaptivity (personalization), tasks are different for every student. The system autonomously decides time and content of material to be revised. Thus, a teacher can create fully individualized course and anticipate the final quality of knowledge.
Stepik	A construction kit of free open online courses and lessons providing possibility to create interactive courses with feedback loop.
Plario	Platform created aiming at decreasing teacher’s workload during the process of freshmen adaptation. On the basis of results of initial diagnostic testing in mathematics the system detects existing problems and designs scheme of the detected problems improvement through framework of microlearning. Algorithm of adaptive learning in the system leads a student from the simple to the complex. Learning material is provided in small portions, tasks are specifically aimed at training separate mathematical skills. Every problem in the system has example of solving and a student can address to it at any time. In addition, the system contains elements of gamification aimed at students’ interest raising to the process of education and training.
MOODLE (Modular Object-Oriented Dynamic Learning Environment)	LMS Moodle allows generation of own system with necessary functional possibilities, namely: management of learning activity of students, controlling tasks completion, designing individual sets of educational and training tasks, adjusting the structure of a course to the personality of every separate student.

Analyzing all the adaptive learning systems mentioned above we can make a conclusion that Big Data (big volume of structured and non-structured information operating for data collection, storage and processing) and Data Mining (work with several structured data; search for interconnections in-between big volume of data, anticipation, classification and visualization) – these are basic technologies of any modern intellectual interactive adaptive system [11-15, 19-20].

On the basis of analysis of existing adaptive learning systems we had an opportunity to find out definite drawbacks (absence of information about psychological readiness of students to study, it could have greatly facilitated the process of adaptation and improve the quality of education in general; there is unified model for adaptive learning designing) and advantages (possibility to collect, store, synthesis and systematization of large volume of personal information about a student aiming at further adaptation of learning process; saving teacher’s time for checking tasks completed, analysis of problem issues and arrangement of individual learning path for every student.

In order to implement adaptive learning in the course of Higher Mathematics teachers of Department of Natural Sciences designed and created information adaptive environment on the basis of System of E-Learning Management of KSMA (https://mdl.ksma.ks.ua/login/index.php) for students of Navigation Faculty. The course of Higher Mathematics for students of Marine Engineering Faculty was delivered using traditional mode and methodics.

Experimental work aimed at introduction of adaptive learning in Higher Mathematics course for future seafarers was conducted using existing information system (https://mdl.ksma.ks.ua/login/index.php), which is adequate enough for learning separate disciplines and utilizes mediated interaction of distantiated participants of education and training process in specialized environment functioning on the basis of modern psycho-pedagogical and information-communication technologies [19].

When learning professional disciplines students need quite high level of mathematical background. For example, before starting learning the course of Celestial Navigation students are proposed to take diagnostic testing aimed at defining gaps in mathematical background. In case of passing the test with high or sufficient level a student receives access to electronic course of Celestial Navigation. To the contrary, failing this test (the result of the test is average or lower than average) a students is sent to by the link to special course of Mathematical Foundation of Navigation, which in its turn has cyclic and adaptive nature of learning materials delivery (Fig.2).

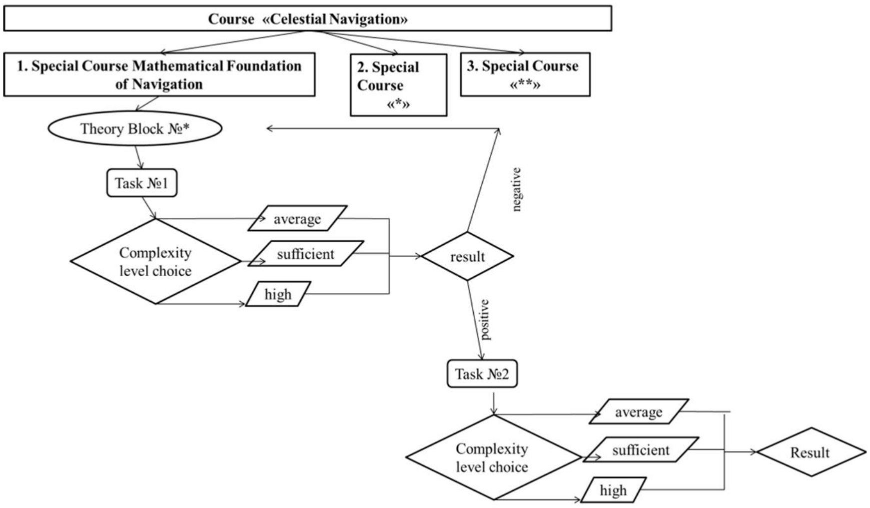


Fig. 2. Model of cyclic management of students' adaptive learning (special course Mathematical Foundation of Navigation)

Model of cyclic management of students' adaptive learning for electronic special course Mathematical Foundation of Navigation includes following steps:

Familiarization of students with the programme of special course Mathematical Foundation of Navigation and with evaluation and assessment criteria as well as with the specifics of learning the material using MOODLE platform.

Students' independent choice out of the proposed learning materials of the course of: a) level of the course materials (high, sufficient, low); b) types and number of mathematical tasks corresponding to the chosen level of complexity; c) forms of current check.

Coordination with the teacher of the chosen types of learning materials, forms and schedule of current check.

Student's mapping out of individual plan for completion, recording and reporting of the chosen individual tasks connected with the Module 1 (individual learning path) and introduction of it to the teacher through filling in and downloading of corresponding Google form.

Teacher's familiarization with students' individual plans, their systematization according to the levels, arrangement of corresponding groups of students.

Drafting of group online consultation schedule.

Providing of online consultation of students' groups differentiated according to the levels of complexity in line with the schedule.

Presentation of completed individual tasks (projects, laboratory works, solved applied problems, etc) through Internet.

Online discussion of the presented tasks: their peer review, possible improvement proposals, defining the best works, etc.

Doing current stop and check tasks, taking online progress tests and offline final test on Module #*.

Assessment of all tasks and tests, putting marks in e-register and proposing final module #* mark for every student.

Student's reflection of the proposed final mark for the Module #* and development of correction programme as well as defining its terms of completion in case of insufficient result.

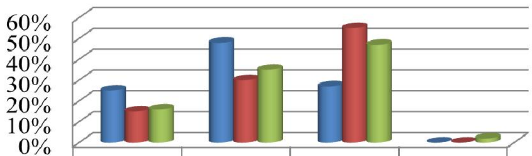
Correction of learning outcomes through doing additional tasks, having next final evaluation and assessment and putting final mark for Module #* in e-register.

Adaptive learning of Higher Mathematics course for future navigators was implemented through: adaptive provision of learning content of the course; support for problems solving in the form of examples and designed algorithms of solving for typical problems of the course; adaptive testing; analysis of answers of the testing tasks; scheduled teacher's consultations; creation of conditions for constant support in students' individual tasks completion; adaptive course navigation, etc [19-20].

Interactive lecture material is delivered in small portions, after every portion student receives stop and check questions and, in case of wrong or insufficient answer system sends a student to the page of lecture containing necessary information. Access to the learning content of the next level is provided only in case of sufficient completion of previous task. Every module ends up with final evaluation and assessment. After being tested students have the possibility to review the questions with wrong answers; to receive necessary online teacher's consultation and to be tested and evaluated once more. All tests and tasks of the course are compiled in unified base, which is used for the final evaluation and assessment test at the end of the course of higher Mathematics. Thus both a student and a teacher can anticipate final performance and achievement after having the results of every test.

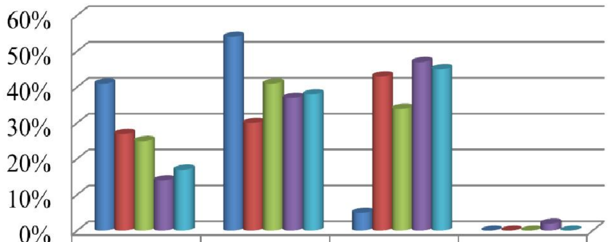
The experiment for checking efficiency of information adaptive system during the course of Higher Mathematics was held during the process of students' selection for their first onboard practice by the company Marlow Navigation. The selection consisted of two stages: internal and final one. It took place right after completion of the course of higher mathematics. The aim of the selection was to check readiness of students to implement their mathematical competences in practice of real industry. We compared adaptive course of higher mathematics (Navigation Faculty students) and traditional one (Marine Engineering Faculty students). Test in mathematics, provided by the company, was aimed at checking the level of mathematical competence development of future maritime specialists and their readiness to solve problems of navigation and marine engineering onboard. The results of this test we consider to be valid ones as the test was created by stakeholder's representative from the industry and was checking the applied nature of students' competence level.

The content of the test tasks was aimed at checking following mathematical skills: solving triangles on a plane; solving rectangular and spherical triangle; finding of the differences in vessel's location between sets of coordinates (latitude, longitude); finding the shortest distance between ports (orthodromic distance); finding distances at sea and azimuths of ports from vessels; usage of proportion to solve maritime problem; finding latitude of parallel etc. Content of all these tasks correspond to International Maritime Organization Model Course for higher mathematics [18-20].



	Excellent (90-100)	Good (74-89)	Satisfactory (63-73)	Unsatisfactory (0-62)
221	25%	48%	27%	0%
222	15%	30%	55%	0%
321	16%	35%	47%	2%

Fig. 3. Distribution of Marine Engineering Faculty students according to levels of mathematical competence



	Excellent (90-100)	Good (74-89)	Satisfactory (63-73)	Unsatisfactory (0-62)
121	41%	54%	5%	0%
122	27%	30%	43%	0%
123	25%	41%	34%	0%
124	14%	37%	47%	2%
125	17%	38%	45%	0%

Fig. 4 Distribution of Navigation Faculty students according to levels of mathematical competence

Diagrams given in Fig.3-4 reveal that students of Navigation Faculty showed higher level of mathematical competence development than students of Marine Engineering Faculty. The highest quality level of mathematical competence was found among the students of Group 121. This group has the highest percentage with high and sufficient levels (41% and 54% correspondingly). Groups 121-123, 125 have 100% performance results according to the test results. Group 221, also showed quite high results in the tests, but in general Marine Engineering Faculty students have the indices that are much lower than those of the students of Navigation Faculty. Thus, students being delivered with adaptive learning through adaptive learning environment showed good results.

4. Conclusions

Implementation of adaptive learning in the course of Higher Mathematics for future seafarers is done through designing of adaptive learning environment, which implies: creation of individual learning path (pace of learning, complexity level, terms for completing individual tasks); possibility to conduct constant monitoring and consulting and to evaluate objectively the learning activity of students; promotion of research activity and motivation through high level of autonomy; encourage development of students' research skills; creation the atmosphere of partnership and cooperation. Usage of the e-learning platform creates conditions for more effective development of mathematical competence. One of the most important elements of this environment is psychological adaptation of students for learning process in the educational establishment. This adaptation is effectively done in the friendly environment created both by teachers and by students. Further research is needed in order to elaborate possibilities of adaptive learning environment for future maritime officers education and training.

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Use of the dynamic mathematical program of GeoGebra in classes in mathematical disciplines in the conditions of blended learning

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Abstract

This article describes one of the universal tools for facilitating blended learning of mathematical disciplines, in particular linear algebra, is the dynamic mathematical program GeoGebra. This program helps to visualize the mathematical objects studied, demonstrate their properties, avoid routine actions, etc. Using GeoGebra makes it possible to improve the quality of the process of solving mathematical problems and improve the professional, mathematical and informational competence of future mathematics teachers. The results of student survey are analyzed and presented regarding the expediency of using this technology in future professional activity. It is established that the, the dynamic mathematical program GeoGebra is a universal tool for organizing blended learning. Using its capabilities, you can both organize the work during the lesson and further independent performance of tasks, and use it at any stage of the lesson.

Keywords

ICT, dynamic mathematical program GeoGebra, future math teachers, blended learning, mathematical competence, informational competence.

1. Introduction

1.1 Formulation of the problem

The rapid development of information technologies, their application in all fields, everyday life, their penetration into the field of education, necessitates computer support of the educational process. That is why the priority of education in the National Doctrine of Education in Ukraine in the XXI century [25] is the introduction of modern information and communication technologies that further improve the educational process, accessibility and effectiveness of education, preparing the young generation for life in the information society. In particular, the document identifies one of the ways to achieve this is by the introduction full-time learning along with distance learning with the use of information and communication technologies along with traditional teaching aids.

The combination of full-time and distance learning tools in the educational process of higher education institutions provides blended learning. Modern students are representatives of the «digital» generation who want to learn quickly, efficiently and dynamically. Blended learning is one way to

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give them that opportunity.

1.2 Analysis of recent research and publications

One of the important factors that determine the level of economic and socio-political development of the country is the quality of education of its population, in particular, mathematics. Improving the quality of mathematical knowledge of higher education seekers is one of the most urgent and important tasks modern higher education institutions in general, and pedagogical, in particular, face. The use of blended learning contributes to the improvement of mathematical knowledge of future mathematics teachers, the improvement of the educational process, the rational use of time and resources, and the increase of students' motivation for high-quality mastering of mathematical disciplines.

Some aspects of the use of the model of blended learning in the education system were covered in the works of domestic and foreign scientists: Barna OV [17], Bugaychuk KL [18], Kademiya M.Yu. [21], Korotun OV [22], Krivonos OM [22], Murashchenko TV [24], Nakitina MS [26], Tkachuk GV [27], Moebs S. [10], Weibelzahl S. [10], Charles R. Graham [4], Ismail A. O [5], Mahmood AK [5], Abdelmaboud A. [5], Ghazal S. [3], Al -Samarraie H. [3], Aldowah H. [3], Owston R. [11], York D. [11], Malhotra T. [11].

Today, the term «blended learning» (blended or hybrid learning) in domestic and foreign scientific and educational literature has different interpretations:

- a practical tool for modernization of modern education, that creates new pedagogical methods, which are based on the integration of traditional approaches to the organization of the educational process, where the transfer of knowledge and elearning technologies is happening [22];
- purposeful process of acquiring knowledge, skills and abilities in the context of integration of classroom and extracurricular educational activities of educational subjects based on the use and complementarity of traditional, electronic, distance and mobile learning technologies in the if a student properly manages time, place, routes and pace of study [23];
- learning system, which includes the integration of various forms of learning (full-time learning in classrooms, e-learning and individual learning), which results in a better formation of competencies [26].
- pedagogically balanced combination of traditional, electronic, distance and mobile learning technologies aimed at the integration of classroom and extracurricular learning [24];
- combination of distance and traditional communication in the process of integrated educational activities [10];
- an approach that combines traditional learning with the use of online learning methods (for example, podcasts, materials and activities conducted on the Internet through educational platforms) [4];
- combining traditional formal learning tools: working in classrooms, studying theoretical material - with informal, like, with discussions via e-mail and Internet conferences [20];
- a kind of hybrid method, that combines online learning, traditional and independent learning [28], etc.

The effectiveness and efficiency of the use of blended learning in the process of the students acquiring mathematical knowledge depends on a rational combination of different approaches, methods of presenting, types of work, teaching aids and more. Teaching aids should be modern, reliable, accessible and easy to use. One of the universal tools for facilitating blended learning of mathematical disciplines is the dynamic mathematical program GeoGebra, which helps to visualize the mathematical objects studied, demonstrate their properties, avoid routine actions, etc. Using GeoGebra makes it possible to improve the quality of the process of solving mathematical problems and improve the professional, mathematical and informational competence of future mathematics teachers.

Much attention has been paid to the peculiarities of using the dynamic GeoGebra package in the educational process by foreign scholars, such as: Mailizar [8], Johar R., [8], Jorge Olivares Funes [7], Elvis R. Valero Kari [7], Jorge Andres Olivares Funes [6], Elvis Valero [6], Barahona Avecilla F. [2], Barrera Cardenas O. [2], Vaca Barahona B. [2], & Hidalgo Ponce B. [2], Arceo-Diaz S. [1], Barrios EEB [1], Maravillas JA [1], Salazar-Torres J. [1], Sugandi AI [14], Bernard M. [14], Majerek D. [9], Septian A. [12] , Suwarman RF [12], E. Monariska [12], R. Sugiarni [12], Septian A. [13], Darhim [13], Prabawanto S. [13], Yismaw A. [15], Wassie G. [15], Awgichew Z., [15], Ziatdinov R. [16], Rakuta V. [16].

Thus, scientists Yismaw A., Wassie G., Awgichew Z. [15] analyzed the possibilities of GeoGebra in process of teaching mathematics and found that the use of this system helps to increase students' interest in learning mathematics. Ziatdinov R., Rakuta V. [16] emphasizes the effectiveness of using the GeoGebra environment for the formation of algebraic thinking skills.

The purpose of the article is to highlight the feasibility and effectiveness of using the dynamic mathematical program GeoGebra in classes in mathematical disciplines (on the example of linear algebra) in a blended learning environment.

2. Methods of the study

Methods used in the research process include: analysis of theoretical sources, generalization of the best pedagogical practices of foreign and domestic specialists of using the dynamic mathematical program GeoGebra in classes in the process of teaching mathematical disciplines (using the example of linear algebra) in a blended learning environment; synthesis, generalization and conceptualization for the development of the main research provisions; interviewing students; generalization of results.

3. Results

One of the most important disciplines of the fundamental cycle of training future teachers of mathematics is linear algebra. The purpose of the discipline «Linear Alge-bra» in pedagogical universities is: to reveal the concept of linear transformation in finite-dimensional spaces, understanding its position and role in the general system of mathematical knowledge and ability to apply it in specific situations, as well as education of algebraic and numerical culture.

When solving a series of problems in linear algebra, it is often time-consuming to perform cumbersome calculations. This leads to a focus on minor details, the performance of ordinary mathematical calculations, and important, significant points are ignored. Therefore, to ensure the automation of solving a certain group of problems, increase the efficiency of learning using the latest techniques and technical teaching aids, in the course of linear algebra it is appropriate and effective to use a dynamic mathematical program GeoGebra.

In addition, the use of the dynamic mathematical program GeoGebra in learning linear algebra is reasonable due to many other factors, including:

- intensification of the educational process, in connection with which more and more hours for the study of linear algebra are allocated for individual learning. So, for example, in Pavlo Tychyna Uman State Pedagogical University, the linear algebra curriculum dedicated 180 hours to the discipline, out of them 94 hours are set aside for independent study of educational material by students.
- the difficulty of studying linear algebra by students, in particular due to the need to cover a lot of theoretical material, therefore there is a need to constantly intensify the educational activities of students and promote interest in the discipline.
- the need to visualize educational material, to quickly and effectively evaluate the results of educational activities, etc.

GeoGebra software can be used to increase the efficiency of individual learning of linear algebra, and during lectures and practical classes as part of full-time and distance and blended learning. During practical training in linear algebra, GeoGebra can act as an intermediary between the teacher and students, acting as a simulator in solving certain types of problems. For example, the applet «Gauss-Jordan – Latest» can be used during the practical lesson for first-year students majoring in 014.04

Secondary Education (Mathematics) on «Systems of linear equations», aiming to develop practical skills and ability to solve systems of linear equations by Gauss and Jordan-Gauss (Fig. 1) [19].

Figure. 1. The GeoGebra applet is designed to solve systems of linear equations

In a practical lesson, before students use the applet on their own, the teacher needs to show all its possibilities by a concrete example. One must first propose to solve a system of linear equations that has one solution. By identifying a single solution using an applet, students can check the notebook on their own. For example, one can consider the solution of the system $\begin{cases} 2x_1 + 6x_2 + 7x_3 = 25, \\ x_1 + 2x_2 + 3x_3 = 10, \\ x_1 + 4x_2 + 6x_3 = 17. \end{cases}$ The functionality of the simulator involves the introduction of any system (Fig. 2).

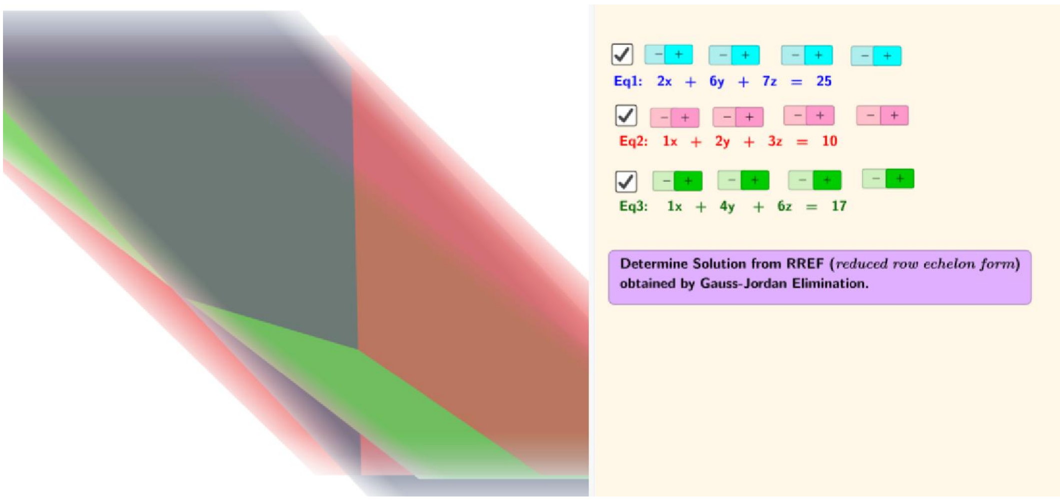


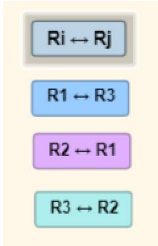
Figure 2. Writing a system of linear equations

Using, a specific example, the teacher shows that with this applet you can work the following elementary transformations on the rows of the matrix:

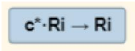
1. Permutation of two lines in places.

Rearrangement of two lines in places can be done using the appropriate button 

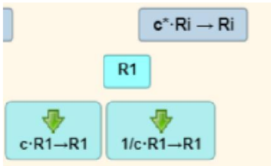
, which

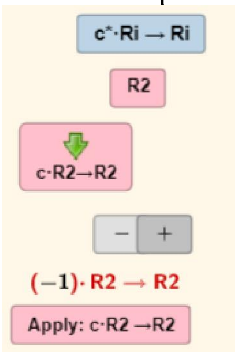
after pressing takes the following form: 

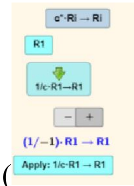
. At this stage, students should be given useful advice that it is desirable to choose the leading element of the first line so that it is not zero and is equal to ± 1. Rearranging lines in places will help to do this.

2. Using the button 

(which after pressing is transformed into a button 

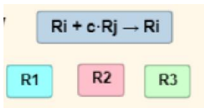
, 

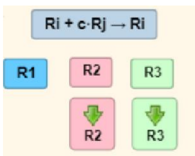
, 

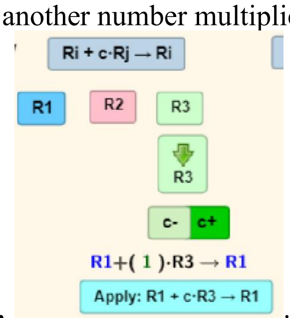
) you can multiply the selected line by any number. At the stage of multiplying a line by a number, the teacher draws attention to the fact that there may be cases when it is possible to reduce both parts of the equation by a number (say c), which will simplify the following calculations. This can be done by multiplying the row of the extended system matrix by the number $\frac{1}{c}$ (

).

3. Add a line multiplied by some number to another line.

You can add another number multiplied by a number to one line using the button 

, 

, 

. At this stage, the teacher needs to explain why the leading element of the first line was made the number ± 1, demonstrating with the help of the applet of addition to each line of the first, multiplied by the corresponding coefficients.

By reducing the matrix to a stepped shape, the teacher can use this simulator to continue to transform the matrix of the system into a consolidated stepped shape, reminding students of the difference in solving systems of linear equations by the Gaussian and Jordan-Gaussian methods.

After writing down the solutions of this system, students can be asked to solve two more systems of linear equations, for example, the system $\begin{cases} x_1 + 2x_2 + 3x_3 = 4, \\ 2x_1 + x_2 - x_3 = 3, \\ 3x_1 + 3x_2 + 2x_3 = 7. \end{cases}$ $\begin{cases} x_1 + 2x_2 + 3x_3 = 4, \\ 2x_1 + 4x_2 + 6x_3 = 3, \\ 3x_1 + x_2 - x_3 = 1. \end{cases}$ one of which has many solutions, and the other has no solutions.

If the lesson is in remote or mixed modes, then the demonstration of the use of the dynamic mathematical program GeoGebra should be done screen sharing using video conferencing programs, such as Google Meet, Zoom, etc.

Despite the simple and intuitive tools of the applet, before letting the students to use it independently using it independently, the teacher must not only introduce students to the functionality by solving specific problems, but also provide students with instruction cards. Instruction cards should be compiled in such a way that the student can work independently with the service without the help of the teacher (see Fig. 3). To do this, one needs to include QR-codes with a link to the applet and other useful links, as well as a specific example, to show the stages of solving a system of linear equations in the instruction cards. Since some students may have difficulty understanding the purpose of certain buttons, it is desirable that the instruction cards have a translation of the inscriptions.

We offer to provide students with a bank of tasks (3-6 tasks), which they must perform with the help of a simulator. This type of work will contribute to the formation of practical skills and abilities to reduce systems to row echelon form and reduced row echelon form, to solve systems of linear equations by the Jordan-Gauss method. This type of work with this simulator will teach students to perform methodically correct transformations, without wasting time on simple calculations. However, as practice shows, students make the most mistakes performing simple calculations, which leads to incorrect solutions. Therefore, after working in the program GeoGebra, it is necessary to offer students to perform several more tasks in notebooks, in order to prevent errors in actions with coefficients.

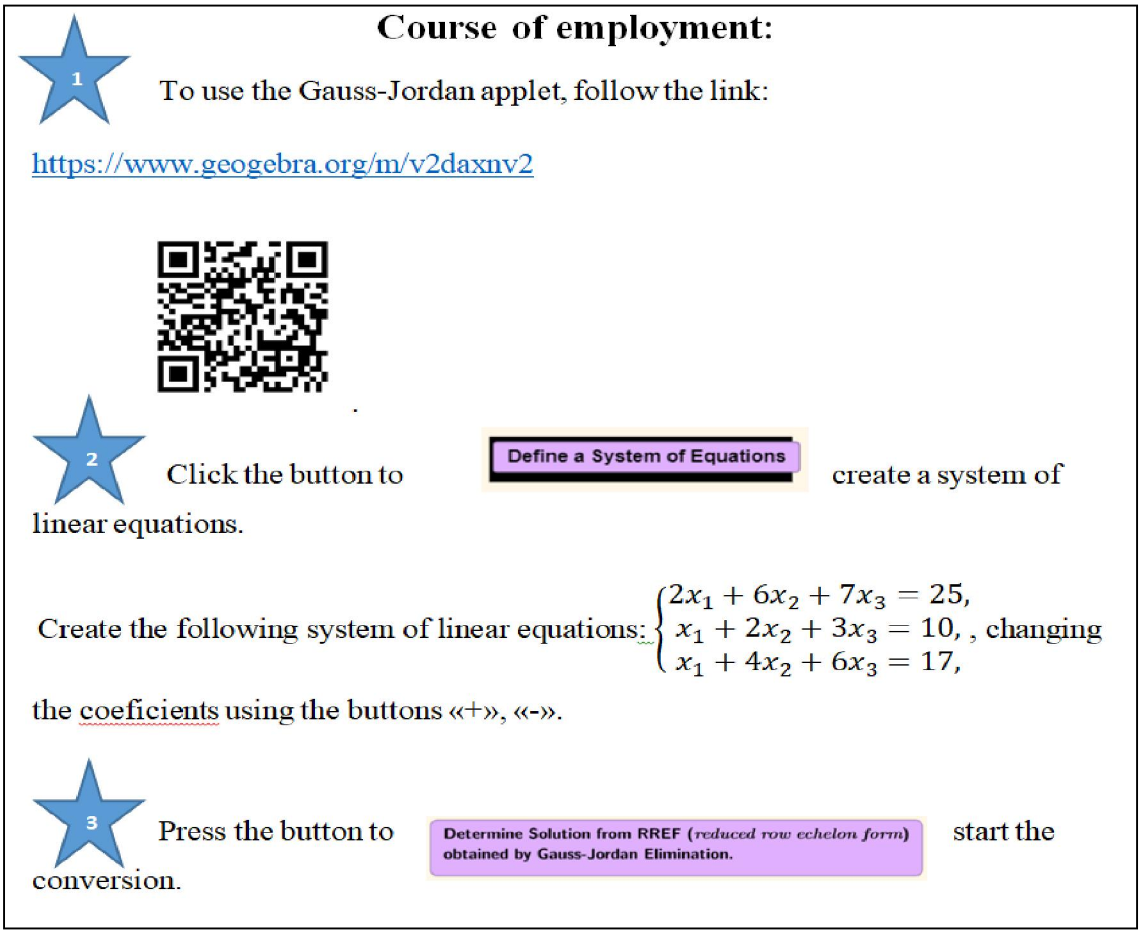


Figure. 3. Fragment of the instruction card

Availability of GeoGebra program promotes realization of an educational path of applicants of higher education. Students can work with the program not only during classes according to the schedule, but also in extracurricular, convenient time. They can choose the appropriate composition and number of tasks, the resolution of which, in their opinion, is necessary and sufficient (depending on individual capabilities and needs) for the comprehensive assimilation of educational material and the development of appropriate computational ability and skills.

There are many advantages to using the «Gauss-Jordan - Latest» applet [19] during practical problems in linear algebra. The main ones are:

- increase of the efficiency of formation of practical skills and abilities of students to solve systems of linear equations by Gauss and Jordan-Gauss methods by developing a clear, methodically correct algorithm of students' actions;
- significant time savings due to elimination of routine calculations;
- involving students' cognitive activity;
- work with the simulator can be done not only with the help of desktop computers or laptops, but also with the help of tablets or smartphones, which allows for teaching in the places other than computer classrooms. Connected to the Internet, students can have online can complete tasks as effectively as during face to face classes. Thus, the GeoGebra software becomes an indispensable assistant in blended learning;
- GeoGebra applets are easy to integrate into electronic manuals or textbooks.

However, there are significant disadvantages of using this simulator, among them:

- the need for tools to work with the program GeoGebra, as well as connection to the Internet;
- insufficient level of computer literacy and methodical preparation for practical work using the dynamic mathematical program GeoGebra;
- students use programs for other purposes, which can lead to poor learning of educational material.

After conducting classes in linear algebra in a blended learning environment using the dynamic mathematics program GeoGebra, students were surveyed about the interest and effectiveness of using this program. Students were presented with a QR code, with the link to the questionnaire the students could answer using their phones and tablets.

The survey can be conducted both synchronously (in the audience, «here and now») and asynchronously - at any time within a specified interval of the survey.

- 9 students of the Faculty of Physics, Mathematics and Informatics of Pavlo Tychyna Uman State Pedagogical University took part in the survey. The results of the survey are presented in Figures 4 and 5.

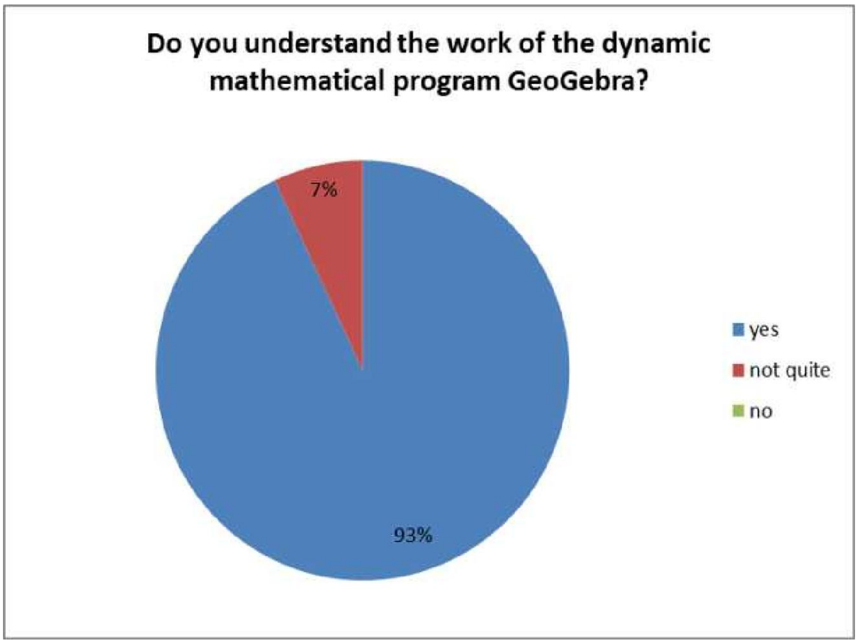


Figure 4. Results of students' questionnaire

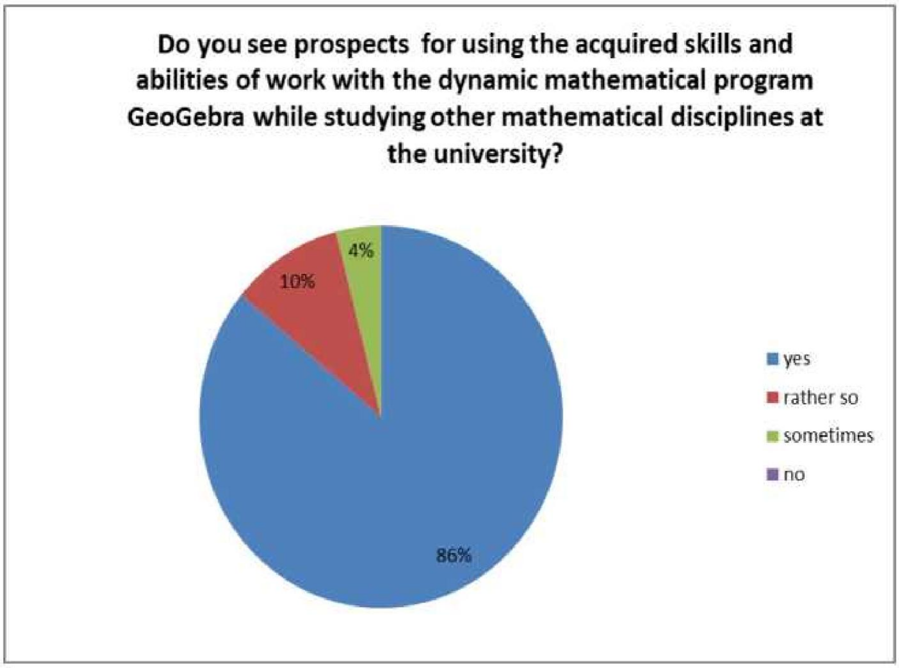


Figure 5. Results of students' questionnaire

The interaction of participants in the educational process with various computer based teaching aids, so-called teaching aids, should be used in classes in professional disciplines as often as possible, so that future teachers can successfully and skillfully implement them in their professional activities. After all, such computer-based learning tools allow to optimize and bring excitement and interest in the educational process, and motivate students.

The use of GeoGebra should not be limited to lectures or practical classes, one can ask students to do homework on their own in a notebook, and only then check in the program. One can use the proposed program to effectively check the completed task, when the teacher is the one checking, or when students check each other's work in pairs or groups. Thus, the dynamic mathematical program GeoGebra is a universal tool for organizing blended learning. Using its capabilities, one can both organize the work during the class at first, and then implement it into independent learning, and use it at any stage of the lesson.

4. Conclusions

Dynamic mathematical program GeoGebra, that clearly demonstrates the formal, algorithmic nature of problem allows students to form an algorithmic style of thinking, master modern information and communication technologies and get a powerful tool for solving problems. One of the effective means of increasing the effectiveness of teaching mathematical disciplines, including linear algebra, is the pedagogically balanced use of computer-based learning systems. The use of the dynamic mathematical program GeoGebra during the blended learning of mathematical disciplines brings the educational process to a qualitatively new level, provides an opportunity to build the educational trajectory of each student individually, taking into account his/her abilities and needs.

Further research should focus on the use of dynamic mathematical program Geo- Gebra in teaching students of other disciplines.

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Features of introduction of components of gamification in the course of development of constructive strategies of overcoming youth's life crises

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Abstract

Information technology is becoming an integral part of the lives of modern youth, opening wide opportunities for their use in various fields of public practice. The statistics presented in the article on increasing the demand for products of the gaming IT industry update the search for ways to implement components of gamification in the educational space in order to optimize the process of professional development of a competitive specialist. The article considers the introduction of gamification in the educational process of higher education institutions in order to develop stress resistance of the individual, as a factor in choosing constructive strategies for overcoming life crises in young. Based on the analysis of scientific research, the concept of gamification is investigated. The advantages of using gamification in the educational and psychocorrectional process are determined. The use of simulator games with elements of augmented and virtual reality in the process of development of constructive coping strategies of individual behavior in conditions of uncertainty and overcoming life crises is substantiated. The article presents the experience of interdisciplinary research in the framework of scientific cooperation between STEAM-laboratory, Laboratory of Psychophysiological Research and Laboratory of Health Psychology of Bogdan Khmelnytsky Melitopol State Pedagogical University. The paper describes in detail the step-by-step empirical study on the introduction of gamification components and augmented and virtual reality technologies in a comprehensive training program aimed at developing resilience, emotional stability, as a predictor of constructive strategies for overcoming life crises in young. The implementation of the experience is described in the implementation of the ascertaining and shaping stages of the study. According to the results, it was found that the implementation of a psycho-correctional program with elements of gamification helped to increase the level of emotional stability and stress resistance of the individual. Representatives of the experimental group, who underwent active training using gamification elements and AR / VR technologies, in contrast to the control group, which did not undergo training, showed significant changes in the choice of constructive strategies for overcoming life crises.

Keywords

gamification, stress resistance, life crises, coping strategies for overcoming life crises, simulation games, augmented reality technology, virtual reality technology.

1. Introduction

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Trends in the development of modern society, enhancement of computer technologies, globalization and informatization affect all spheres of social life, including higher education. The significance, aim and mission of modern education is not just the acquisition of basic knowledge and development of necessary competencies, it is the also a development of a cultural code, an independent approach to the acquisition of new knowledge, cultural values, new forms and activities. Information culture and awareness of the use of innovative augmented reality elements are some of the most important and basic competences in the process of training of future specialists, who are competitive, capable of self-realization, professional and emotional stability in the world of unstable socio-economic conditions of society. The use of the opportunities of augmented reality and simulation games in education and psychological practice can regenerate the process of visual perception of necessary information, simultaneously involving person's cognitive and sensory systems in this process. Reproduction of some processes for visual representation in real dimensions gives an opportunity for complex perception and holistic immersion into the phenomenon under study [1].

The key characteristics of the modern educational process in education are: digitalization of the educational environment with a focus on the individualization of the educational process; development of adaptive technologies, technologies of electronic and mobile learning, means of identification and personalized access. All these characteristics contribute to the design of educational process models based on the development of the individual educational route of a student [2]. Change of processes and protocols for the formation and dissemination of new knowledge contributes to the design of open architecture of the educational environment, construction of the model of open education. Open access to modern information technologies changes people's lives for the better, contributes to the transformation of the education system, increases productivity and competitiveness of any country in the world market.

At the current stage of the development of informative society there are main educational trends, including remote and mobile learning, MOOC, augmented reality, cloud LMS, personalization, BigData, gamification, which can change not only the content of education, but also affect its quality undoubtedly. Gamification or gaming is expanding to all spheres of life. The modern system of education in the conditions of transformational changes is at the top of implementing acquisition of the scientific and technological progress. Five educational trends that are reported by Forbes magazine: remote education, personalization, gamification, interactive textbooks, video game learning – four of them are gamification. Recently, global IT companies are working on gamification actively to improve existing educational platforms and to create new game training programs for use in open information and educational environment.

Nowadays, the most famous are Classcraft, Minecraft: Education Edition, Power Point Quick Starter, Paint 3D, LinguaLeo, Lego Education WeDo 2.0., SimCity, etc. These products have become an integral tool for educators in the context of digitalization and blended learning [3]. According to the statictics for 2020 fiscal year, the video game industry's total revenue forecast is $ 159.3 billion and the number of players is $ 2.7 billion. Regarding Ukraine, there is the latest data for 2018 from Newzoo. According to their information, video game profits in Ukraine was $ 161 million. According to the survey, the most active users of the gaming industry are young people under the age of 25, that is 72% of all respondents of different age. The relevance of the implementing of gamification's elements in to the higher education system is proved by the international project "GameHub-collaboration of universities and gaming industry enterprises in Ukraine" that is aimed to form GameHub infrastructure in Higher Educational Establishments in Ukraine (project partners). It will give an opportunity to involve interested people in learning and to improve required skills and competencies in the gaming industry.

But the issue of the research of impact of innovative components of gamification, AR technologies on the mental characteristics and adaptive abilities of the individual remains quite extensive and uncovered. A number of issues related to the identification of the features of the use of modern simulation games for the development or stimulation of certain mental functions raises the need to create a continuum of multidisciplinary research programs. The urgent issues are to determine the features of the impact of simulation games on the future specialist's psychological features, in order to improve the capacity and construction of a new paradigm for future professionals' training, taking into account changing conditions of existence of modern society.

2. Literature Review

The term, methods and basic principles of gamification came to us from foreign research and they were related to the business sphere, although not limited to it. Karl Kapp's studies were particular fundamental, who changed the approaches and methods of the learning process thanks to gamification [4]. The significant potential of using game mechanisms in a non-game context and particularly educational has become a common practice and an extremely effective learning tool, which has attracted the attention of domestic researchers. The theory and practice of gamification are presented in the works of Kevin Werbach and Dan Hunter, in which scientists confirm that "entertainment is an extremely valuable tool for solving serious business problems related to marketing, efficiency, innovation, customer engagement, staffing and stable development" [5]. Deterding S. explored general concepts of human-computer interaction to find out where the term "gamification" came from [6]. Yu-kai Chou studied the motivational component of gamification [7]. The stages of creating a gamified system are considered in detail by Janaki Mythily Kumar and Mario Herger [8]. The experience of using video games during learning is viewed in a series of articles by Shapiro J. The author is a supporter of the use of game methods in the educational process, but he emphasizes that "it is always necessary to explain to students how and why the game fits into the general learning context [9].

On the other hand, game designer Koster R. sees learning as an integral part of the game [10]. Domestic scientists attach special importance to updating the process of implementing into the higher education system. As part of optimizing the implementation of the competency approach in the process of professional training of the future professionals in the context of digitalization of education, scientists suggest the implementation of game stimulators to develop soft skills competencies. Researchers present the possibilities of using the game simulator Game Dev Tycoon for the development of professional soft skills in future software engineers in higher education, describe in detail how students can develop professional soft skills in the process of using game simulators [11]. Bugaeva V. Yu. considers general information on the use of game tools in non-game educational process and emphasizes the positive impact of gamification in higher education that increases the competitiveness of future professionals [12]. Our theoretical review lets us say that the scope of researches related to serious video games at the international level is quite wide. One of the priority areas of the gaming industry is the introduction of elements of AR / VR-technologies, which allows to bring game markers closer to reality, promotes better visualization and perception of virtual images. Analyzing the latest innovative approaches and models of the use of augmented reality components in education, we should pay attention to S. Litvinova's research, aimed at the introduction of cognitive tasks using computer modeling as a determinant of increasing students' cognitive activity [13]. It is worth mentioning O. Pinchuk, V. Tkachenko, O. Burov's research, which is aimed at comparative analysis of the use of mobile applications as elements of creating cognitive tasks for students in the process of natural and mathematical disciplines learning [14]. In the framework of interdisciplinary research we have to take into account scientific analysis of the effectiveness of the use of search algorithms of learning based on cognitive visualization (L. Bilousova, L. Gryzun, N. Zhytienova, V. Pikalova) [15] and the experience of implementing an innovative approach while providing a support for pedagogical interventions in information technologies for education based on Bayesian networks (J. P. Martínez Bastida, E. Gavrilenko, A. Chukhray) [16]. Theoretical analysis of the research results on the impact of integrative combination of game technologies and AR / VR-technologies on psychological features and human conditions is presented in Table 1.

Table 1
Analysis of modern research on the impact of game technology, augmented reality on emotional states and physiological characteristics of the individual in the process of overcoming life crises and stressful situations (foreign experience)

Authors	Study	Concept of study
Róbert Sabo, Jakub Rajčáni, Marian Ritomský (2018)	Designing database of speech under stress using a simulation in virtual reality	The aim of this study was to provide a methodological foundation for creating language database under pressure that could be used in future experiments focused on the research of speech under stress. To trigger stress-related language changes, speakers participate in a virtual reality simulation of roller coaster riding. Heart rate and skin resistance are monitored as body features, whereas subjective experience is monitored using the Stress and Excitation List (SACL) [17].
Chelsea Dobbins, Stephen Fairclough, Paulo Lisboa, Félix Fernando González Navarro (2018)	A Life-logging Platform Towards Detecting Negative Emotions in Everyday Life using Wearable Devices	The development of sensory technology helps to raise awareness of physiological states associated with negative emotions and this technology is aimed at the development of effective strategies for overcoming stressors. Smartphones and other devices use several built-in sensors that are able to capture everyday behavior on an ongoing basis that can provide a basis for self-reflection and understanding. The authors describe a mobile life-logging platform that uses augmented reality technologies which monitor and classify stress levels [18].
Anna Stahl, Kristina Hook, Martin Svensson, Alex S. Taylor, Marco Combetto (2009)	Experiencing the Affective Diary	The authors demonstrate the experience of developing and implementing a digital diary called "Affective Diary", which provides users with an opportunity to write down their notes, but it also allows the users to record data from body sensors and mobile devices regarding certain physiological and emotional states of the users [19].
Diana MacLean, Asta Roseway and Mary Czerwinski (2013)	MoodWings: A Wearable Biofeedback Device for RealTime Stress Intervention	Despite the increasing availability of sensors and methods for detecting stress, little attention has been paid to automated stress interventions and their actions. The authors introduced MoodWings: a wearable butterfly that displays the user’s tense state in real time by means of activated wing movement. Researchers have developed MoodWings as a stress alert system and there is also a physical interface that allows users to manipulate their affective state. Accordingly, they have found out that MoodWings helps users to calm down and work better while fulfilling stressful tasks [20].
Daniel McDuff, Amy Karlson, Ashish Kapoor, Asta Roseway,	AffectAura: An Intelligent System for Emotional Memory	AffectAura allows users to reflect on their emotional states for an extended period of time. Researchers have developed a multimodal sensor setup for continuous recording of audio, visual, physiological and

Mary Czerwinski (2012)		contextual data, a classification scheme for predicting the affective state of the user, and an interface for displaying the user. The system constantly predicts the valence, excitement and activation of the user and associates it with event information, communication and data interaction [21].
Pablo Paredes, Matthew K. Chan (2011)	CalmMeNow: Exploratory Research and Design of Stress Mitigating Mobile Interventions	The researchers have created four prototypes to study the usability and effectiveness of mobile interventions for stress management: - Social networks: a text interface using SMS to deliver alarm messages is created. - Playing games: commercially available mobile games with simple tasks such as mazes and basic interaction games (slopes, moves, rotations) as stimulation of the distraction factor are used. - Managed acupressure: uses two vibration tactile motors in the bracelet, which stimulate acupressure points in the wrists and chest; these points are known to reduce stress. The researchers used the Wizard of Oz technique to monitor the time of this stimulus. - Controlled Breathing: using the same bracelet, participants are trained to breathe according to known methods of deep breathing; proper breathing rhythm is one of the key elements of achieving a calming effect. Authors researched the effectiveness of this comprehensive approach [22].
Akane Sano, Andrew J. Phillips, Amy Z. Yu, Andrew W. McHill, Sara Taylor, Natasha Jaques, Charles A. Czeisler, Elizabeth B. Klerman, Rosalind W. Picard (2015)	Recognizing Academic Performance, Sleep Quality, Stress Level, and Mental Health using Personality Traits, Wearable Sensors and Mobile Phones	The researchers have collected extensive subjective and objective data through mobile phones, surveys and sensors. The authors have analyzed daily and monthly behavioral and physiological patterns and identified factors that affect performance (GPA), Pittsburgh Sleep Index (PSQI), stress scale (PSS), and overall mental health score (MCS) with SF-12, using the data obtained [23].

The analysis of scientific sources and personal experience have revealed the main benefits of using gamification, which affect the effectiveness of professional development and development of professionally important qualities of future professionals, namely:

- in contrast to traditional technologies, gamification has an entertaining aspect that helps to have high involvement in the educational process;
- gamification is a helpful tool that increases cognitive activity and motivation;
- gamification allows students to develop flexibility of mind in solving practice-oriented tasks;
- gamification allows students to cooperate not only with each other but also with the teacher, to feel equal with him, which helps to remove psychological interaction barriers;
- gamification creates a sense of competition, causes positive emotions;
- Gamification provides feedback. There is a feeling of excitement, curiosity is aroused;
- gamification creates a spirit of competition, which provides an opportunity to form constructive coping strategies of behavior in stressful situations and overcoming life crises [25].

However, despite the deep analysis of the information given above, the mechanisms of using augmented reality gamification in educational and psychocorrectional practice, taking into account the individual characteristics of young people, remain insufficiently studied, which led us to write this article.

3. Research Methods

This research was conducted in the framework of joint research work of teachers and students (future psychologists and programmers) at the Laboratory of Health Psychology, Laboratory of Psychophysiological Research and STEAM-Laboratory. The interdisciplinary approach was implemented in the doing of the research work at the expense of the general fund of the state budget: "Adaptive system for individualization and personalization of professional training of future professionals in blended learning" № state registration: 0120U101970. A comprehensive interdisciplinary study was conducted in the framework of scientific cooperation between STEAM-laboratory, Laboratory of Psychophysiological Research and Laboratory of Health Psychology of Bogdan Khmelnitsky Melitopol State Pedagogical University (Fig. 1).

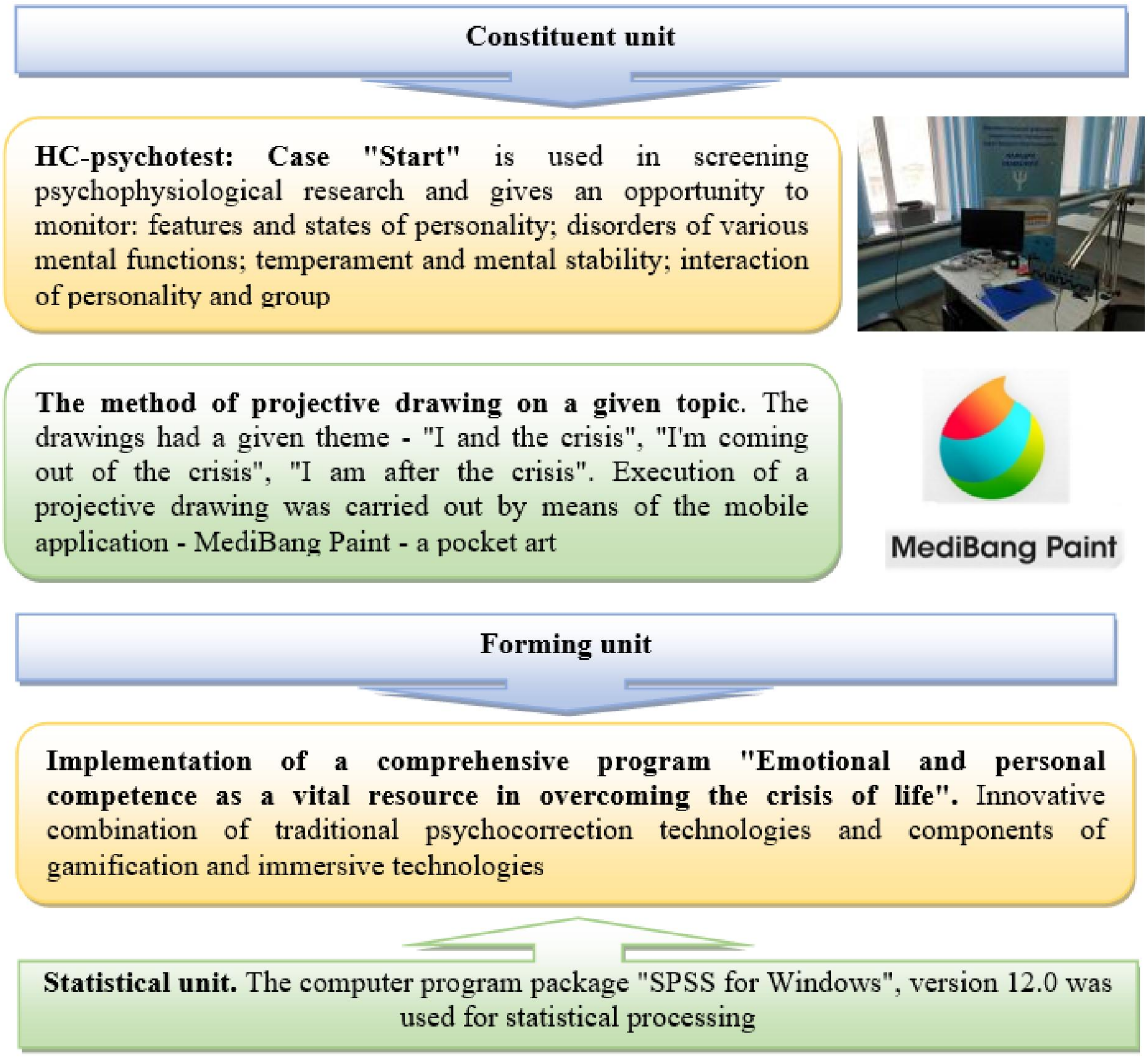


Figure 1: The structure of the research program

The methods used in the process of research are the following:

I) theoretical - analysis, synthesis, comparison, generalization, systematization of theoretical and research data (identification of the state of the research problem, approaches to self-regulation analysis, general principles and advantages of simulated games based on augmented reality technologies in the development of personality stress as a factor of choice constructive strategies for overcoming life crises by young people, defining the basic concepts of the study);

II) The experiment, which was conducted in three stages:

A) ascertaining stage - psychological diagnosis by methods with the help of computer complex HC-psychotest and Google Forms:

To identify strategies for overcoming life crises were used:

1. Methodology "Indicator of coping strategies" by J. Amirkhan (J. Amirkhan The Coping Strategy Indicators);
2. Questionnaire of the questionnaire type "How I overcame the crisis of life"). The method of projective drawings was used as an auxiliary one. There was a given theme of drawings - "I and the crisis", "I'm coming out of the crisis", "I am after the crisis".
3. Reflexive survey (compiled by the authors) using Google Forms, provided an opportunity to summarize the subjective assessment of personal and behavioral changes of respondents after experimental exposure.

In our research, we used both qualitative and quantitative approaches to study the problem, in order to supplement the results of each and cross-validate the obtained data.

B) forming stage. At the formative stage we integrated traditional psychological training on the use of cognitive-behavioral, relaxation and case-study techniques and the innovative opportunities of gamification components with AR technologies. The formative stage was carried out on the basis of STEAM-Laboratory.

C) statistical processing of experimental data - calculations of measures of variability of results, correlation analysis (Pearson, correlation analysis by Charles Spearman), Mann-Whitney discrepancy criterion and Student's t-test. The computer program package "SPSS for Windows", version 12.0 was used for statistical processing.

4. Research Results

As a result of a comprehensive analysis of data, technical capabilities and close cooperation of teachers and students (future psychologists and programmers) a comprehensive program for the implementation of gamification components with AR-technologies in the development of adaptive coping behavioral strategies in overcoming life crises.

The pilot study consisted of ascertaining and formative stages. Total sample (randomized), made by a stratification method - n= 92 people (future programmers and psychologists). According to the research objectives, the respondents were divided into control and experimental groups. No training sessions were conducted with respondents of control group. Specially organized corrective work was carried out with the respondents of the experimental group. Individual and group forms of training work were used within the limits of personality's stress resistance development. The training included elements of traditional psycho-correction work and gamification components with AR technologies. The study was conducted during 2019 - early 2020. Let's consider each research stage in turn.

1. Ascertaining stage. Pilot psycho-diagnostic research was conducted at the Laboratory of Psychophysiological Research with the use of an innovative computer-based complex of HC-psychotest. Respondents were also offered the use of mobile applications for the purpose of reflective interviewing and realization of self-control:

- Psychological tests (http://surl.li/adboq). A set of personality questionnaires, projective tests, aimed at studying the cognitive, personal, emotional, volitional, motivational and behavioral areas.
- Digital Freud: Psychological Tests (http://surl.li/adbpa). The application allows you to get objective knowledge about yourself, see the reflection of your personality in the digital world using innovative algorithms.
- Socionics, psychology, tests (http://surl.li/adbpg). Socionics studies the process of information exchange between a person and the outside world, i.e. how people perceive, process and issue

information. With the help of the appropriate application, respondents have the opportunity to analyze the features of interaction with other people, their own psychotype and personal ability to overcome the impact of stressors and life crises.

One of the tasks of our psychodiagnostic study, which was conducted using the innovative computer system HC-psychotest and Google Forms, was to study what life situations, events a person in adolescence considers a crisis, what is their content, whether they differ in boys and girls and representatives of different age groups. Let's turn to the results of the study. During the procedure of conducting the questionnaire "How I experienced a life crisis" most students were responsible for the tasks, joined the work quickly, were interested in the results of the study. Almost all respondents (96.8%) were able to define the term "life crisis" and describe its various characteristics. Moreover, the number of definitions and described meaningful characteristics of the life crisis increases significantly with the age of the participants, ie the largest number of definitions was recorded at the age of 17-18 years. The average indicators of the number of definitions and characteristics of the life crisis, indicated by the respondents ofdifferent age groups are following: to $x = 3.7$ ($\sigma = 0.40$) - in 15-16-year-olds, $x = 5.4$ ($\sigma = 0.28$) - in 20-21 years old. According to the results of calculating the Mann-Whitney discrepancy criterion, for the age groups 18-19 years and 20-21 years, a significant statistical difference was found (the criterion ranges from 146-162, at $p = 0.05$). There is no statistically significant difference on the basis of gender.

Among the recorded characteristics of the studied features of the life crisis is most often noted "lack of resources to overcome the crisis", as well as "having no idea about the ways to solve the problem": "Lack of strength and capabilities", "I do not know much and I am not able to do it "," I do not know how to get out of this situation, what to do when it happens… "etc.

From the qualitative analysis, it is clear that a number of situations are perceived almost equally by both boys and girls. However, girls, unlike boys, more often described in more detail situations related to emotional content - "dissatisfaction with themselves or their appearance", "loneliness", and boys - those who have a rational character - "deductions from higher education. institution "," financial problems ".

As for the "emotional" situations, boys experience "public humiliation" and "betrayal" more difficult than girls. There are differences among the studied groups of different age. In that way, older respondents (aged 20-21 years) more specifically and described in more detail the various events and situations in life that caused the crisis.

According to the results of the survey, a certain typicality in response to a crisis and stressful situation was revealed, with its subjective uniqueness for each subject. If we combine the respondents' answers on the emotional principle and psychophysical response, they can be reduced to the following : short-term loss of reality and pain, sleep disturbances (or its loss), muscle tension, loss of appetite, indigestion, somatic diseases, anxiety and depression, self-doubt, increased excitability and irritability or vice versa apathy and indifference, impaired thinking and concentration, avoidance of difficulties (mentally and in real action), mental absorption of the problem, subjective feeling of burden of responsibility, sense of loss of meaning life, anger, shame and guilt, a sense of uncontrollability of what is happening, an understanding of the need to do something to change the situation. The typicality of the response was confirmed by the fact that the differences were not found between participants of different ages. However, there are statistically significant differences in reactions to such situations among the girls and boys.

The results show that girls experienced heart failure and difficulty breathing more often than boys (103, at $p = 0.002$), they could not perceive reality correctly (158, at $p = 0.005$), felt bad (criterion is 167, $p = 0.002$), were too excited and irritating (166, $p = 0.005$). Boys, on the contrary, more often felt a state of apathy and indifference (168, at $p = 0.005$).

According to table 2 it is seen that the number of choices of each of the studied participants as a whole in the sample is 3-4 such methods and they do not differ statistically in different age groups. No gender differences were recorded. Such data indicate that subjects of different sexes and ages are equally likely to note one or another way of overcoming life crises. They actualized them in their descriptions as those that are recorded in individual experience and implemented in life. About 30 different ways of overcoming difficult life situations were named from the sample. The list of overcoming ways is mentioned in the amount of at least 1% of all these, and presented in Appendix E. This includes ways that can be related to the 3 main areas of personality - or the emotional sphere ("I try to keep myself in hand", "I despair", "I got into a dead end", etc.), or to the cognitive sphere ("I'm trying to understand how this could have happened", "I'm looking for a logical explanation for what happened", etc.), or to the behavioral sphere of personality (I pretend that nothing happened, that I'm fine "," I'm trying to move on to another case ", etc.)

Table 2

The average indicator of ways of overcoming life crises

		Total	18-19 years	20-21 years	Girls	Boys
arithmetic mean (X)	3,65	3,76	3,38	3,85	3,59	arithmetic mean (X)
standard deviation (σ)	0,36	0,31	0,34	0,40	0,43	standard deviation (σ)

So, young people prefer search activity, the use of self-control and logic to find reasons, etc .; girls prefer emotional reactions, imagination, seeking support and communication, transmission of anxiety and problems of another person, that is, among the girls' ways of reactions emotional ones are dominated. According to the Mann-Whitney test, there are also some statistically significant differences between participants of different ages (range from 141 to 159, p = 0.05).

In order to help young people, conceptualize their ideas about how to overcome crises, they were asked to draw pictures on topics - "I and the crisis", "I overcame the crisis", "I am after the crisis". We assumed that with the help of a drawing it is possible to actualize unconscious symbolism and imagery. It should be noted that some complications were caused by this technique while performing and trying to "protective" avoid reflection ("I can't draw"). However, all those who participated in the study completed this task. Due to the nature of the symbols and the peculiarities of the image, we conditionally called these types "fighter", "infantile" and "seeking support" (Table 3).

As can be seen from Table 3, among the studied the most filled are 2 types - "Fighter" and "Infantile". Moreover, 20-21-year-old participants and young men are the majority in the type of "Fighter". The Mann-Whitney test is 148 and 143, respectively, at p = 0.002.

Table 3

Types of symbolic representation of the process of overcoming life crisis for the individual, (in %)

		Total	18-19 years	20-21 years	Boys	Girls
"Fighter"	55,4	47,5	64,6	66,5	43,2	"Fighter"
"Infantile"	35,5	42,8	29,3	28,3	41,5	"Infantile"
"Seeking support"	9,1	9,7	6,1	5,2	15,3	"Seeking support"

The "Fighter" type is characterized by images of complex abstract symbols - various elements (eg, water, sky, volcano, flood, fire, etc.), cosmic bodies (planets, sun, stars, space, constellations, etc.), complex geometric shapes (spirals, inscribed and described circles and rectangles, spheres, etc.). It is usually a metaphorical image in the form of a complex image that gives a complex meaning.

In addition, for all drawings referred to this type, the individual active position is characterized by the image of his struggle with the circumstances. In some drawings (8.3%) there are contradictions - for example, the simultaneous depiction of the desire for leadership and the need for care, patronage.

The "Infantile" type is characterized by the image of plot drawings with a clear and quite detailed image of yourself or self-portrait. Sometimes (5.2%) there were abstract, rather schematic images. However, the symbol "I" is more often (68.3%) depicted separately, as if "along the plot line", is outside the overall plot, or not depicted at all (26.5%), which indicates that the individual's non-involvement in overcoming life crisis and in feelings about it.

The “Seeker of Support” type is distinguished by a set of different images that show the direct expression of the feelings and sensations associated with a seeking support and a help. As a rule, plants, landscapes, animals, people and specific plots that show the search for and receiving a help from others were depicted.

Identified types of symbolic representation of the life crisis for the individual show insignificant differences between the samples of boys and girls and 18-19-year-olds and 20-21-year-olds according to t- Student's t-criteria. It is 2.36 at the significance level $p < 0.05$. This means that the subjects that we have classified into separate types belong to one population. This is also confirmed by the strong association between the sample of boys and girls and 18-19-year-old and 20-21-year-old subjects according to Pearson's agreement, which is 0.756 and 0.62, respectively, at a significance level of $p < 0.001$.

That is, these samples coincide in the symbolic representation of the life crisis for the individual. To clarify and differentiate the priority and significance for the studied participants of separate ways of overcoming life crises, as well as to better systematize them in self-awareness, the method of ranking was used in our research.

To do this, the participants were asked to read the list and main characteristics of coping methods, which they had named, and evaluate the methods of overcoming their priority for themselves during a difficult life situation by assigning each of them the appropriate rank. The participants were given the task to determine their attitude to each method of overcoming by the criterion "I used it" or "I did not use it".

Then participants had to find the place of each method in their lives, determining their rank on the scale "It's important to me" and "I'll use it in the future." This technique makes it possible, on the one hand, to diagnose the level of identification with the peculiarities of ways to overcome life crises, and on the other hand it gives a chance to activate the independence of thinking in choosing different ways.

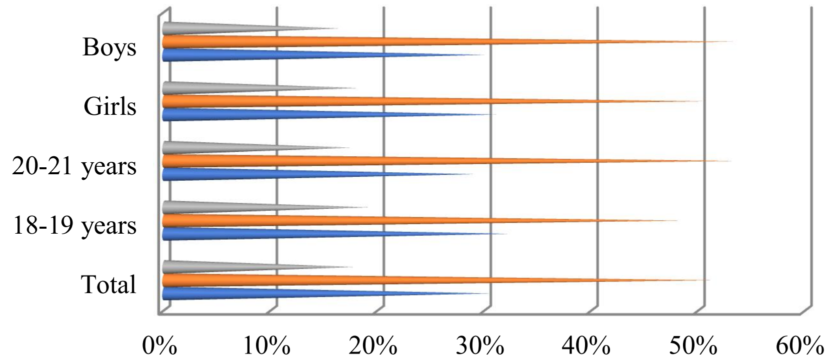
The ranking results show that there are age differences in the use of ways to overcome life crises. The Mann-Whitney discrepancy criterion for the age groups 18-19 and 20-21 years varies between 144-160, at $p = 0.05$.

For participants of older age (20-21 years), in contrast to younger ones, more significant and priority for the future use are ways to overcome life crises, which are connected with the activation of social connections and communication, including with professionals, as well as stress resistance, emotional stability, resilience, low anxiety, self-control, self-regulation, self-belief, self-esteem and the use of creative activities and hobbies. In addition, younger students are more likely to choose crisis management mechanisms such as search activity and imagery in the future, and 20-21-year-olds are more likely to choose physical activity. Analysis of the results of ranking the ways of overcoming by girls and boys showed that in general there is no statistically significant difference between girls and boys. However, there are differences in the use of certain methods in the future. Girls are more often than boys tend to choose in the future such ways of overcoming crises as the use of imagery, emotional reactions, as well as relaxation, meditation, breathing exercises, etc., and boys - a logical search for causes and increase self-esteem. The Mann-Whitney discrepancy criterion for these indicators varies between 142-154, $p = 0.05$. Based on the obtained data after the ranking, the participants were joined into 3 groups based on the level of acceptance of ways to overcome life crises. A small assignment of ways to overcome the criterion of "This I will use in the future "is characterized for those who showed a "low level of acceptance of ways to overcome".

Participants from this group are selected and included in the list "It is important to me" all the proposed methods, but due to ignorance of the possible use of selected methods they cannot choose them for the future use in a difficult life situation or crisis. As a rule, for further use, they chose a small number of ways to overcome.

The "high level of acceptance of coping methods" is characterized by the coincidence and strong connection with Spearman's (p) rank correlation between the lists of coping techniques according to the criteria "It is important for me" and "I will use it in the future". The rank correlation index is in the range from +0.56 to +0.835 (significance level $p < 0.001$). The level of "confusion" is characteristic of those young people who have demonstrated differences between the ways of overcoming that are important to them and those that they will use later in their life. That is, such participants who chose one list of methods as important for the individual and another one - that might be used in the future. Comparative data are given in Fig.2. Significant difference in age and gender statistically was not found.

A comparison of the results of the representatives of different types symbolic representation of life crisis for the individual in the drawings showed that the group "Low level of acceptance of overcoming ways represents the types "Infantile" (68.5%), "Seeker" (27.9%) and "Fighter". (3.6%). The group "High level of acceptance of overcoming ways " consists of 84.2% of representatives of the type "Fighter" and 15.8% "Seeker of support". And the third group "Confusion" includes 56.3% of students, who are of the type "Seeker of support", 30.7% - "Infantile" and 13% - "Fighter".



	Total	18-19 years	20-21 years	Girls	Boys
Perplexity	17.80%	19.20%	17.50%	18.10%	16.40%
High level of acceptance of ways to overcome	51.60%	48.50%	53.50%	50.70%	53.50%
Low level of acceptance of ways to overcome	30.60%	32.30%	29%	31.20%	30.10%

Figure 2: Levels of acceptance of overcoming life crises ways

Thus, the majority of young people 51.6% were able to accept, understand the suggested ways of overcoming difficult life situations and include them in the arsenal of potential ways that can be used in the future. In general, it should be noted that adolescence is characterized by the desire to seek a help and a support from the close environment, that the young person trusts more both parents, loved ones, friends and so on. Boys and girls show a desire to keep away from strangers, including professionals. Relevant empirical data are the basis for the implementation of the formative stage of the research.

2. Formative stage. At the formative stage we integrated traditional psychological training on the use of cognitive-behavioral, relaxation and case-study techniques and the innovative opportunities of gamification components with AR/ VR technologies. The formative stage was carried out on the basis of STEAM-Laboratory. Traditional training, presented at the formative stage, included the psycho-corrective program "Emotional and personal competence as a vital resource in overcoming the crisis of life". The purpose of the program is for participants to acquire knowledge about psychological support and the use of elements of gamification in the process of psychological support of young people in crisis situations and to acquire practical skills for its application in everyday life. Particular attention is paid to the formation of a positive image of a stressful situation, learning how to analyze the situation in a cognitive way, updating the skills of arbitrary relaxation and gaining the experience of applying techniques and formulas of constructive response in stressful situations. In the process of implementing the comprehensive program, the following psycho-correctional methods were implemented: resource exercises, interactive mini-lectures, discussions, facilitation, brainstorming, clustering, moderation, role play, "aquarium", reflection, sharing. The corresponding program consists of three blocks: development of cognitive sphere, formation of constructive coping strategies of behavior of youth in the course of overcoming of life crises (behavioral sphere), development of sanogenic potential and stress resistance (emotional and volitional sphere). An innovative trend in the implementation of a comprehensive program "Emotional and personal competence as a vital resource in overcoming the crisis of life" is the introduction of gamification components and augmented and virtual reality technologies.

The program is created in accordance with the principles of the concept of Accelerated Learning Theory and uses all the latest developments in the field of methodology of adult learning. Note that smartphones, tablets, laptops have become an integral part of youth's lives, and the versatility of these powerful high-tech devices remains largely unclaimed. Active attempts to use these devices in the educational process are characterized in the literature as a trend BYOD (Bring Your Own Device). From the point of view of reorganization of educational process and psychological support of youth implementing of BYOD brings many useful opportunities.

Using the concept of BYOD as a universal tool for psychological support of youth provides a unique opportunity to combine traditional training technologies with components of gamification and AR / VR technologies in the development of stress resistance and the formation of constructive strategies for overcoming life crises by future professionals. This provides an opportunity to implement at a higher level such principles of psychological influence as clarity, accessibility, awareness, connection with life, and most importantly - to develop the desire for self-change and introspection, promote cognitive activity, initiative, develop the ability to define problems and find ways for their solution.

Psychological technologies of the complex program were implemented on the basis of the Laboratory of Health Psychology, components of gamification and elements of augmented and virtual reality in the corresponding program were implemented on the basis of STEAM-Laboratory of Bogdan Khmelnitsky Melitopol State Pedagogical University (Fig. 3).

In order to implement the constructs of virtual and augmented reality we have used special technical equipment of STEAM-Laboratory. The minimum set of equipment, which is required to implement such an integrative approach is the following: required number of smartphones and VR helmets; tablet; computers; Wi-Fi router, Internet access; system of remote update; educational videos and software; touch pad. The XRcase system gives the opportunity to deliver classes on 10, 16 or 30 virtual reality devices. In the process of traditional training delivering, the elements of AR technologies were actively used, namely [24]:

1. While implementing the elements of cognitive-behavioral therapy, desensibilization techniques, aimed at reducing anxiety (fear) to scary objects or situations (such as fear of flying, heights, fear of spiders, mice, snakes), the following Google Play applications were used:

- VR Thrills: Roller Coaster 360 (Cardboard Game). An amazing roller coaster adventure in virtual reality mode. This game provides the users with the opportunity to see many different types of roller coaster in virtual reality mode. It gives the chance to feel and reflect on various mental and emotional fears, maybe even frustration.
- VR Heights Phobia. A virtual reality game with a challenge! While completing the mission, participants cope with their phobias in the VR world. They use their own body to navigate the three-dimensional world, bounce their heads up and down, and the avatar moves as well. Each movement is monitored by a telephone gyroscope, giving participants a realistic, enjoyable experience, and the participants focus on and deal with their emotions.
- VR - Phobia Horror Spider. Through this program, participants try to overcome their arachnophobia. Students explore the world of spiders at 2 different levels and their environment. This virtual, but very close to reality case, develops the skills of self-control and emotional stability in extreme stressful environments.
- VR Maze. VR Ball Maze for cardboard and daydream virtual reality glasses. Participants need to roll the ball across the maze from start to exit. The ball always moves straight. The movement of the ball is controlled by the rotation of the head. This game is aimed at the development of concentration and stability of attention, emotional intelligence, and internal analysis of psychophysical states.
- VR Mission Leviathan – underwater expedition. Virtual reality attraction VR Mission Leviathan is a 360 VR adventure. A VR helmet, goggles, or card-board allow participants to fully experience the depth of field explorer. Mission Leviathan's VR attraction is an underwater mission simulator. Surrealistic virtual reality with carefully crafted sound and detailed 3D graphics, clear, vivid and colorful models and characters, is aimed at a comprehensive impact on all senso-ry features of the person, at the same time arouses a variety of emotions, feelings and experiences, shapes cognitive-reflective skills of information processing and making decisions in difficult conditions.

2. In order to implement relaxation techniques using AR technologies, the following applications have been used:

- Graffiti Paint VR. In Graffiti Paint VR participants spray Graffiti in virtual reality! They just choose a can or create their own one with a certain color and start to spray it. This application provides the possibility of psycho-emotional relief, overcoming neuropsychic tension.
- Art Therapy. Art Therapy is an application for adults that helps users concentrate on positive emotions, create their own art masterpiece, relieve emotional tension and relax.
- ArtOlg: Introduction. A workshop of intuitive creativity for meditation is a kind of Art Therapy. This technique is very simple, anyone, who wants to open up their inner world, realizes hidden abilities, expand consciousness, can start drawing. Intuitive painting will help users get rid of the stereotypes of thinking that prevent them from living a common life and enjoying it. The main aim of manual art therapy is to harmonize the mental state of the individual through the development of the ability to express themselves through creativity.
- Thisissand - Art, Creativity & Relaxation. Thisissand is a creative space for designing objects from colored sand; it is focused on reducing psycho-emotional stress, situational and personal anxiety, as well as on the promotion of personality's creative potential;
- Relax River VR. Participants can achieve emotional and psychological comfort while having a virtual reality boat tour, sailing on a beautiful river, with picturesque scenery of mountainous area and incredible creatures. It is a fully automatic tour, without any settings.

1. The use of augmented reality components while implementing cognitive-behavioral therapy and self-reflection:

- Moodpath - Depression & Anxiety Test. Moodpath is focused on assessing mental health, monitoring and reflecting one's own mood, as well as taking a break from negative thoughts and negative emotions. Moodpath is used as an intelligent mood tracker. Through it, participants are provided with a chance to have a quick overview of their emotional states throughout the day, master cognitive-behavioral therapy (CBT) activities, understand the cause-and-effect relationship between events and emotional states, integrate mindfulness into their daily lives, develop empathy and skills of self-observation.
- CBT Companion: (Cognitive Behavioral Therapy app). It is the most comprehensive cognitive-behavioral therapy application available today. It is equipped with easy-to-use visual tools. The application presents the scheme of formation of certain skills through cognitive-behavioral therapy. A block of video lessons is also given.
- ACT iCoach: Acceptance Commitment Therapy App. ACT iCoach is a comprehensive application that covers all aspects of acceptance and commitment therapy. Participants learn and practice ACT skills using video tutorials and fun animation that help them learn more. The application provides participants with convenient tools for tracking their mood, emotions.
- CBT Thought Diary - Mood Tracker, Journal & Record. A central element of cognitive behavioral therapy (CBT) is training to identify negative and distorted patterns of thinking in order to change one's own emotions and behavior for the better. In cognitive-behavioral therapy, "record of thought" leads participants through the stages of detection, denial and rethinking of negative models of thinking. With the Thought Diary, participants can record their negative emotions, analyze the drawbacks in their thinking, and re-evaluate their negative thoughts into more balanced ones.

The following game technologies were recommended for the purpose of introduction of games-simulators within each corresponding training block:

1. Development of cognitive sphere of personality:

- "Mind Games" is a collection of amazing educational games based on the principles of cognitive psychology and aimed to develop mental abilities. The application includes more than 24 educational games. All games keep track of successes, with numbers and graphs. Personal best results for all time and for the current day are given on the page of the list of games. All indicators are evaluated on a common scale, and the participant can easily see exactly what skills you need to work on. This game trains concentration, reaction speed, memory, flexibility of thinking.
- "Left vs Right: Brain Games for Brain Training" is a game designed to check awareness, adaptability, reflection, prudence, accuracy and patience, stimulates the development of interspheric interaction of the brain.

- "NeuroNation" is a set of 27 interesting games, exercises and personalized courses that stimulate the development of intelligence, memory and logical thinking, increase volume and concentration of attention.

- "Lumosity" is a set of 25 cognitive games that stimulate development
cognitive and motivational sphere of personality.

- "Brain Games" is an interesting brain simulator which consists of various games: games for memory development, thinking, cognitive games, intelligence games, attentiveness games. An application with simulator games develops the mind, abilities, strengthens cognitive connections, expands consciousness, increases, attentiveness, trains memory, adjusts the mental process.

2. Development of emotional and volitional sphere:

- "Emoji Puzzle" is an imagination game in which you need to match pairs of emotions with associations, it stimulates the development of emotional competence;

- "Harmony" is a puzzle game that combines art therapy technology, music therapy and an exciting gameplay in which you need to click on the squares and create good symmetry. When you press each square, music plays, which stimulates the harmonization of psycho-emotional state.

- "Anti-stress" or relaxing simulation games is the collection of simulation games which helps to relax or switch attention temporarily. In this game you can listen to a bamboo bell, play with wooden cubes, move your finger on the water, press buttons, draw with chalk and so on.

3. Development of the behavioral sphere:

- "Easy Game" are the games-simulators presented in the application and provide an opportunity to make decisions based on the cognitive abilities of the individual in difficult life situations and situations that require quick choices.

- "Virtual High School Teacher 3D" is a simulator game, which stimulates the development of constructive behavioral strategies in professional activities.

- "Homescapes" is a simulator game focused on the development of constructive behavioral strategies in overcoming stressful life situations.

Figure 3: Practical implementation of a comprehensive program "Emotional and personal competence as a vital resource in overcoming the crisis of life" with a combination of traditional psychocorrectional technologies and elements of gamification with augmented and virtual reality

We used re-diagnostic data as a criterion for assessing the effectiveness of the training and the changes that occurred with the respondents, using the method of "Indicator of coping strategies" by J. Amirkhan, the procedure for ranking ways to overcome life crises and a questionnaire on changes that occurred after training. Indicators of the experimental and control groups were compared with each other. Statistically significant differences between them were analyzed by the criterion of Mann-Whitney differences.

Representatives of the experimental group, who underwent active training with the use of gamification elements and AR / VR technologies, in contrast to the control group, which did not undergo training, showed significant changes in the choice of strategies to overcome everyday difficulties. Only 3 people from the experimental group chose, as before the training, an avoidance strategy, and the vast majority implement new active methods of overcoming. The vast majority of the control group did not change their strategies for solving daily problems. The Mann-Whitney test shows statistically significant differences between the results of the experimental and control groups (164 at $p = 0.05$).

Table 4

Comparative data of the researchers using the method of "Indicator of coping strategies" by J. Amirkhan

Strategies	Experimental group				Control group			
	Before training		After		Before training		After	
	Persons	%	Persons	%	Persons	%	Persons	%
Problem solving	-	-	11	47,8	-	-	2	8,7
Search for social support	5	21,7	9	39,1	4	17,4	5	21,7
Avoidance	18	78,3	3	13,1	19	82,6	16	69,6

As a result of the re-ranking of coping techniques according to the criteria "It is important for me" and "I will use it in the future", out of 25 representatives of the experimental group 17 showed a coincidence of sets of coping methods that are important to them and that they will use in the future (Table 4). This is an indicator of a high level of awareness of these methods and their acceptance (the value of Spearman's rank correlation coefficient varies in the range from +0.46 to +0.71 at the significance level $p < 0.001$). That is, these subjects significantly improved their results and were assigned by us to the group with a "high level of acceptance of ways to overcome life crises", which also includes representatives of the control group (Fig 4). This is confirmed by Student's t-test, which shows insignificant differences between the two samples (2.34 at the level of significance $p < 0.05$).

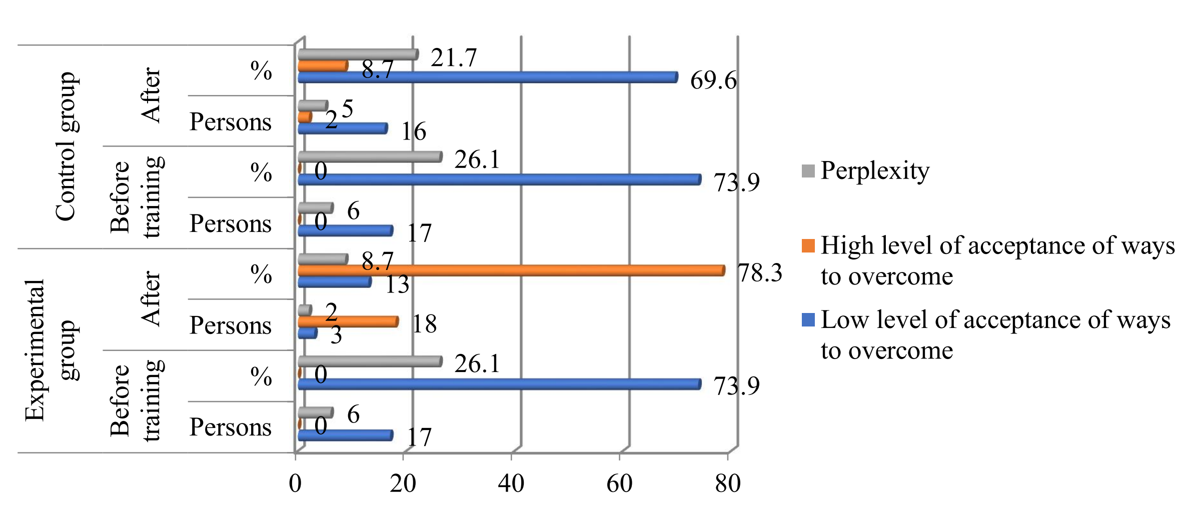


Figure 4: Comparative data of the studied by the method of ranking ways to overcome life crises

5 young people from the experimental group, according to the ranking, showed a result identical to the one they demonstrated before the training, ie 2 people remained in the group "confused" and 3 - "low level of acceptance of ways to overcome". Perhaps, the positive changes in these subjects would be more pronounced if they had the opportunity to receive additional training in the formation of practical skills of choice and application of possible ways to overcome life crises. In contrast to the experimental group, most of the control group (21 people) did not change their level of acceptance of crisis management techniques, only 2 people were able to improve their previous result and showed a high level. The differences between the control and experimental groups are statistically significant. The Mann-Whitney test is equal to 161 at the significance level $p = 0.05$.

According to the results of the survey, the vast majority of respondents noted and named specific changes that they were able to notice in themselves, their own behavior, etc. (Table 5).

Table 5

The results of self-assessment of changes in the experimental group

The nature of the changes	Persons
Convinced of their ability to cope with life's difficulties	21
Learned to control their emotions	19
Learned different ways and techniques to deal with problems	18
Understood the value of supporting relatives and friends in difficult situations	17
Self-confidence has increased	17
Learned to analyze problem situations	17
Became more positive about themselves	15
Anxiety decreased	13
Self-esteem has increased	12
Understood the need for more flexible behavior in a problematic life situation	11
Became calmer	10
They found that there is a way out of any situation	9
We were convinced that it is possible to change oneself	8
We understand that if the situation cannot be resolved, it is possible to change the attitude to it	8
Learned to perceive problems philosophically	6
Learned to plan their actions	5
Gained new life experience	3
Gained new life experience	3

The results presented in Table 5 show that the vast majority of the experimental group named the changes that took place in themselves, the experience and skills of self-regulation of emotions, which, in our opinion, also indicates the effectiveness of the training program with elements of gamification.

5. Conclusions and Recommendations for Future Research

The key features of the education system are the results of globalization and technologization, which can be observed at the present stage of society development. Under the conditions of globalization, a network model of knowledge dissemination is being formed. It is characterized by the rapid dissemination of a new information product through the Internet. In the context of the society technological development, new approaches and for-mats for the presentation and transfer of knowledge are being formed. They provide available, high quality and personalized access; new conditions of professional activity realization due to the development of modern technologies (artificial intelligence, robotics, 3D modeling and prototyping, virtual reality, etc.). Analyzing the works of foreign authors on this topic, it should be noted that the increasing popularity of the augmented reality technology and interest to it, at the present moment, is driven by the research works that provide the rational for the prospects of using augmented reality technology through the expansion of production sphere and creation of completely new spheres and service markets in the near future. Due to such a global introduction of gamification components and augmented reality elements into education, our research, aimed at the implementation of an integrative approach in the development of youth's stress-resistance, choosing constructive strategies for overcoming life crises has turned out to be a very vital and important one. This research shows an innovative combination of traditional psychodiagnostic and corrective influences with of gamification components and AR/VR technologies. This research was conducted within the framework of the cooperation of laboratories – Laboratory of Psycho Physiological Research, Laboratory of Health Psychology and STEAM-Laboratory. At the methodological level of the research we have analyzed and substantiated the ways of combining traditional methods with gamification components and AR/VR technologies, and the model of development of constructive strategies for overcoming life crises in adolescence. At the empirical level, the effectiveness of implementing gamification components and AR/VR technologies into the process of stress resistance development, as an integrative feature of future specialist, that directly influences productivity and efficiency of the future activity, has been proved. The perspectives for further research are the following: development of the concept of the purposeful use of gamification components and AR/VR technologies while constructing an effective personality-oriented vector of higher education; research of the impact of augmented reality elements on a person's mental characteristics.

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Training of Specialists for Adaptive management. Techniques for Teaching Computer Analysis of Automated Production Systems in the FlexSim Environment

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Abstract

The article deals with the problem of teaching students and practitioners in methods of searching for reserves to increase the efficiency and reliability of automated control systems for various purposes. The article shows that in the conditions of the fourth industrial revolution, the requirements for the efficiency and quality of variant analysis of the "what if?" type. The necessity of using a new generation of simulation modeling environments in making management decisions has been substantiated. The analysis of the simulation modeling software used in practice and in the educational process of the universities of the world has been carried out. The advantages of the FlexSim software environment are described and the expediency of switching to the use of this environment in the practice of variant analysis of automated systems as well as in the educational process of universities and in the retraining of specialists is shown. A library of typical FlexSim models has been developed, providing training for a specialist who is able to analyze current problem situations in the design and operation of automated production and control systems. The authors have developed a methodology for the continuous use of FlexSim in the preparation of IT students. The method is designed for use in classical and technical universities, focused on training IT specialists, analysts and managers in structures for advanced training and retraining of personnel for modern automated production as well as for self-education.

Keywords

Simulation model, automated control, adaptive management, optimization, efficiency, reliability, training, professional competencies, automated system, information technology

1. Introduction

The Fourth Industrial Revolution is a modern technological strategy that improves the efficiency of production processes by achieving high flexibility and resource optimization [1]. This concept is based on the introduction of cyber-physical systems into production [2-4].

Technical objects of the production environment, which are equipped with a communication interface and integrated information processing capabilities, interacting via the Internet, optimally adapt their behavior to specific production conditions [5].

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This approach is based on the technologies of data mining, the Internet of Things and augmented reality [4, 6]; it determines the emergence of production systems of a new type, which provide automatic management of production and sales processes throughout the entire life cycle of a product [7].

Often, student learning technologies do not keep pace with the modern progress of science and production[8-12]. Therefore, today more and more often they pose the problem of adaptive learning [13-16] as well as the problem of rapid variant analysis of possible ways to improve the efficiency of automated systems [1,3,17].

2. Problem Statement

The integration strategy of modern Internet technologies with physical processes in production was first initiated by German companies as the central basis of Industry 4.0 political program [4], and later was adopted by almost all industrialized countries [18]. A significant advantage of the strategy is to improve the competitiveness of enterprises in their continuous development through individual adjustment of production by increasing resource efficiency and reducing costs [19].

As part of the Industry 4.0 strategy, the simulation is one of the key technologies [1, 20-22]. For example, in [20] with the help of simulation models the influence of the properties of different architecture of decentralized production management on the duration of the production cycle is evaluated and compared. For research, a simulation model of a production system consisting of four operating complexes and a robot manipulator was built. Experiments on the model were carried out using both deterministic and stochastic input data. Based on the analysis, conclusions were made about how different architectures are suitable for Industry 4.0, and a set of actions to develop production management facilities in Industry 4.0 was obtained.

Practice has confirmed that simulation modeling is effectively used to solve such tasks [23-24]:

- production reengineering (adaptation of production processes to consumer needs, organization of production and management based on efficient computerization; uniform distribution of labor and technological resources);
- production planning (forecasting the objectives and stages of the production process in the conditions of dynamic changes, expansion of the commodity range, the introduction of new products or services, the use of new equipment; elimination of weak places in the production system);
- warehouse management (elimination of downtime in warehouse departments; identification of goods; strategy of their rational placement and grouping; efficient use of warehouse space; minimization of transportation costs);
- management of material flow and reserves (regulation, rationing, stock control and raw materials; prediction of material needs, determining the average delivery time and frequency of supplies; rational distribution of material and industrial stocks).

Currently, there is a wide selection of simulation programs: MATLAB/Simulink, Arena, Enterprise Dynamics, GPSS World, Excel/Solver, etc.[24-27] The most modern tool that is successfully used to model and analyze production processes is FlexSim software. This program supports all known modeling methods (discrete, continuous, agent, statistical), it has a three-dimensional medium of constructing models and is integrated with C^{++} programming language [28].

The authors of publications [28-29] present practical examples of using simulation models developed in the FlexSim environment as a result of working with students in higher education institutions and in the field of industry. This program is used in the educational process of universities; in particular, it has been introduced into the curricula of the Polish State Eastern European University in Przemysl [30].

Also known is the practice of its introduction in industrial enterprises. A large automobile company FIAT used FlexSim to optimize the production line of EURO 5 and EURO 6 engines [31].

It should be noted that the transformation of production sets new tasks for education. It is assumed that future graduates will be traced with complex problems in the management level [31-33].

The future specialist must have new competencies in accordance with the requirements of the Fourth Industrial Revolution [34-36].

In this regard, it is important to pay attention to the emergence of new technologies associated with Industry 4.0 and take into account them when preparing students of engineering and computer specialties in order to form the necessary professional skills and competencies. In [1], it is noted that human resources play an important role for the implementation of the Industry 4.0 concept. Studies conducted in [10, 37-40] determine the group of key competencies necessary for the development of Industry 4.0. Also, the authors prove that the use of FlexSIM software in the educational process, research projects, diploma and course works contributes to the development of professional competencies in the direction of Industry 4.0.

Thus, obvious is the following:

- one of the most modern software media simulation of complex systems is FlexSim;
- modern automated production by rapid pace introduces approaches of variant simulation using FlexSIMtechnologies;
- building a learning process to prepare IT-Direction students in the most rating universities in the world focuses on the use of FlexSIM simulation technologies, as evidenced by individual publications;
- in Ukraine there is no practical experience of using FlexSim as well as systematic research on the methodology and methods of implementing this software technology in the educational process of universities.

In this regard, the task of this work will be defined as follows - to develop a method of end-to-end teaching of students, the purpose of which is to master modern tools for analyzing the effectiveness of the functioning of complex automated systems and finding possible ways to improve it, using the FlexSim software.

To achieve the goal, you need to solve such tasks:

- investigate the relevance of reorientation of the educational process to the use of FlexSim software;
- describe typical problem situations of decision support in automated production and training-oriented techniques for using FlexSim simulation models to solve them;
- describe the experience of introducing the methodology of the end-to-end use of the FlexSim program in the educational process in the preparation of IT students and further prospects for its use.

3. Results

3.1. Analysis of the feasibility of teaching students decision-making techniques using FlexSim in problems of managing complex automatic systems

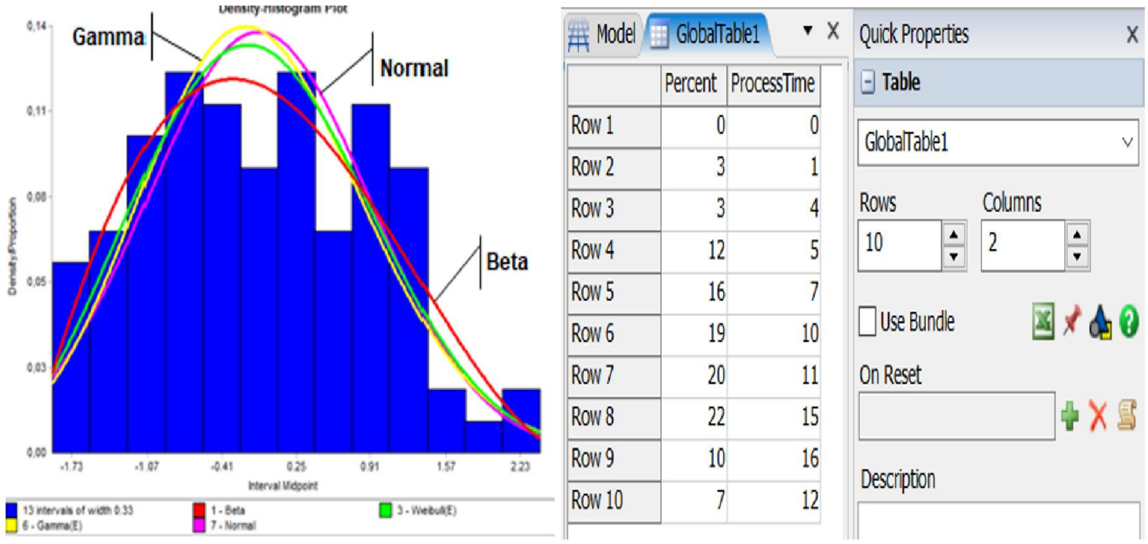
We will analyze the feasibility of teaching students decision-making techniques using FlexSim in the management of complex automated systems.

FlexSim is an integrated environment for building and examining simulation models. At the initial stages of modeling, considerable attention is paid to establishing the probability distribution laws that characterize the input data collected from the modeled system. An incorrectly defined distribution law leads to an erroneous assessment of the parameters of the system's efficiency .FlexSim contains a built-in ExpertFit tool that automatically analyzes the input data and evaluates it according to a certain distribution law. The analysis process consists of the following stages: construction of a histogram of frequencies, selection of the distribution law, and statistical refinement of the parameters of the distribution law.

In production systems, the laws of distribution reflect stochastic processes: the speed of operations (processing, packaging, and assembly), the intensity of the supply of components and raw materials to the work site, time to repair equipment, etc. Figure 1(a) shows a frequency histogram constructed by means of ExpertFit on numerical data, describing the length of stay of parts in the intermediate zone before processing. Analysis of the graphs shows that the Beta distribution law better matches the histogram pattern.

The calculation according to the criteria of the Kolmogorov-Smirnov test and the χ-square determines the correspondence of the chosen distribution function and its parameters. If the random process cannot be described by the parametric distribution law, the FlexSim program provides for the use of data in tabular format without a functional description (Fig. 1, b).

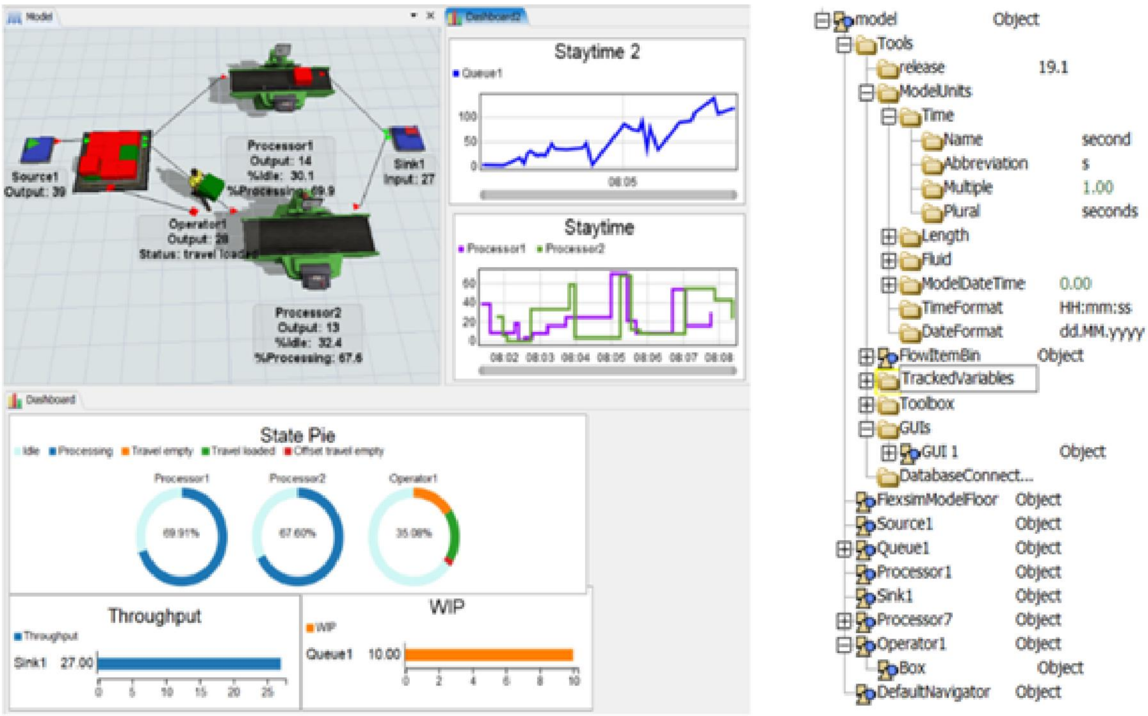
At the stage of building a simulation model, the structure of the system is reproduced. FlexSim 3D objects are designed to build models contained in a set of standard program libraries, divided into categories by functionality and determining their ease of use for the implementation of both discrete and continuous processes. When building models, the principle of visual programming is implemented, according to which the user creates a model from a set of standard blocks and performs calculations. For each object, the corresponding parameters are set to meet the requirements of the simulated system.



a b

Figure 1:Identification of the law of distribution of sample data: selection of the parametric law (a); description of empirical data with a table of values (b)

Figure 2(a) shows a model consisting of a source of parts (Source); fixed resources (Processors 1 and 2 performing processing) and queues (places of waiting for the overflow of elements before performing processing operations); and a mobile resource (operator who moves parts for processing). Connections between fixed resources determine the direction of movement of material flows.



a b

Figure 2:Example of a simulation model in the FlexSim environment: model with statistics (a), model tree (b)

Statistics for each object are displayed in text mode. More detailed statistics are shown by graphs and charts located on information panels. The types of graphs are set by the user and depend on the studied indicators of the system's efficiency.

Pie charts show resource utilization and help you identify periods with high workloads. The graphs show the average waiting time for parts in the queue (Staytime 2), processing time (Staytime), work in progress (WIP), and system performance (Throughput). A user-friendly software interface, support for three-dimensional animation, and realistic graphics allow you to analyze production processes for risks, involve other specialists and experts in the organization to find problems, interact with project customers, take into account the proposals of experts and working groups to improve the system operation, make appropriate changes to the models, and evaluate the effectiveness of these changes.

The model is driven by data. FlexSim can import/export information from other software environments (for example, MS Excel), read from databases (MySQL, Oracle, SQLite, etc.), and create global tables with data.

It should be noted that the models of systems in the FlexSim environment are developed on the basis of object-oriented approach. So in addition to the three-dimensional view, the model can be represented as a tree structure of hierarchically subordinate objects. The tree model provides an effective tool for finding and accessing work variables used during startup, experimentation, and model optimization. Figure 2(b) shows the tree of the model shown in Fig. 2(a). The nodes of the tree model contain data and functions of objects that determine their properties and actions. The names and symbols of the nodes depend on the type of data being stored.

Support for an object-oriented approach enables the implementation of agent modeling. FlexSim does not have special library blocks that provide agent functionality. The built-in FlexScript scripting language and the C^{++} programming language are used to describe the rules of interaction and the state of the system agents. Software commands also set up messaging between objects, ensuring effective coordination and management of the model. Thus, there is a possibility of establishing information flows and feedback between the structural elements of complex systems.

Simulation models can be built for single use, for example, in solving the problem of optimal allocation of resources between departments, or for multiple use - in the development of parallel and alternative routes of manufacture and processing of products. Disposable models are usually handled by experienced users who are familiar with imitation. Specialists and experts in a particular subject area work with multi-purpose models. This creates the need to implement a graphical interface designed for easy data entry and results in a clear format. An example of a decision support system model based on a simulation model (Fig. 3) was developed by the Mississippi State University to evaluate the performance of the production system as part of the implementation of the concept of lean production (Leanproduction). The system was developed in the FlexSim environment using the GUI linker.

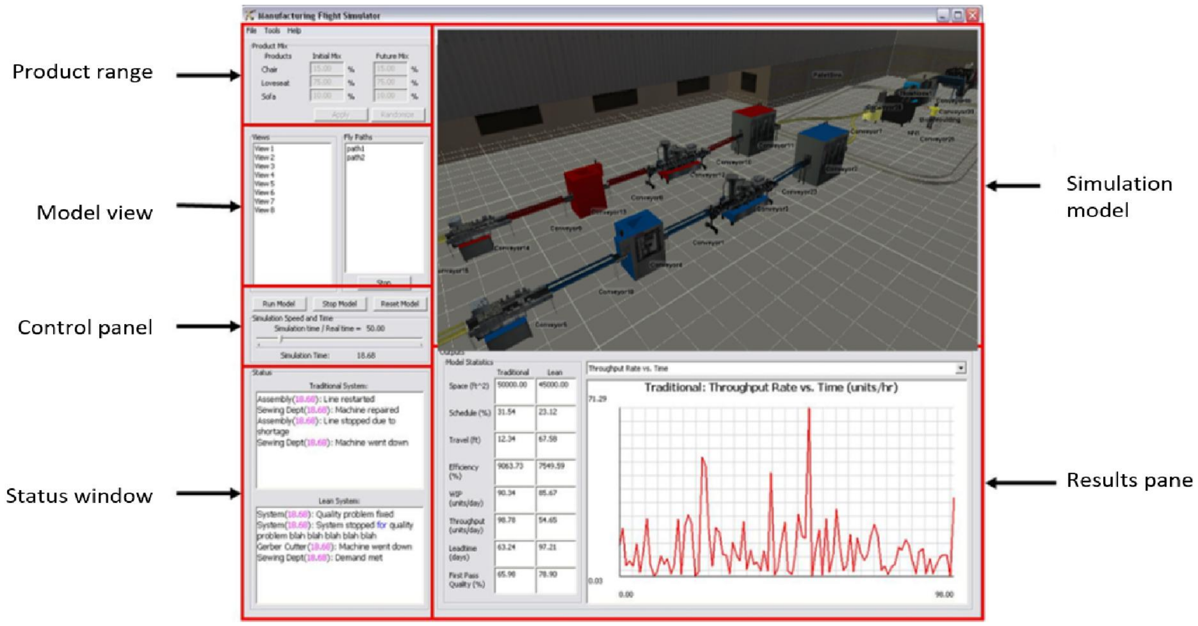


Figure 3:An example of building a DSS model in the FlexSim environment

The model is shown in the center, the input data is entered on the left side of the interface, and the lower part is intended for displaying system performance indicators in graphical and tabular formats. This model interacts with databases, analysis and optimization procedures to support the search for effective solutions.

A key aspect of the Fourth Industrial Revolution is the creation of "Digital Twin" systems that perform the function of remote monitoring and control of the production process in real time. The use of FlexSim for the practical implementation of this approach is provided by the possibility of integrating the program with information systems of the enterprise SAP (ERP, MRP, CRM, etc.), with databases, support for standards of CALS-technologies .

The advantages of FlexSim include the availability of convenient tools for conducting experiments and calculating their results. The built-in ExpertFit module launches multiple scenarios and the model runs within each scenario in a single execution.

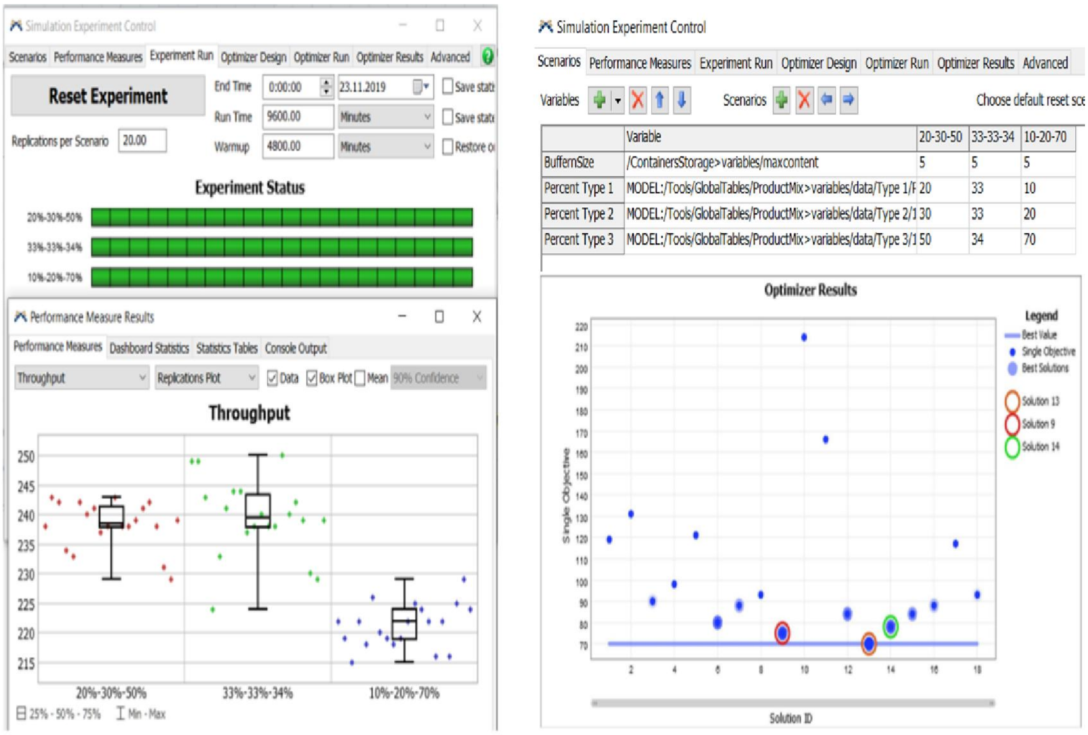
To conduct experiments, you need to set:

- a number of scenarios (experiments);
- a number of runs (model runs) and their duration within each scenario;
- a warm-up period of the model.

Figure 4(a) shows an example of conducting experiments with a model when investigating the effect of the number of workpiece assortment on the performance of the system. Three experiments with 20 runs were performed with the model. The warm-up period lasted 80 hours; the duration of the runs was 160 hours. The results of the experiment made it possible to establish that the highest productivity will be provided with the percentage ratios of the product range of 33% -33% -34% of the 1st, 2nd and 3rd types of parts, respectively. Thus, according to the results of the experiments carried out, the best parameters of the system are selected by analyzing possible alternatives. For organizations, this "what if ..." approach provides significant time and cost savings in decision making. If necessary, the results obtained can be exported from HTML format as CSV files to create and print reports and for their further analysis.

The FlexSim experimenter, during operation, automatically distributes program threads between the available computer processor cores, as a result of which the model runs in parallel. Therefore, the implementation of experiments for complex systems with a large amount of input data requires minimal time. Experiments designed to evaluate individual model scenarios are constructed by analysts for specified input data values. Therefore, experimental results depend on the practical experience of experts.

The OptQuest optimization tool built into FlexSim uses evolutionary algorithms to find optimal solutions based on specific criteria. Fig. 4(b) demonstrates the result of the optimizer's work



a b

Figure 4: An example of model research: experimental results (a), optimization results (b)

The duration of the production cycle was chosen as the objective function, and the parameters of the system being investigated were the size of the buffer zone and the discipline of service in the queue. The program found 18 solutions. The graph shows the order in which they were received. The optimal solution is 13, at which the duration of the production cycle acquires a minimum value of 71 minutes.

The optimizer continues to run until one of the conditions is met :

- all possible values of the decision variables are considered;
- the time interval allotted for the search for solutions has ended;
- a given number of solutions has been received.

The analysis shows that FlexSim is a leading software tool for modeling and research of systems. Significant functionality of FlexSim software includes:

- modeling of complex production situations;
- analysis of workload;
- support for CALS-technology standards;
- integration of models with enterprise information systems and databases;
- optimal distribution of resources between departments;
- multi-agent modeling;
- realistic 3D-animation and visualization of processes;
- availability of convenient tools for analysis, experiments, and optimization of systems.

3.2. Model of end-to-end training of students in the specialty "Computer Science" using FlexSim software

Given the need of organizations for qualified specialists capable of using modern information technology to solve production problems, Sumy State University has for the first time introduced a comprehensive curriculum that provides end-to-end training, using FlexSim software.

The Department of Computer Science has established a Training and Research Center for Simulation Modeling and Systems Analysis (TRC SMSA) whose activity is to improve the educational process of student training.

The creation of the training center became possible thanks to the grant activities of the Polish foundation InterMarium, whose representatives organized and conducted training for higher educational institutions of Ukraine and provided licensed FlexSim software for implementation in the educational process. The comprehensive program has been tested in the preparation of bachelor's and master's degree students in the specialty of computer science. The main goal is to train an IT specialist with practically oriented competencies necessary for solving problems that are relevant in production conditions.

Table 1 lists the disciplines and topics required to provide a comprehensive training program.

Table 1

Disciplines included in the program of end-to-end training by means of simulation modeling (fragment)

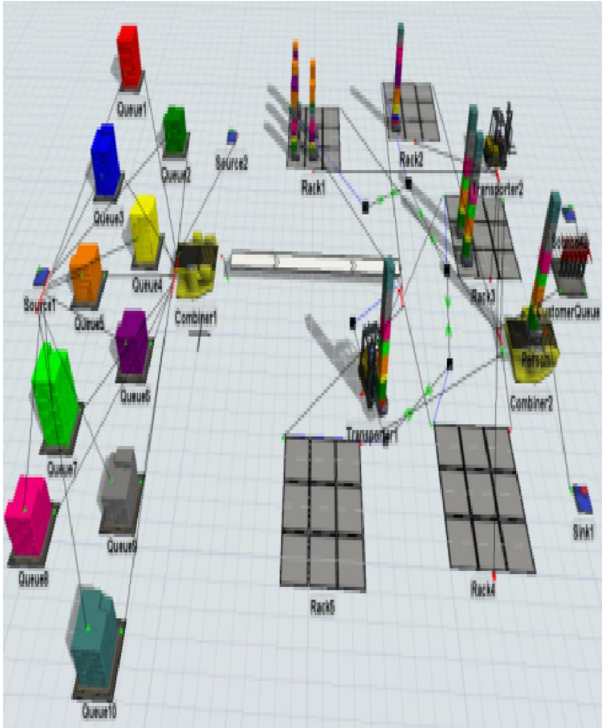
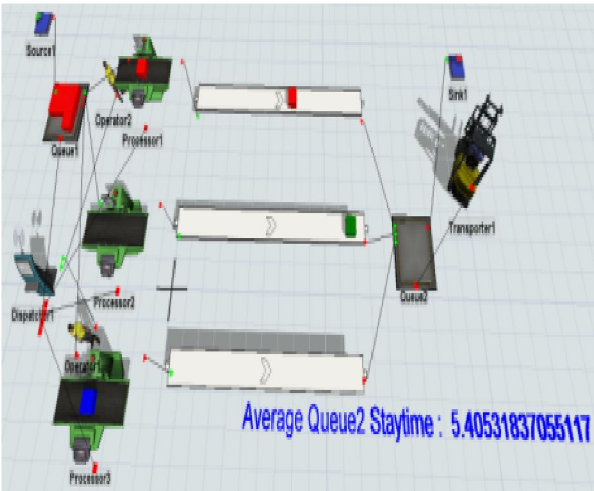
Disciplines	Teaching course	Topics
Organization and processing of electronic information	1	• Analysis of simulation software • Integrated environment of FlexSim simulation modeling software • The use of simulation for solving practical problems
Fundamentals of object-oriented programming	2	• Hierarchical architecture of FlexSim software • Basics of the FlexScript programming language • Object-oriented programming in the C ++ language • Programming objects and agents in the FlexSim environment
Computer graphics	2	• Development of 3D objects of simulation models and their import into the FlexSim environment
Corporate information systems	3	• Methods and tools for integrating simulation models into corporate systems SAP (ERP, MRP, CRM)
Systems modeling	3	• Modeling and analysis of queuing systems • Simulation of random events • Discrete-event modeling in FlexSim environment • Modeling of continuous processes by means of FlexSim • Construction of model logic by means of ProcessFlow • Multi-scenario experiments and model optimization
Organization of databases and bases of knowledge	3	• Ways to organize the input data of the simulation model • Integration of FlexSim software environment with databases
IT project management	4	• Life cycle of simulation modelingand analysis (IMA) • Distribution of roles and responsibilities in the IMA project • Modeling project management
Decision theory	5	• Decision support systems based on simulation models

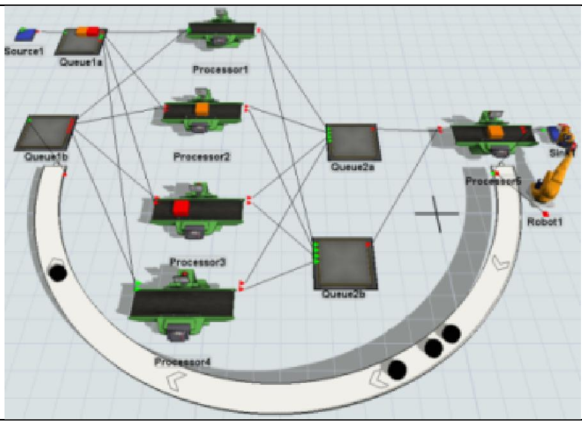
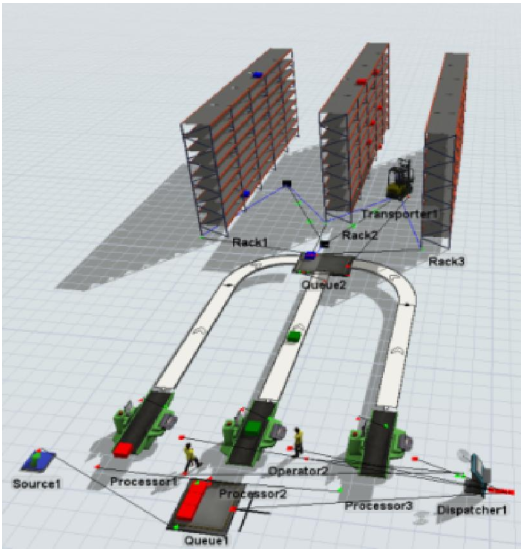
The end-to-end training model combines the key disciplines of the professional and practical direction from the 1st to the 6th year inclusive and is implemented by the following activities: complex theoretical training; comprehensive practical training; course design; diploma design; research projects.

The end-to-end training program places great emphasis on the practical component. To ensure the educational process in the FlexSim environment, a set of 25 basic simulation models of production and service systems has been developed. Fragments of the models and their brief descriptions are given in Table. 2.

Table 2

Library of FlexSim simulation models for the learning process (fragment)

Model 1	
	Scope of application: Service. Description: The model reflects the complete set of products for customers, each of which has its own order profile. The supply of certain types of products and the receipts of customers are stochastic values. Results: The mode of operation of the service resources of the system has been determined, in which the time for forming an order is minimized
Model 2	
	Scope of application: Production. Description: Three types of products enter the system, enter the queue zone 1, are processed by operators on the machines, through the conveyor belt they are delivered to the queue zone 2, and are removed by the conveyor from the system. Results: The influence of different methods of ordering products in the queue (LIFO, FIFO) on the system performance was investigated
Model 3	
	Scope of application: Production. Description: Four types of parts enter the system, depending on the type of parts processed on one of the 4 machines. The robotic arm performs quality control of the parts. Defective parts are returned

<table>
<tr><td></td><td>to the repetition of technological operations and are processed out of turn.
Results: Identification of bottlenecks in the system operation: equipment downtime, places of accumulation of work in progress</td></tr>
<tr><td colspan="2">Model 4</td></tr>
<tr><td></td><td>Scope of application: Production.
Description: Operators process 3 types of parts, which are transported by a conveyor belt to the queue zone, from where they are moved by a forklift to the racks of the warehouse and, depending on the type of parts, are located on the corresponding shelves. Operators and equipment are easy to operate.
Results: It was determined how many work resources (operators and foprklifts) are needed to ensure the required system performance; it is investigated how the replacement of manual labor with an automated one affects the throughput of the system</td></tr>
</table>

The theoretical and practical parts of the program, in addition to studying development methods, building simulation models, researching and optimizing them, are also aimed at developing skills to work with customers, prepare technical and user documentation, validate, verify, and provide technical support for simulation models.

In order to ensure interdisciplinary links, work was carried out to coordinate the working programs of training courses and developed methods of organizing the educational process. This takes into account the recommendations of the Council of Employers which includes specialists from leading companies in the Sumy region. Within the framework of diploma and research works, special attention is paid to projects, the topics of which are relevant, and the results can be implemented in the practice of enterprises and organizations.

Graduates who have mastered a comprehensive training program can work as business analysts of production systems. Such a specialist is able to develop and implement a simulation model within the chosen methodology, check it for correctness and use it for analysis and optimization of production processes. Successful work in the field of business process modeling is provided by the formed practical skills. Implementation and research of simulation models related to production and service processes develop students' practical competencies related to these areas and allow them to gain the necessary skills to work with software.

In the course of the educational process, it is recommended to provide students with the opportunity to experiment with models, implement their proposals and ideas to improve the operation of systems, which may consist in changing the mutual arrangement of equipment, reducing or increasing their number, changing statistical distributions and system parameters. The high flexibility and convenience of the software environment allows them to quickly evaluate the results of the changes made and arouses interest in the learning process.

Modeling is an important tool for supporting decision-making processes in solving problems related to improving systems. Construction and research of the developed typical models in the FlexSim environment (Table 2) contributes to the development of professional competencies of students.

4. Conclusion

Due to the increasing power of computer systems, it is possible to move from complex, imperfect and little-understood analytical methods to simulation models. There are many information environments for building models. The most widespread programs among them are MATLAB/Simulink, Arena, and AnyLogic.

One of the newest and most promising tools for simulation is the FlexSim system.

Studies have shown:

- the use of FlexSim software in the educational process contributes to the forma-tion of graduates' key competencies in the field of Industry 4.0;
- in Ukraine, there is no practical experience in implementing the FlexSim program in higher education institutions.

In this regard, there is a need for effective teaching of students of different courses in basic concepts and possibilities of simulation.

At the Department of Computer Science of Sumy State University, a comprehensive program of end-to-end training in simulation tools was developed using the latest FlexSim software.

The main contribution of this work is to provide practical experience and educa-tional information on the use of modern computer simulation technologies.

The experience gained allows us to state the following:

1. The use of FlexSim is possible for end-to-end training of students of computer specialties from 1 to 5 years inclusive.
2. When preparing bachelors, it is recommended to direct the educational process to:
- methods of collecting and analyzing information about the system;
- establishing laws for the distribution of input data;
- construction of a conceptual model of the system;
- determining ways to store input data;
- development and implementation of simulation models of the system;
- development of user interfaces;
- collection of statistics and analysis of modeling results.
3. In the master's cycle it is recommended to pay more attention to:
- validation and verification of simulation models;
- planning and conducting experiments with models;
- single- and multi-criteria optimization of systems;
- interpretation of modeling results;
- development of recommendations for improving the efficiency of systems.
4. The most promising and suitable for gaining practical experience with the FlexSim program are models that reflect the production and maintenance processes.

The use of the developed basic simulation models, as an element of professional training, makes it possible to systematize knowledge, taking into account their role and place in solving applied problems of a particular industry.

There is an opportunity to build a practice-oriented training of specialists aimed at analysis and research, provides the development of analytical thinking, the formation of skills in applying the acquired skills in new conditions of activity associated with the introduction of the concepts of Industry 4.0.

The developed typical simulation models in the FlexSim environment and me-thods for their study can be recommended for mass distribution and implementation in the educational process of higher education institutions that train specialists for the IT sphere.Man-machine interaction in discrete automated systems can be well described using models, based on functional networks. Adaptive

changes in man-machine interaction can be reduced to the problem of step-by-step choosing the optimal fragment of the functional network.
The method adapts the system to the peculiarities of the human-operator and environmental parameters.The combined model, which consists of a neural network for forming initial data, a functional network for modeling a dialogue and a neural network for managing the dialogue process provides a higher level of adaptation to a human operator than the known models built on the basis of unmanaged functional networks.
The computer program was used in the design process for systems of various purposes and its effectiveness was shown. Experimental studies have shown the constructiveness of the developed method.

Models will be useful for automated control in industry, agriculture and e-learning

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Extended Reality in Digital Learning: Influence, Opportunities and Risks' Mitigation

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Abstract

The paper discusses AR/VR/MR/XR technologies in learning namely their influence/ opportunity and risks' mitigation. Main aspects are as follows: methodology (factors influencing a student's cybersickness in AR/VR/MR/XR, the improved model of the cognitive activity in synthetic learning environment). It has been developed the technique and ICT to study psychophysiological changes in normal and stressed conditions. The experimentation results demonstrated that decrease in myocardial tension index under cognitive performance conditions in immersive activity over time of observation was more significant and this fact could be accounted in measurement of influence of the synthetic environment on students, as well as the technique to measure AR/VR/MR influence. The technique proposed by the authors is based on modified ICT and used in previous research: to assess influence of AR/VR/MR/XR as changes of short cognitive/perceptual tests (3 minutes before the work and afterwards) with registration of physiological indices informative in our research.

Keywords

ICT, synthetic learning environment, AR/VR/MR, cybersickness.

1 Introduction

Transformational effects created by information and communication technologies (ICT) in various fields of activity attract the attention of researchers because of changes in skills needed [1]. The dynamics of this sector depend on global challenges and broader trends that determine the long-term priorities of science and technology in the 4th Industrial Revolution [2]. One can highlight current trends in (1) *technology*: development of 3D modeling tools for biomedical engineering as a life support technology; creation of effective forms of visualization of information, content and knowledge as technologies of knowledge engineering; (2) *content industry*: the emergence of additional media products in the form of games, virtual realities (VR) and their integration with other media products and social networks through the creation of common stories as a convergence of content delivery models [3]. Note that converging nano, bio-, info- and cognitive technologies create a qualitatively new environment for human life [4]. Thus, due to the development of advanced algorithms and programs for processing, storage and transmission of images of various nature in the near future is expected to increase the efficiency of virtual scene technology and augmented reality (AR), three-dimensional (3D) modeling, in particular for biomedical engineering [5]. As a result of the technological evolution of AR (from VR helmets in the 1970s, AR displays and the first mobile AR applications in the 1990s to "smart" AR glasses today), the preconditions for the use of AR technologies for virtual training of doctors and surgeons have been created [6]. AR technology will "collect" all the necessary information for operations (received in the process of conditions' monitoring from sensors and video cameras) in a single image, adapted to the rapid perception and learning [7]. That created conditions for a significant improvement in the quality of professional activity for the near future, including mobile [8]. However, the main obstacle predicted by experts will be the lack of specialists, both relevant professional skills,

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in particular, and relevant digital competencies in general [9]. Another drawback of extended reality technologies is the insufficient understanding of the psychophysiological "cost" of activity in the virtual environment [10] due to insufficient knowledge of the characteristics of human consciousness in a synthetic environment [11] and possible cybersickness [12]. The latter has been researched and characterized in VR for decades, but we don't know as much about the extent it affects users of AR/VR/MR/XR technologies. Typically, VR users experience more symptoms on the disorientation to nausea end of the scale, whereas AR users are more likely to experience headaches and eyestrain [13]. While these symptoms may not sound debilitating, when AR headsets are used for extended periods of time, these symptoms can have a significant impact and, as indicated by a recent study, be as severe as those associated with VR exposure.

Purpose. To develop the model of risks related to AR/VR/MR/XR technologies in learning, as well as ICT structure and technique to study influence of these technologies at the learner performance and cybersickness.

2 Methodology

The life cycle of technologies, innovative technological products and services will only accelerate. In such conditions it is natural that scientists connect their hopes for creation of the positive integrated reality under conditions of convergence of physical and virtual learning environments. In these conditions, the role of research and development in the field of educational applications of ICT, in particular in general secondary education, remains extremely important. Corporate learning has pioneered such applications, drawing on best practices in VR and AR, artificial intelligence, including the use of chat bots, knowledge bases, including video content creation, micro-learning and mobile learning. These processes push the evolution of tools, forms and methods of teaching in general education as well.

We adhere to the opinion that the potential of the information and educational environment saturated with digital technologies, first of all, should be considered from the standpoint of the development of cognitive activity of learning subjects. If students learn information images, including real natural phenomena and processes, through experimentation with various digital tools and technologies (simulations, computer simulations, virtual and augmented reality, etc.), it will provide creative activity in an integrated (real and virtual) learning environment, will affect the cognitive motivation of students, will contribute to the formation of appropriate digital competencies [14].

An important role in identifying areas for possible transformation of the education system is shared access to new digital technologies. According to world experts, the tools of virtual reality VR, augmented reality AR and augmented virtuality AV, mixed MR and extended reality XR (the latter includes all previous ones as well) are developing at the highest rate. The fourth industrial revolution is accompanied by the transition of production and, consequently, education in a synthetic environment of activity (both production and training). Education reform requires the accelerated implementation of augmented reality tools into the educational process, as well as the preparation of future employees to interact with artificial intelligence systems, as well as robotic systems.

The difference between these terms and means is that they are different combinations of real (RR) and virtual reality, forming variants of an immersive learning environment in which perception is the result of a synthesis of consciousness and feeling [15, p.16]. The most widespread over time from this spectrum are augmented, virtual, mixed and extended realities, for which the following types are distinguished:

- *supplemented* - market-oriented AR, location-based AR, overlay-based AR, projection-based AR; all these types can be used in the educational process [16];
- *virtual* - non-immersive VR, full immersive VR, shared VR, web VR;
- *mixed* - options for combining real, augmented reality, augmented virtuality and virtual reality.

Augmented reality includes the whole spectrum, from "complete real" to "complete virtual" in the concept of the continuum of reality-virtuality, proposed by Paul Milgram. With the development of technical means of virtualization of reality and means of registration of indicators of human sensory systems and the impact on them there is a specialization and separation of new types of immersive environments. For example, SR (substitutional reality), 360 virtual reality (or 360 VR, which allows to observe the object from any angle), etc. It can be expected that the range of synthetic "realities" will further expand, accounting the possible relationships of human sensory systems, cognitive models of activity and real reality [9].

2.1 Factors influencing a student's cybersickness in AR/VR/MR/XR

It is important that the synthetic environment is not natural for humans, and its impact on his/her mental and physiological processes remains insufficiently studied. Until now, among the factors influencing the synthetic environment with different forms of virtualization on a person and his health, it is proposed to distinguish the following:

1) *personal*: *internal* (inherent in man) - hereditary, gender, age, ethnic; *physiological* - interpupillary distance, flicker fusion frequency threshold, postural stability, strength and mobility of nervous processes, plasticity, cardiovascular system, vestibular apparatus; *mental* - consciousness, cognitive features, spatial operations, thinking; *health* - diseases, disorders of the visual system;

2) *technological*: optical factors; reflection factors; factors related to spatial tracking; sound factors; factors related to the form factor;

3) *operational* – adaptation, the degree of control, head movements, general visual (other sensors, in addition) flow, speed linear and rotational acceleration, speed of self-movement, density and height of the visual scene above the terrain, brightness level, vection (illusion of self-movement), duration, cognitive workload. The model of influencing factors demonstrates their systemic nature (Figure 1).

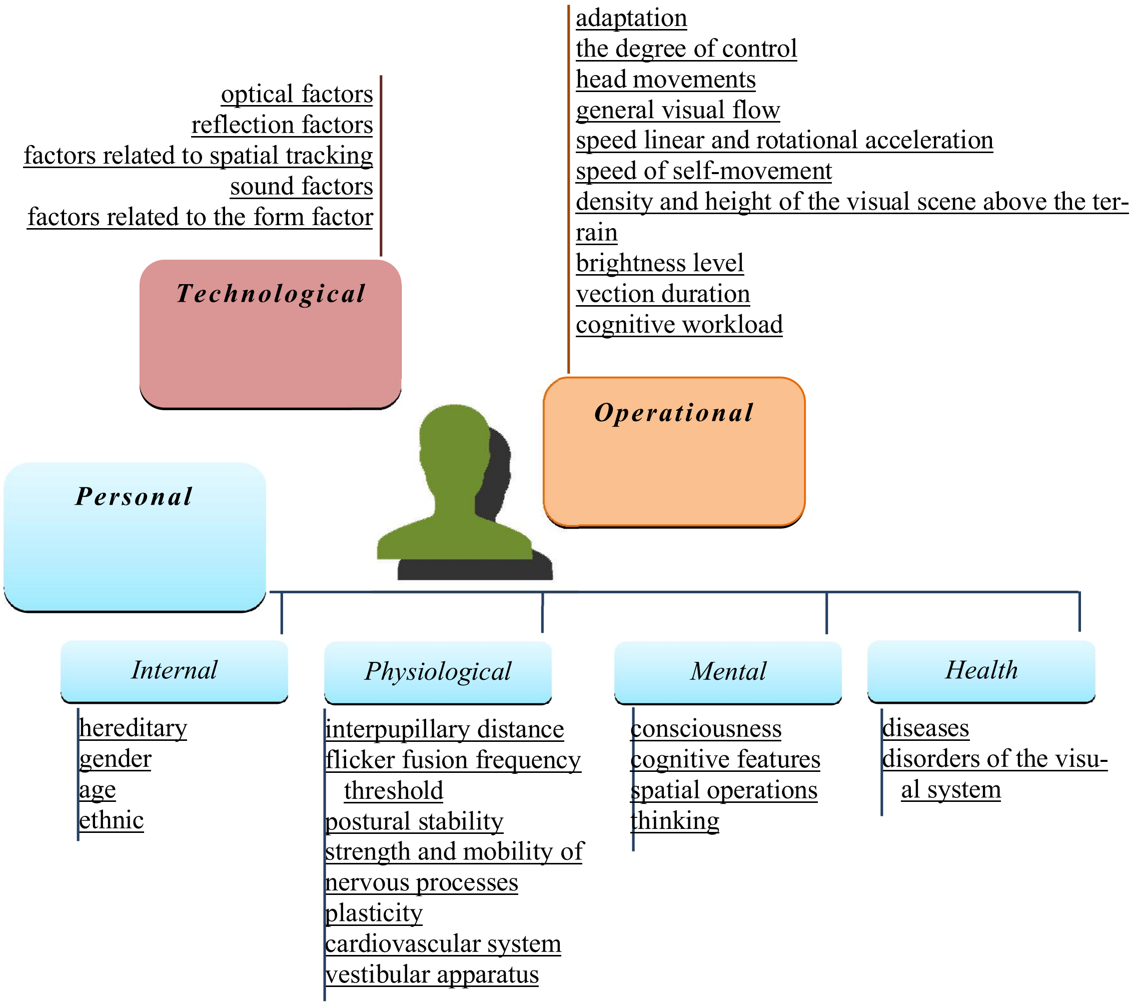

Figure 1. Factors influencing the synthetic environment

For learning, the most significant factors are that relate to the person features/abilities and operational ones.

There is increasing interest in determining any risks of using such technology and any aftereffect from exposure. But the duration of the aftereffects from virtual environment (VE) exposure are not well studied to date even after 20-years study [17]. Head-mounted display manufacturers provide general usage guidance, but this is *ad hoc* and there is limited recent evidence comparing early virtual environment studies with experiences from modern head-mounted displays. The primary objective of the study [18] was to explore response activation and inhibition after participants experienced a typical virtual environment in a head-mounted display. The evidence of participant fatigue in the reaction time tests was found. This work confirms safe use of virtual reality experiences in modern head-mounted displays for short duration exposures (15 min) and identifies issues with reaction time testing that are in need of further investigation. Duration of VR activity in many researches are limited by 15-45 minutes. In modern devices (f.e., Oculus Glasses) it is recommended the time of take at least a 10 to 15 minute break every 30 minutes, independently on age, sex, mental health level etc.

But there is only a few studies that aimed to assess the physiological “cost” of cognitive work in VR. The investigation of VR-induced aftereffects on various basic cognitive abilities and its relationship with cybersickness. Previous studies suggest an adverse effect of VR exposure on simple reaction times. Aftereffects on other basic cognitive abilities have rarely been studied. The authors propose a general aftereffect of VR exposure on reaction times that is only slightly related to subjective degrees of cybersickness. Taken together, however, usage of VR systems, even if inducing moderate levels of cybersickness, leads only to minor decrements of cognitive performance [19]. The question aroused in relation to day-to-day stability-instability of cognitive tasks performance: was this characteristic of only selected professionals or our findings had more general nature for people working with digital technologies? Future psychophysiological VR-induced aftereffects needs to be studied in relation to age, experience and prolonged (cumulative) usage of learning/training/work with VR.

VR technologies make learning more visual, enable trainees to be activated, and more fully engage them in the learning process. These technologies facilitate and simplify the collaboration of people who are at a distance, who can meet with the help of AR, prepare joint documents, lead projects and perform many other work almost as effectively as with personal contact in real world. Teachers and students have the opportunity to use virtual laboratories to study the world around them, develop skills, as well as to demonstrate their development and automated assessment [20].

Cognitive activity in VR is the brightest manifestation of the immersive environment for education/training. Virtual Reality glasses, helmets, 360° panoramic cameras and screens, as well as CAVEs give new opportunity for learning, and have some specific features in comparison with more traditional digital devices:

- If in the real world the user interacts with the digital world through a "window“ (computers, tablets and mobile gadgets) observing what is happening "from the outside“, "immersion" is the condition in which the user loses awareness of the facts actually occurring in an artificial world.
- If in the real world the user involves almost only vision (other sensors are not involved or they supply non-observational information), in “immersion”, the user experiences the virtual world with involved his/her senses and is able to interact with the virtual environment.
- Sensory useful (target) load approaches 100% and requires 100% attention and concentration, regardless of the significance of the task. Sensory "hunger" (with monotonous operator activity) can be replaced by sensory exhaustion.

The question is what could be VR/AR/MR consequences for health? How safe are virtual reality technologies for human health? The long-term consequences of using these technical means are not yet clear. But it is already obvious that they are invading the work of the human body. And we are talking not only about the curvature of the spine due to the prolonged wearing of a heavy device on the head, but also about the impact on the user's eyes. The headset forms a wide field of image; it is a rather complex device that interferes with the normal operation of the visual apparatus. A systematic study of the impact of immersions in virtual reality on human health in general and on his mental health is still an open question [21]. Medical and physiological studies over the past quarter century have shown [22] that immersing a person in a specially designed virtual reality can significantly affect his/her mental health (treatment of depression, elimination of alcohol dependence and other mental disorders.

However, all these studies are still quite fragmented, and the proposed methods require a qualified psychotherapist that is not applicable in education/training [23].

Further research of the problem should focus on the detailed development of types of threats to participants in the educational process, as well as methods of counteraction. A special point should be resistance to cyber-hazards, which can use the experience of training emergent industries' operators primarily diagnosing the current state of the person and necessary adjustments in order to optimize its activities.

2.2 Model of the cognitive activity in synthetic learning environment

As it was stated [24], VR/AR/MR/XR are the brightest manifestation of the immersive environment for education/training, and have some specific features in comparison with more traditional networks/devices, and the object of activity (mental) is not external in relation to the human, but internal one [25]. The model of the cognitive work (P. Anokhin's model of the activity functional system that has been developed by authors for cognitive activity) can be specified for the case of VR/AR, where activation of the sensory (affector) inputs (Figure 2) happen not so from the outer environment, as from the *Virtual Act Program* without activating the *Act Program* mechanism (as in physical activity).

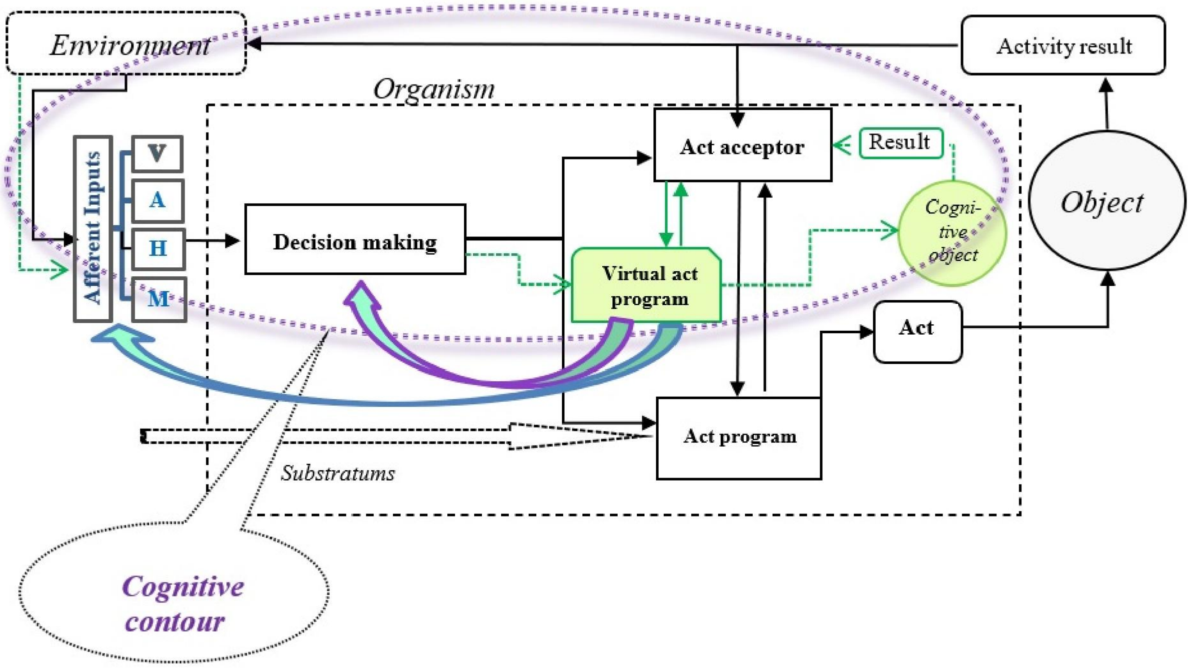

Figure 2. Theoretical scheme of the functional system of learning activity in VR/AR/MR, where the cognitive contour is associated with the "internal" activity (modified from [25]). Note: "Afferent Inputs" are: V -visual, A - audial, H – haptic, M – motion

In other words, the chain "*Act acceptor – Act program – Act – Object – Result*" in traditional activity transforms into the chain "*Act acceptor – Virtual act program – Cognitive object – Cognitive result*". The most important feature of such a process is that *all* system elements and their interactions are part of the human organism, i.e., its internal environment, in contrast with physical (or miksted) activity, where its object is located outside the organism and activity takes place in whole or in part of the external environment. We believe, that this model can explain, why such regulation can deplete and imbalance the body: *Act Program* works in coordination with the *Act Acceptor* and *Substratum* needed for the normal life and activity. But lack of the signals from the *Act Program* cannot activate the general feedback from activity, only simulating it at the neurological level [25, p.352].

Another difference is influence of the *Virtual act program* on the *Decision making* block, because both blocks and the *Cognitive objects* are parts of the same cognititve process. Besides, the *Virtual act program* can influence on the *Afferent inputs* activating sensors participated in the particular cognitive activity according to the work task.

As a result, all neurophysiological subsystems (blocks in the schema) are more active the more immersive is the task performance. That is why the control of operational parameters in AR/VR/MR/XR is so important to mitigate cybersickness, especially in learning process that can take hours of a human activity, in general.

3 Results and Discussion

To date, it was confirmed that changes in efficiency of immersive cognitive activity with digital units had strongly individual nature in day-to-day performance of the same complexity that could be explained by the internal (physiological) and external influences on a human.This notion has been confirmed by the high relationship between indicators of test performance (rate and reliability of problem solving) and physiological indices. Only the simultaneous activation of both paths (energy and information) provides higher level of optimization of educational/training capacity - quality education [9]. An unbalanced path and thus the strain of regulatory mechanisms of adaptation may be the cause of functional impairment and eventually the case of violations of students' health. It has been found that:

- Work with computer in "classroom" can blur attention because of low workload of non-active sensors and their ability to be affected by unplanned external signals.
- Higher workload of all or many sensors can be accompanied by more significant increase of adverse changes in physiological support of activity.
- Because involvement of a user into VR activity is very high (motivation, sensors workload), information environment coincides with cognitive one, but the latter is significantly *individual*.

It should be noted that the psychological/psychophysiological aspects of cybersecurity, inherent in the human factor in human-machine systems, can be significantly enhanced in the synthetic environment, which is currently an unexplored area in general and in education in particular [26]. On the other hand, the use of models for predicting the effectiveness of learning (included in adaptive systems) allows to assess and predict the effectiveness of augmented and virtual reality for synthetic learning environment [27] and human integration in general [28], epecially accounting modern trends in the ICT evolution [29]. To realize such an approach, the methodology described above was used as a basis to apply appropriate ICT that provides methodical maintenance of cybersickness risks' measurement and assessment, test generation and control, data storing, data analysis and necessary service for researchers.

3.1 Method

In our previous research the cybersickness has been modeling in experimental study of cognitive activity with measuring of its psychophysiological response to a human focused cognitive test performance (high motivated, without external disturbances) with and without time pressure [25]. In addition, the technique included measurement of electropuncture diagnostics' indices by Nakatani (24 regular points and 3 stress' points), as well measurement of lipid metabolism using sweat collection before and after the test session for each subject. Subjects included 28 males of 18-40 year old.

The experiments differed by the test (permutation of random non-repeating digits from 0 to 9 in ascending order) workload: training E1 (60 min); E5 - free rate ("«auto-pace"), and E6 - fixed rate calculated as average by results of the appropriate test performance in E1. The E6 could be evaluated as the model of immersive cognitive test performance (high motivation and time "pressure", because according to our previous study the individually "average" rate of task exposure was more difficult than twice as slow or as fast). Duration of the test performance session was 3-hours long.

As indices of physiological “cost” of activity and the human state we registered a heart rate HR and blood pressure (systolic BPs, diastolic BPd) by means of the cardio-monitor "Solveig". The indices HR, BPs and BPd we registered during 10 min prior to the tests beginning (index “0”) and 10 min after finishing (relaxation), as well as every 5 min during the test activity [25, p.352]. Clear changes appeared in physiological response: increase of the level of low density lipids, energy balance (Electropuncture), heart rate (myocardial tension index after R. Baevsky) and blood pressure. The data received have demonstrated quite individual nature of changes in time.

To study that phenomenon, we carried out the similar experiments, but with another analysis of data stored. The method of computer data processing was aimed to analyse physiological changes at different phases of test performance that would correspond phases of a human performance after Egorov&Zagriadskii. Because diastolic blood pressure has been revealed as the most informative (sensitive to the cognitive workload) physiological index, BPd was averaged for consequent 20-minutes intervals and was represented at the “phase plane” (vector diagram where one point corresponded to one 20-minutes interval). Vizualization of the physiological changes on the phase plane (Figure 3) has confirmed that first 20…40 minutes of tests performance are accompanied by the higher systolic pressure and/or at the end of the performance (this corresponds the phase of the “end gust effect” after Egorov&Zagriadskii). But the first phase could have individual features from viewpoint of time structure, if to analyze it in more detailed way (f.e., minut-by-minut or in 5-minute intervals) that could be significant accounting that VR/AR activity longer 40 minutes were not studied, and “normal” academic hour is 45 minutes.

The next step of analysis was carried out to study myocardial tension index’s variation (after R. Baevsky) at the 1st 45-minutes interval of test performance (that could be considered as equivalent of the academic hour) with 5-minut consequent phases. We compared physiological workload in experiments E5 and E6 again. If in previous analysis with 20-minutes phases some individual differences were registered, it has been revealed a clear trend in subjects’ myocardial tension between experiments E5 and E6: the higher level of tension under “harder” conditions (experiment with time “pressure”) during first 20 minutes (four phases) of test performance (Figure 4).
In other words, decrease in myocardial tension index under cognitive performance conditions in immersive activity over time of observation was more significant and this fact could be accounted in measurement of influence of the synthetic environment on students.

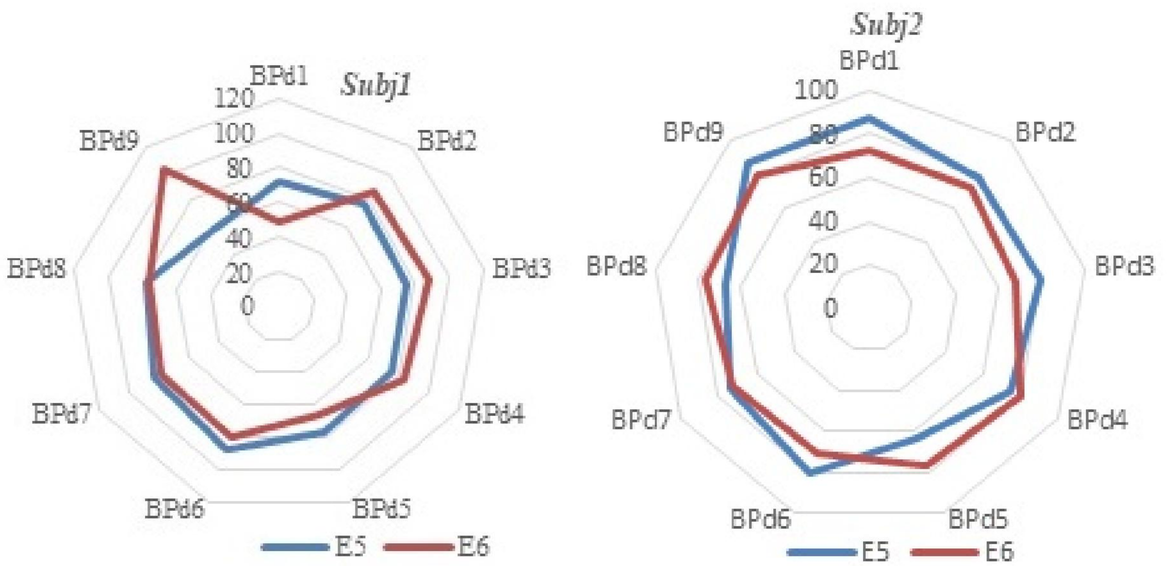

Figure 3. Physiological (blood pressure) changes on the phase plane in two subjects

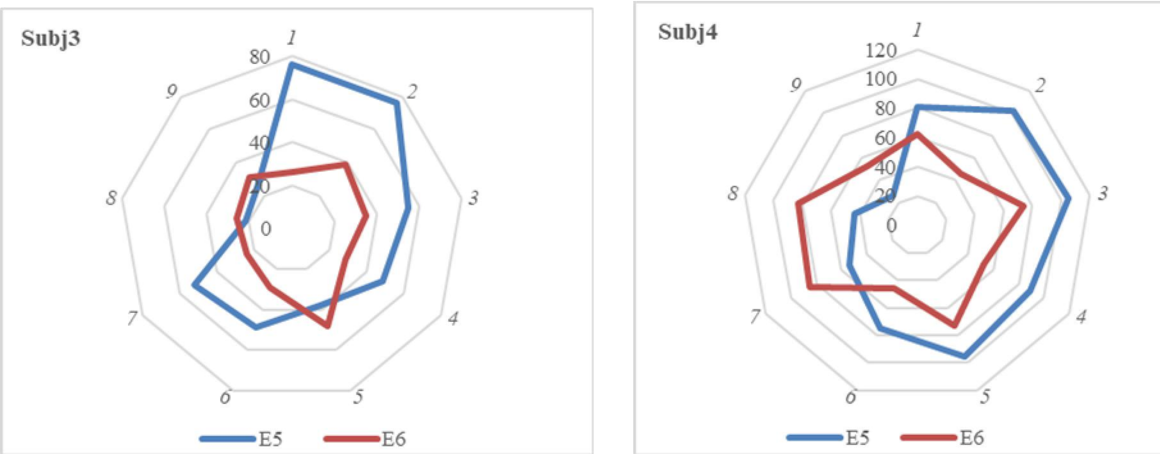

Figure 4. Physiological (myocardial tension index) changes on the 45-minut phase plane in two subjects

3.2 The technique to measure AR/VR/MR influence

The main difficulty in measuring influence of AR/VR/MR/XR on a human cognitive performance is to differentiate psychophysiological effects of usual cognitive workload and synthetic “realities”, especially in the education process. This is a general problem of assessment of Associations Between Digital Technology Engagement and Mental Health/efficiency Problems. Even more, according to the study [30], there is no evidence that associations between adolescents’ digital technology engagement and mental health problems have increased over. These results are based on observation of 430,561 participants (adolescents) over period 1991-2019 in the United States and United Kingdom. But that study did not take into account that everyday environment of todays’ young people is digital with related specifics. That is why measurement of possible influence of the synthetic environment should be provided by means the same or similar digital tools.

The technique proposed by the article authors is based on modified ICT described above and used in our research. But we plan to assess influence of AR/VR/MR/XR as changes of short cognitive/perceptual tests (3 minutes before the work and afterwords) with registration of physiological indices informative in our research.

Thest performance is controlled by appropriate ICT in on-line or off-line modes.

4 Concluding Remarks and Future Work

Augmented, virtual, mixed and extended realities become the part of a human everyday life in all areas of life and activity. It is important that the synthetic environment is not natural for humans, and its impact on his/her mental and physiological processes remains insufficiently studied. Factors influencing a student’s cybersickness in AR/VR/MR/XR can be considered as: *personal* (internal, inherent in human; physiological; mental; health); *technological* (technical means, ergonomic); *operational* (adaptation, the degree of control, head movements, general visual flow, linear and rotational acceleration, speed of self-movement, brightness level, vection (illusion of self-movement, duration, cognitive workload).

It has been developed the theoretical scheme of the functional system of learning activity as a further development of the TFS model for learning. It was highlighted that all neurophysiological subsystems are more active the more immersive is the task performance. That was why the control of operational parameters in AR/VR/MR/XR was so important to mitigate cybersickness, especially in learning process that could take hours of a human activity, in general.

Decrease in physiological indices (myocardial tension index and blood pressure) under cognitive performance conditions has been revealed in immersive activity over time of observation, and it was more significant than in “normal” conditions. Those results were confirmed by use of the technique “phase plane” proposed by authors.

That fact could be accounted in measurement of influence of the synthetic environment on students. Application of developed ICT provides methodical maintenance of cybersickness risks' measurement and assessment, test generation and control, data storing, data analysis and necessary service for researchers. Respectively, it was developed the technique to assess influence of AR/VR/MR/XR as changes of short cognitive/perceptual tests (3 minutes before the work and afterwords) with registration of informative physiological indices. Future work is planned to provide evidence of such a technique efficiency for learning.

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The use of WEB-oriented Technologies in the Process of WEB-programming Teaching for Technical Universities Students

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Abstract

The realities of the XXI century - informatization, digital transformation, high technologies, WEB-technologies in particular - put Ukraine state in front of global challenges of creating a digital state. It is the implementation of a number of digital projects which form the digital space of the state, in particular those coordinated by the Ministry of Digital Transformation of Ukraine.

The development of a significant number of applications requires the state to constantly update them, maintain them working, which requires qualified programmers. The task of technical universities is to train competitive specialists in the IT field.

This study analyzes the results of a survey of students of NTUU "Kyiv Polytechnic Institute. Igor Sikorsky ", the purpose of which was to find out what integrated development environments and programming languages senior students independently choose when developing programs within the educational and professional programs of the faculty, and which correlate with software used by programmers in the implementation of large IT-enterprises, in particular WEB-programming languages.

The results of the study showed as well that the rating of programming languages and the use of integrated development environments meet modern requirements for software development. 76.7% of graduates, while being students, are already employed in IT companies as full-time employees. The high percentage of employment suggests that graduate students of the Faculty of Informatics and Computer Engineering of Igor Sikorsky NTUU KPI are competitive in the modern IT labor market.

Keywords

programming language, integrated development environment, IT graduates competitiveness

1. Introduction

Until recently, the labor market in IT was very attractive for novice professionals from all points of view: low entry threshold, high salaries, the opportunity to work in the largest companies. Over the past few years, the number of juniors has significantly exceeded demand, and the quality of programming skills leaves much to be desired. The current crisis has exacerbated the situation, and at present it will take much more effort to become a truly in-demand programmer.

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In today's world of informatization, computerization and digitalization of education, it is very important to increase the level of training of future bachelors in IT specialties, which in turn depends on the level of competencies they acquire during and after graduation [1, p.140].

Every applicant entering a higher education institution wants to be sure that after graduation he will be competitive as well as have a guarantee to be employed. Higher education institutions, together with the ICT Industry Competitiveness Council and leading companies in the field, are implementing the European Educational Initiatives project, which aims to provide everyone willing with quality modern education in the field of information technology.

Nowadays, educational programs are completely revised and modernized, individual learning trajectories are introduced, which allow for a better study of IT disciplines.

2. Research methods

A number of methods were used in the scope of this article: surveys, questionnaires, interviews with students, methods of comparative analysis and statistical data processing.

For achieving the goal of this study the authors used the following methods of systematic and comparative analysis of:

- sociological scientific, pedagogical, psychological sources;
- special literature to clarify the features of the advantages and disadvantages of Web-based learning tools in the training of IT specialists in technical universities;
- programming software languages use before training and, accordingly, during training at a technical university;
- integrated development environments use in program development during university studies;
- programming languages choice while independently studying and self-improving by students of IT specialties, bachelors of computer science in particular .
- the use of programming languages and integrated development environments for third and fourth year undergraduate students in real projects.

In addition, undergraduate students' recommendations on software selection for strengthening the content component of academic disciplines were studied.

3. Research Results

The urgency of the question on WEB-programming specialists training is confirmed by the fact that Ukraine has set a course to create a digital state, namely the implementation of a number of digital projects, including those, coordinated by the Ministry of Digital Transformation of Ukraine, that form the state digital space [2].

Such projects include: "Action Application (Diya)", "Electronic Services", "e-Residence", "Action City", "Digital Education", "Digitalization of Education", "Business", "Children Protection on the Internet", "European Integration" etc. which include a number of subprojects, for example: residence registration, property rights registration, e-entrepreneur, e-baby, digital tax number, online registration, submission of applications to higher education institutions, etc.

The development of such a significant number of applications requires the state to constantly update them, maintain them in working order, forming a need for qualified programmers, which, in its turn, requires competitive graduate students availability. The IT industry in its dynamics, with the development of cross-platform technologies in particular, appears to be quite large and it requires from graduates not only the knowledge of modern approaches, methods, methodologies (Agile) and software development technologies, but also the teamwork skill, modern strategies and technologies abilities, and in particular WEB-technologies and tools of collective software development.[3, p.76]

Both study and application of WEB-technologies are directly related to Web-oriented learning technologies. By Web-oriented learning technologies we mean forms, methods and Web-oriented learning tools [4, p.108]. The approaches to the organization of student Web-oriented education are carried out on an international level, in such projects as Erasmus + "Curriculum for Blended Learning" and "Blended learning courses for teacher educators between Asia and Europe" [5, p.609].

While considering the complex approach to the organization of education , which combines traditional (30%), distance (50%) and project (20%) learning, using cloud-oriented and WEB-oriented technologies [5, p.609], we can see that higher education institutions put great effort to studying the questions of control and assessment of students' learning activity results, as well as the principles of formative assessment and the levels of cognitive, emotional and motor goals that should comprehensively cover the educational and information space are highlighted; as well as peculiarities of assessment tasks formation in distance learning organization [6, p.734].

One of the components of Web-oriented learning technologies is WEB-programming, which, in its turn, is described in the explanatory dictionary as a developing section of programming which focuses on the development of dynamic WEB-applications, in the creation of which WEB-programming languages are used [7]. While looking into WEB-programming languages it is worth noting that they are divided into two groups: server languages and client languages.

With programs written in server languages WEB-programming is performed on the server side, in the form of client request processing, by interacting with the Database Management System (DBMS). The processed request over the network is returned to the client as a file with possible extensions like: HTML, PHP, ASP, ASPX, Perl, XML, SSI, DHTML, XHTML, etc. Programs in client programming languages are processed by the client-side browser accordingly.

There is a large number of programming languages at present time. They are: JavaScript, C #, C ++, Java, Python, PHP, Visual Basic, TypeScript, Ruby, ActionScript, Delphi, Perl, LISP, Kotlin, Swift, Groovy, Go (Golang), Haskel, Scala, Go, Lua and others. This list is constantly growing as the rating of WEB-programming languages is determined annually. Thus, the Ukrainian profile resource DOU.UA conducted their planned survey on programming languages for 2021, which was attended by 7,211 respondents (92% are located in Ukraine) (Figura 1) [8].

The results of this survey showed that among the top five programming languages in Ukraine the leader is JavaScript (18.1%), with the inferior programming languages coming in the following order: Java (14.6%), C # (14.4%), Python (12.1%), PHP (10.1%)

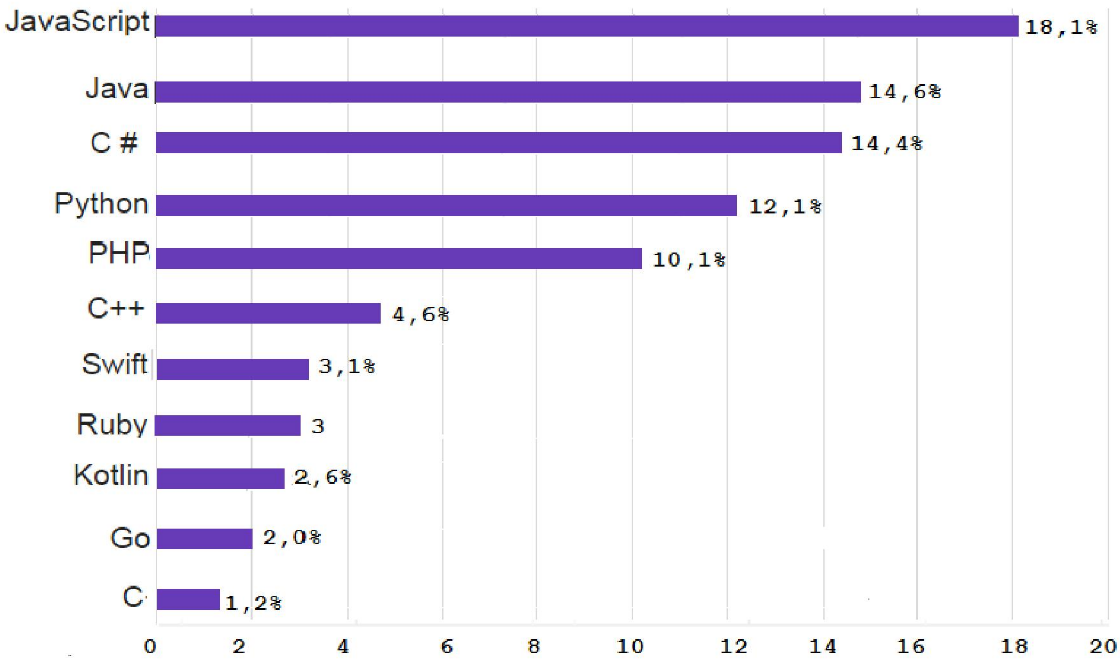

Figure 1: Programming languages rating 2021

While analyzing programming languages basing on Backend, Frontend, Full Stack and Mobile areas of use (Table №1), we see that the rating of the main Back-end languages as: Java (23.4%), C # (20, 3%), HPH (18.4%), Python (12.3%).

The share presence of JavaScript and TypeScript is far not as large and it is comparable to the share of Ruby and Go. It is worth noting that Scala and C ++ are also among the top ten backend languages. In fact, the entire frontend is written in JavaScript (68.2%), TypeScript (26%). The use of other languages is purely marginal. In mobile development, the main languages are Swift (34.2%), Kotlin (26.1%) [8].

Table 1.
Programming languages analysis basing on the spheres of use (Backend, Frontend, Full Stack, Mobile)

Use spheres	Programming languages (%)
Frontend	JavaScript (68,2), TypeScript (26%),Java (1,4) C# (1,2)
Backend	Java(23,4),C#(20,3), HPH(18,4), Python(12,3), JavaScrip(5,6), Ruby(5,3), Go(3,5), TypeScript(2,5), Scala(2,3), C++(1,8) Other(1,4)
Full Stack	JavaScript (36,9), C#(20), Python(10,8), HP(7,7), Java(4,6), Ruby(3,1), Other(3,1)
Mobile	Swift(34,2) Kotlin(26,1), Dart(8,8), JavaScript(8,2), C#(7,9), Java(6,5), TypeScript(3,3), Other(2,8), C++(2,3%)

The European Educational Initiatives project has been implemented in Ukraine since 2016. This is a joint powerful project of the ICT Industry Competitiveness Council, Higher Education Institutions (HEIs) of Ukraine, leading IT companies, which is implemented with the support and partnership with the Ministry of Education and Science of Ukraine, in particular the Verkhovna Rada Committee on issues of science and education.

NTUU "Igor Sikorsky Kyiv Polytechnic Institute" became one of the first institutions of higher education, which started implementing the European Educational Initiatives project in its educational and professional programs. The purpose of the project is to provide everyone willing with quality modern education in the field of information technology, as well as to help IT specialists to be competitive in the labour market and have a guarantee of employment [9].

Thus, within the framework of this project, a survey of students in the field of knowledge 12- "Information Technology", specialties "Software Engineering" and "Information Systems and Technologies" at the Faculty of Informatics and Computer Engineering (FICT) was conducted. The survey was attended by 105 student respondents, among them: 4th year of study students (87%), 3rd year of study (10%), other years (3%).

The purpose of the survey was to find out which programming languages senior students independently choose when developing programs within the educational and professional programs of the faculty and how they correlate with software used by programmers in the implementation of large projects in IT enterprises, including WEB-programming languages, integrated development environments, platforms, frameworks, technologies and libraries.

- Before studying at the university.
- While studying at the university.
- Additional study of software.
- Programming languages and integrated development environments use in real projects.
- Student recommendations on the selection of software to link the content component of the studying course.

Figure 2 presents the programming languages that students managed before studying at the university. It turned out that 36.2% of respondents did not learn any language at all, 36.2% studied Pascal, which is now considered a dead language, 23.8% had a skill of programming in C ++.

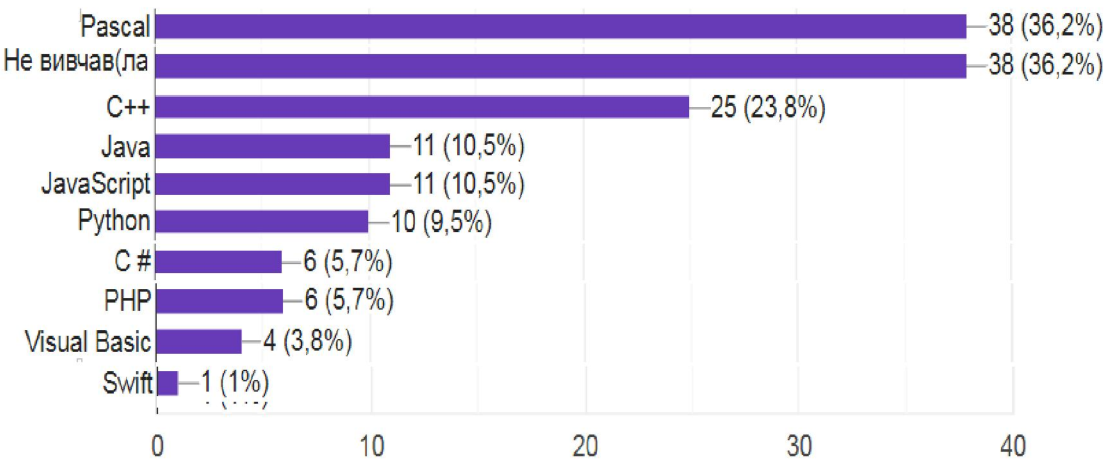

Figure 2: Programming languages managed before the university studying

The results of the survey on the study of programming languages while being at the university showed the following picture: first place - C ++ (69.5%), second place - C # (64.5%), third place for JavaScript (50, 5%). The rating of other programming languages is presented in Figura 3.

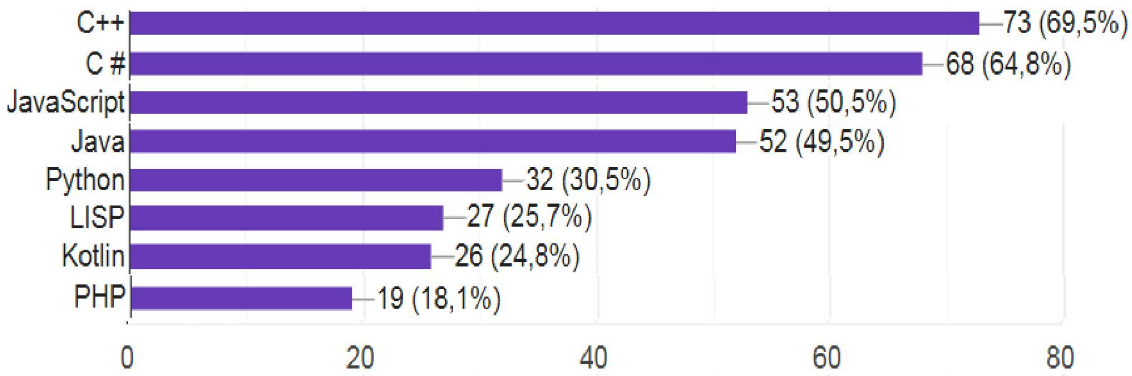

Figure 3: Programming languages covered by educational programs of the university

Throughout the study, along with lectures, seminars, laboratory and practical work, teachers and students pay great attention to the students' individual work, starting from the first year. Individual work organization promotes the development of students' independence, responsibility and organization, as well as forming a creative approach to problem solving on both educational and professional level [10, p.349]. At the Faculty of Informatics and Computer Science, students and teachers develop an extreme level of responsibility on this issue.

The diagram in Figura 4 illustrates the additional study of software, namely the improvement percentage or self-study of new programming languages by students-programmers during their course at the university

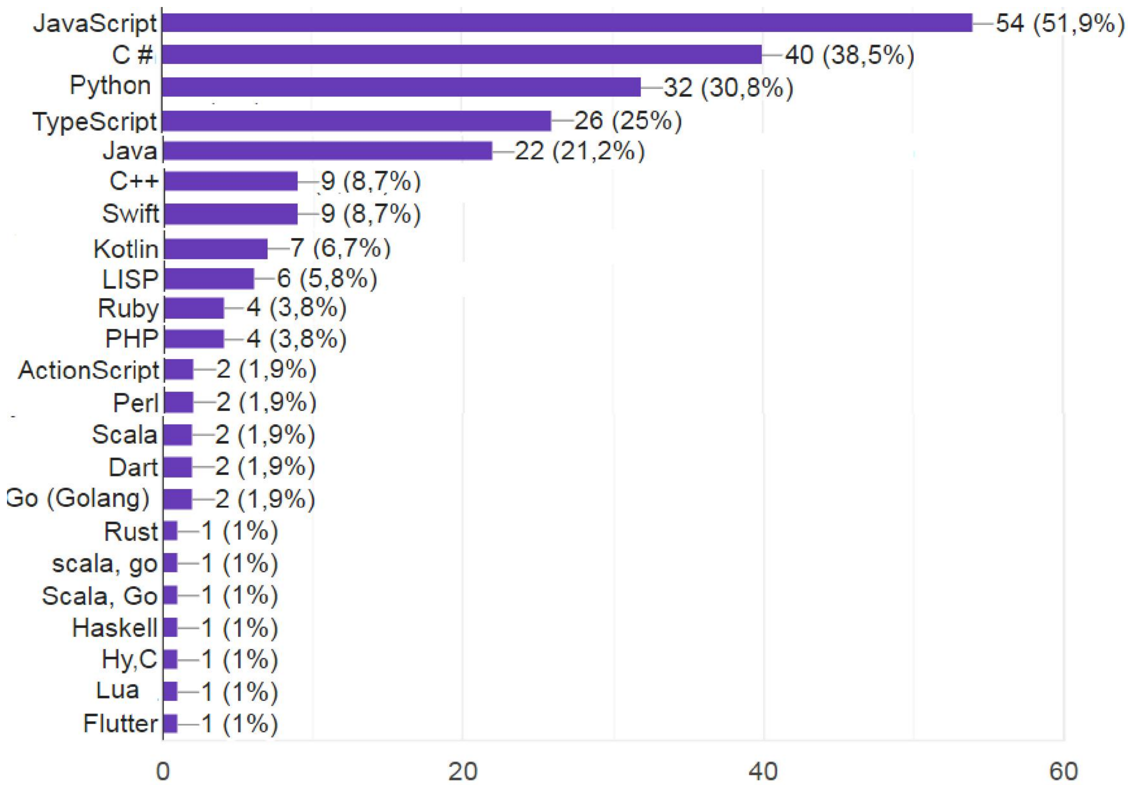

Figure 4: Programming languages that students improve or study independently.

The use of programming languages in IT-firms real projects done by students is shown in Figura 5. We can see that JavaScript comes out on top (51.5% of the surveyed student respondents). The second position is divided between C # (29.7%) and TypeScript (29.7%), the use of which is rapidly gaining momentum in software development. The top three programming languages are completed by Python (20.8%).

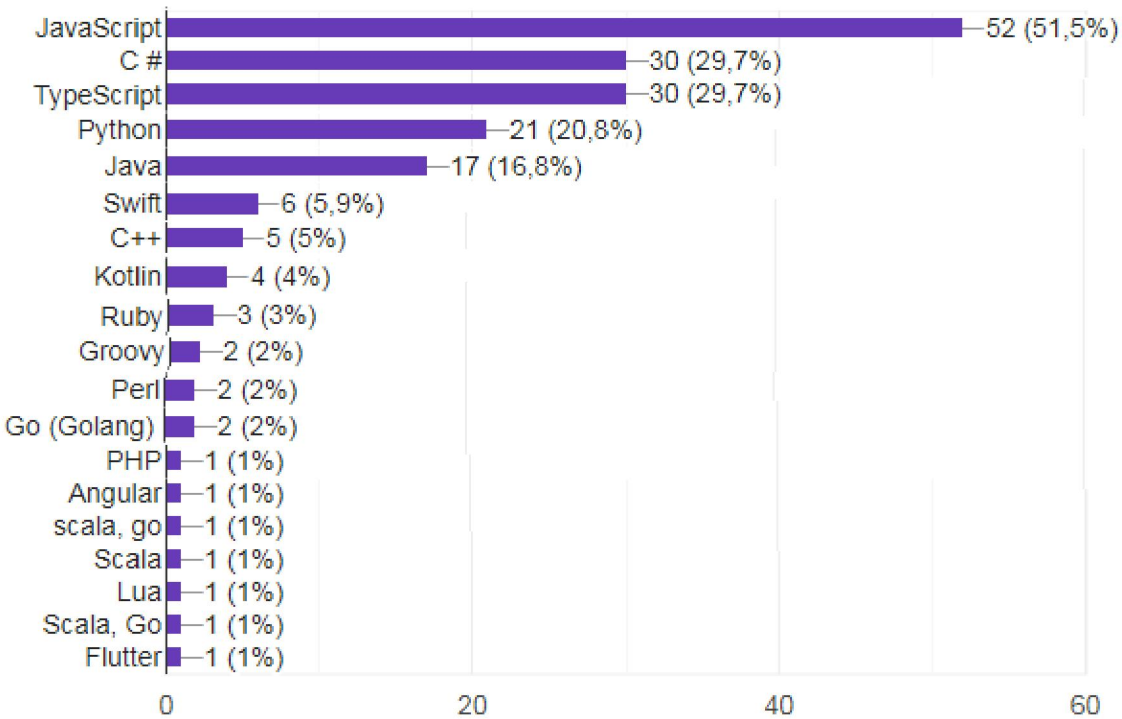

Figure 5: Programming languages used by 4 year students in doing real projects in IT companies.

It appears important to take into account the graduate students' recommendations on software selection to refer to the strengthening component of the course. The results of the survey of those recommendations are presented in Figura 6: JavaScript (79,8%), Python(72,1), C++ (67,3), C#(61,5%), Java(60,6%).

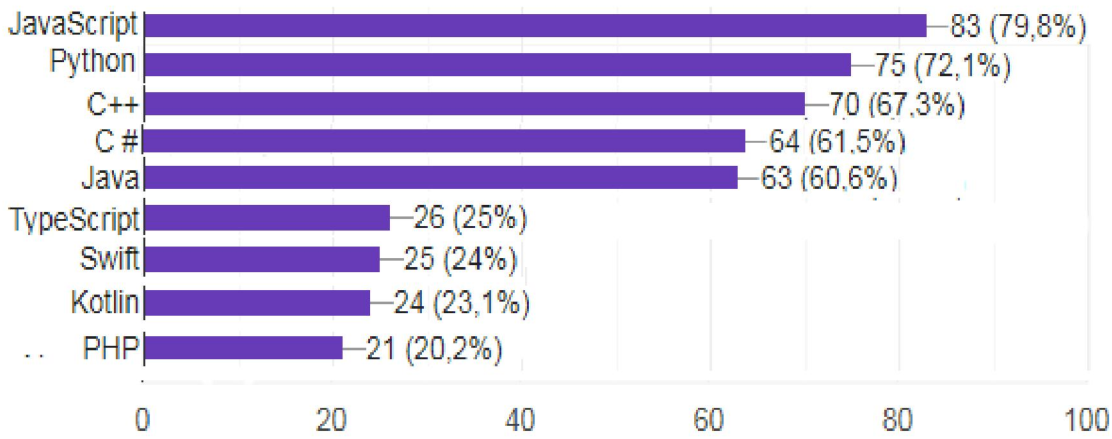

Figure 6: Graduate students' recommendations on programming languages selection

While analyzing the survey results on the use of programming languages by students of the Faculty of Informatics and Computer Engineering, the authors conclude that students most often use JavaScrip both in real projects and in their independent study of new programming languages. It is worth noting that the TypeScript programming language in real projects also ranks as second widespread. The third place belongs to Python (Figura 3, Figura 5).

In the top three use of programming languages in Ukraine, the leader is the JavaScript programming language, which is inferior to the Java and C # programming languages.

The third position of using the JavaScript programming language in university studies, after C ++ and C #, indicates that this WEB-programming language began to be learned from senior courses, in contrast to C ++ and C #, which are studied from the first course and is used in all disciplines, including laboratory work. In the new educational programs, starting from the second year, each student can build an individual learning trajectory.

The other aspect, which was given a lot of attention during the survey, is the selection and use of integrated development environments (IDE) for program code writing. Quite a few of IDE definitions can be found on the Internet. Some of them are given below:

"An Integrated Development Environment is nothing but an application that provides web developers with the tools required for developing software. Ideally, it comes with a text editor, automation tools, code compilation, and a debugger" [11].

Harish Rajora suggests that "Web development IDEs are powerful tools equipped with heavy features such as autocomplete, syntax checking, debugger, provide a suggestion, views live web page inside the IDE for better understanding of the output, etc" [12].

"An integrated development environment (IDE) is an application that facilitates application development. IDEs are designed to encompass all programming tasks in one application. Therefore, IDEs offer a central interface featuring all the tools a developer needs, including the following: Code editor, Compiler, Debugger, Build automation tools. In addition, some IDEs might also include the following: Class browser, Object browser, Class hierarchy diagram" [13].

Depending on the number of supported programming languages, environments can be multilingual or monolingual.

Surveys on IDE use while writing programs during the university studies showed the following results (Figura 7): the greatest demand came for IDE Microsoft Visual Code (61.5%), second place - Android Studio (57.7%) third place - IntelliJ (35,6 %) and Microsoft Visual Community (35,6 %).

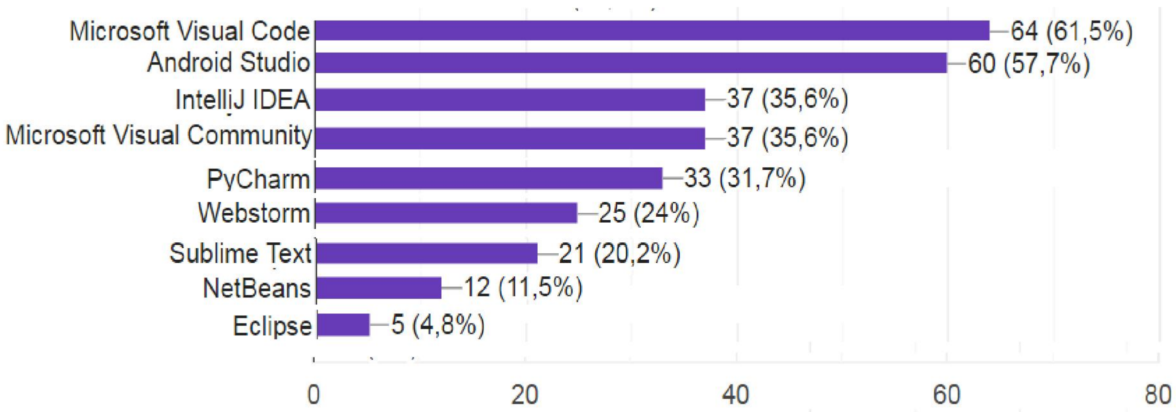

Figure 7: IDE use while writing programs during the university studies

Regarding IDE use in real projects at IT companies done by students, the authors observe that the most popular IDEs appear to be also Microsoft Visual Code (45,1%), IntelliJ IDEA (19.6%), Webstorm (17.6), PyCharm (15,7%), Microsoft Visual Community (15.7%).

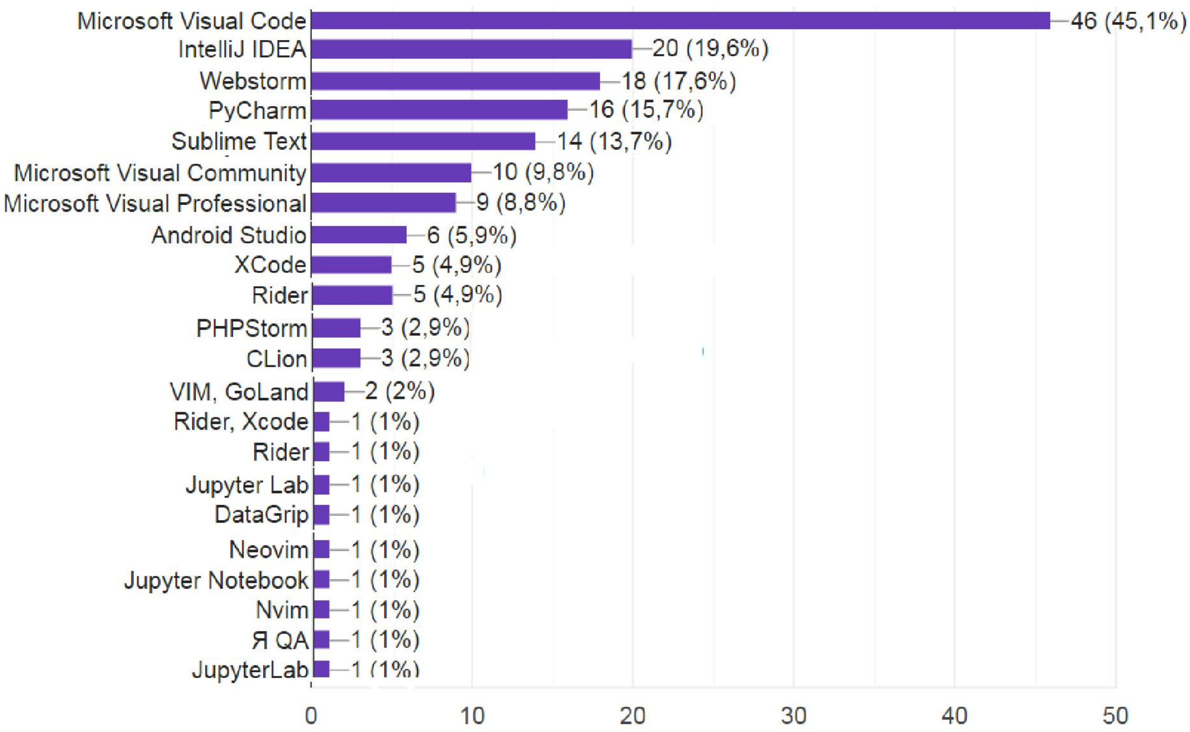

Figure 8: IDE use while writing programs at real projects in IT companies done by students (beyond university)

In their recommendations for studying IDEs within the university educational programs, students also range IDE in the following sequences: Microsoft Visual Code (55.8%), Android Studio 45.2%), Microsoft Visual Community (40.4%), IntelliJ IDEA (40.4%), PyCharm (28.8%), etc.

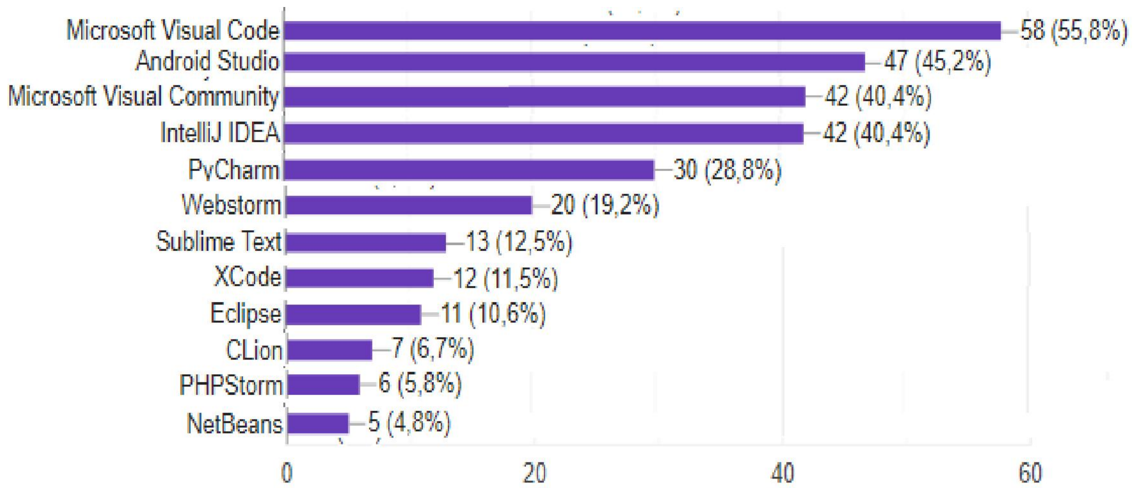

Figure 9: Graduate students recommendations on integrated development environments.

IDE performance is increased by accelerating development tasks, reducing setup time, constant updating developers and development process standardization. Conventionally, IDEs are divided into three categories: IDE for Frontend-development, IDE for Backend-development and cloud IDE.

Each IDE has its own features, advantages and disadvantages. For example, we consider the features, advantages and disadvantages of one IDE from each category, namely Visual Studio Code (Frontend), IntelliJ IDEA (Backend), Visual Studio Codespaces (Cloud) (Table 2) [14]

Table 2.
Programming languages analysis basing on the spheres of use (Backend, Frontend, Full Stack, Mobile)

IDE (Developing company)	IDE specifics	Advantages	Disadvantages
Visual Studio Code Microsoft Windows, Linux и Mac	• Debugging support • Very customizable • Built-in version control • Works well with most popular programming languages • Marketplace with extensions • Live Share for easy remote collaboration	• Cross-platform • Flexible and extensible • Open-source • Free • Popular so it's easy to find help or extensions	• Built on Chrome so uses a lot of memory • Requires extra setup for certain projects and languages •
IntelliJ IDEA JetBrains	• Integrated unit testing tools • Debugging support • User interfaces for common command-line tools • Built-in version control Database tools • Support for plugins	• Customizable • Cross-platform • Lots of tools that make development easier • Similar to other JetBrains IDEs, common experience • Built on open-source platform	• Subscription needed for most use cases

Visual Studio Codespaces Microsoft	• Visual Studio Code in your browser • Works with Visual Studio Code • Works with Visual Studio (though still in private preview) • LiveShare built-in for collaboration • Integrated debugging and coding assistance • Terminal available for command-line tools	• Free if you host an environment yourself • You can use familiar tools (Visual Studio, Visual Studio Code) • Personalization (dotfiles, themes, and certain extensions) carry over between environments • Only the essential processing is done on the server, saving you bandwidth • Very easy to get started •	• You pay for the resources you use

IDE survey results showed that students most often use Microsoft Visual Code, both during studies and in real projects. Next popular are IDE IntelliJ IDEA, Microsoft Visual Community, Webstorm, PyCharm.

The results of the survey also showed that 76.7% of graduate students in the 4th year of studying are already employed in IT firms as full-time employees (Fig. 10). This high employment rate indicates that KPI graduate students are competitive in modern IT labor markets.

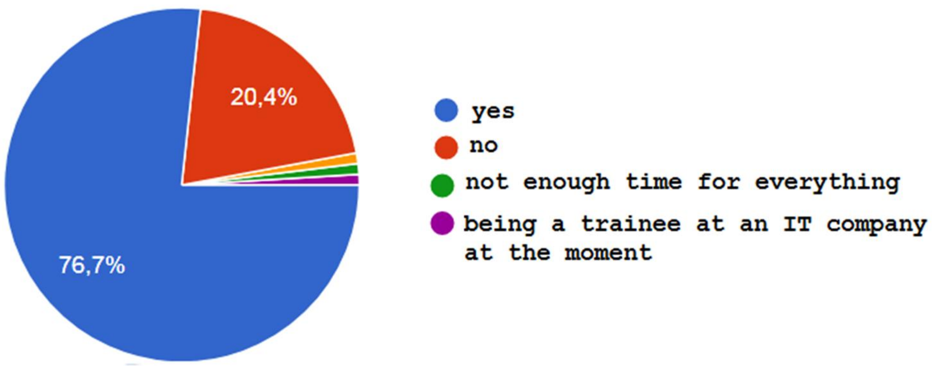

Figure 20: The percentage of studying with work in an IT company combination by students

4. Conclusions and further research perspective

The article studies the analysis of the use of WEB-oriented technologies in the process of WEB-programming learning by students of the Faculty of Computer Science. In the scope of this aim a comparative analysis of students' surveys on the use of programming languages and integrated development environments was conducted.

It was found that before studying at the university, students either studied outdated programming languages or did not study programming at all. During university studying, the priority programming languages were C ++ and C #.

Third priority language is JavaScript, which indicates the fact that this WEB-programming language is studied only at senior years of university learning, compared to C ++ and C # which are studied in the first year at university and is used in all disciplines when performing laboratory work.

New educational programs imply that, starting from the second year of studying, each student can create his or her individual learning trajectory by choosing disciplines offered by the faculty management.

The scientific novelty of the study lies in the fact that a study and analysis was done for the first time on observing student surveys on the use of programming languages and integrated development environments before and during the university course, on the choice of programming languages while independent studying and self-improving in IT specialties, as well as the use of programming languages and integrated development environments in real projects by senior students.

The high level of preparation of students at the faculty is evidenced by the fact that in the 4th year 76.7% of graduate students are already employed in IT companies as full-time employees. It is this high employment rate that indicates that KPI graduate students are competitive in today's IT labor market.

The study is unique, no similar comparisons of scientific papers have been found, so the relevance of this issue is undoubtful.

The authors believe that the material found in this article will be interesting not only for researchers, teachers and students of higher education institutions of Ukraine, but scientists from Europe, USA, Australia, Japan as well for both improving their educational programs and implementing practical work in collaboration with IT companies.

The high level of preparation of students at the faculty is evidenced by the fact that in the 4th year 76.7% of graduate students are already employed in IT companies as full-time employees. It is this high employment rate that indicates that KPI graduate students are competitive in today's IT labor market.

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The relevance of training primary school teachers computational thinking

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Abstract

The article describes the importance of modern school to develop students' problem-solving skills, including through digital tools, which in turn include the development of basic coding skills and digital literacy, the ability to solve problems and make decisions based on planning and analysis of situations. All these skills are the basis of computational thinking (CT). The authors argue that the use of special digital tools promote the development of computational thinking and purposeful formation of computational thinking increase the level of digital competence of both teachers and students. The article analyzes the concept of CT, existing definitions and its components. The list of subjects of curricula of different countries of the world on which the study of CT in primary school is carried out is given. It is emphasized that CT is a fundamental skill of everyone and it should be formed on the basis of integration of different disciplines to solve problems. The connection of the components of CT with the key competencies that should be formed in students by the standard of primary education. The results of a survey of more than 60 primary school teachers from different regions of Ukraine are presented about their understanding of the concept of computational thinking and their experience in the formation of skills related to all components of computational thinking in the teaching of primary school students. An analysis of open educational resources from around the world to support teachers in developing students' CT skills is presented. The model of realization of the concept of CT development for future teachers and primary school teachers is presented, taking into account the ability to use special digital tools.

Keywords

computational thinking, decomposition, abstraction, patterns, algorithms, primary school, standard of primary education, digital educational resources, digital competence of primary school teachers

1. Introduction

Today, during the crisis caused by COVID-19, the low level of digital skills of citizens and the lack of wide access to the free use of digital technologies further exacerbate inequality in society. That is why the action plan for digital education (2021–2027) (The Digital Education Action Plan (2021-2027) envisages strengthening cooperation at European level: learning from the COVID-19 crisis, when technologies are used on a scale not previously seen in education and training, and creating a digital age-appropriate education system. The new Action Plan has two strategic priorities: helping to develop a highly effective digital education ecosystem and enhancing digital skills and

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competences in the field of digital transformation [17]. At the same time, according to the experts of the World Economic Forum (WEF) in Davos, the report "On the future of work" in the list of top-10 skills is dominated by problem-solving skills: Analytical thinking and innovation (1), Solving complex problems (3), Critical thinking and analysis (4), Creativity, originality and initiative (5), Logical argumentation, problem solving and idea formation (10). Therefore, it is important to develop basic coding and digital literacy skills, the ability to solve problems and make decisions based on planning and analysis of situations, which is the basis of CT. It is important to develop such skills from an early school age. But such activities can be carried out by teachers who have the most developed ability to perform operations that make up the structure of CT. Therefore, the purpose of this article is to substantiate the need to teach CT to primary school teachers.

2. Theoretical foundations of the study

CT is a component of human thinking, which provides its activities in solving problems of everyday life, and its importance is constantly growing. Various definitions were used to explain the concept of CT. Today there is no single interpretation of this concept. In Ukraine, the English word Computational, in addition to the use in the mathematical sense (production of calculations), is now used in parallel in a broader sense, related to the term "Computing" – a collective designation of computer science, information technology and information systems, computer and software engineering [4]. The term "Computational Thinking" is tied to the English-language basis and has been used several times in the Ukrainian scientific literature [1-3]. The widespread use of the term Computational Thinking began with the publication in 2006 of the work of the same name by Cornell University (USA) professor Jeanette Wing, who described the definition of CT as follows: computers. Computers are boring, and people are smart and have ideas. We humans make computers efficient. Equipped with computing devices, we use our minds to solve problems that we could not solve before the computer age, and to create systems that have functionality limited only by our imagination" [19]. In particular, Jeannette Wing formulated the following definition: "Computational thinking is a mental process that is involved in problem statement and solution so that solutions are presented in a form that can be effectively implemented through information processing [20]. The documents of the International Society of Educational Technologies (ISTE) and the Association of Computer Science Teachers (CSTA) define "Computational thinking is the process of formulating problems in such a way that it becomes possible to solve the problem with the help of computer technology" [13]. In our study, we draw on the approach of Cynthia Selby and John, who believe that CT is a mental activity aimed at solving problems, better understanding of situations, expression of qualities through the systematic use of abstraction, decomposition, creation of algorithms, generalization and evaluation in the process of producing automated solutions that can be implemented using a digital or human computer (computing) device" [9]. Components of CT are decomposition, pattern detection, generalization and abstraction and development of algorithms (Table 1) [10].

Table 1
Components of computational thinking

Abstraction	Abstraction is the process of making an artefact more understandable through reducing the unnecessary detail. The skill in abstraction is in choosing the right detail to hide so that the problem becomes easier, without losing anything that is important. (Csizmadia et al., 2015, p. 7).
Algorithmic thinking	Algorithmic thinking is a way of getting to a solution through a clear definition of the steps (Csizmadia et al., 2015, p. 7).
Automation	Automation is a labour saving process in which a computer is instructed to execute a set of repetitive tasks quickly and efficiently compared to the processing power of a human (Lee, 2011, p. 33).
Decomposition	Decomposition is a way of thinking about artefacts in terms of their component parts. The parts can then be understood, solved, developed and evaluated separately. This makes complex problems easier to solve, novel situations better understood and large systems easier to design (Csizmadia et al., 2015, p. 8).

Debugging	Debugging is the systematic application of analysis and evaluation using skills such as testing, tracing, and logical thinking to predict and verify outcomes (Csizmadia et al., 2015, p. 9).
Generalization	Generalization is associated with identifying patterns, similarities and connections, and exploiting those features. It is a way of quickly solving new problems based on previous solutions to problems, and building on prior experience. Algorithms that solve some specific problems can be adapted to solve a whole class of similar problems (Csizmadia et al., 2015, p. 8).

In order to develop students' ability to think using CT, many countries have introduced or plan to introduce a special subject of CT into primary and secondary education programs, including programming subjects as compulsory or optional, of which CT is an integral part [7]. ICT and programming are part of educational programs in the UK, New Zealand, South Korea, USA, Estonia, Cyprus, Australia, Poland, either as a compulsory or optional subject [8]. In Greece, a one-year experiment was conducted in which students learn programming by developing games [12]. Spanish scholars describe the experience of integrating CT in two sections of a Spanish high school course. Students work in small groups and encode three small and one three-dimensional digital history of Spanish culture in Scratch. The results showed that students who took a lesson with an integrated computer theme had the same degree of improvement in their knowledge of Spanish culture as their peers who did not take lessons in integrated CT and significantly improved their knowledge of CT [20]. Some Danish primary schools are participating in pilot studies where students in grades 1–9 work with Scratch and Lego MindStorms in STEM subjects (science, technology, engineering and mathematics) [6]. The Netherlands and Japan have also introduced programming as part of primary or secondary education [11, 18]. The National Research Council (NRC) [16] emphasized the importance of familiarizing students with the concepts of CT in the early school years and helped them understand when and how to apply these basic skills. The Association of Computer Science Teachers (CSTA) and the International Society for Technology in Education (ISTE) presented the basics of CT for K-12 schools in 2011 with basic concepts and possibilities of CT, including data collection, data analysis, data presentation, problem decomposition, abstraction, algorithms and procedures, automation, parallelization and modeling [5]. "Thinking by computational method" is a fundamental skill of everyone, not just computer scientists. It can be used to support problem-solving in all disciplines, including the humanities, mathematics and science. This indicates the importance of integrating computational ideas into other disciplines. It should be noted that there are several types of interdisciplinary approach, depending on the links between disciplines: interdisciplinary, multidisciplinary, crossdisciplinary, transdisciplinary [14]. In our opinion, teaching CT in primary school corresponds to a transdisciplinary approach, as it forms the ability to: solve problems and design systems referring to the basic concepts of computer science; create and use different levels of abstraction to better understand and solve problems; think with algorithms and with the ability to apply mathematical concepts for more effective development; understand the implications of scale not only for reasons of efficiency but also for economic and social issues [21]. Transdisciplinary goes beyond individual disciplines, focuses on a specific problem and acquires relevant knowledge that is related to all disciplines, between them and beyond, in order to understand the modern world under the imperative of unity of knowledge (Fig. 1).

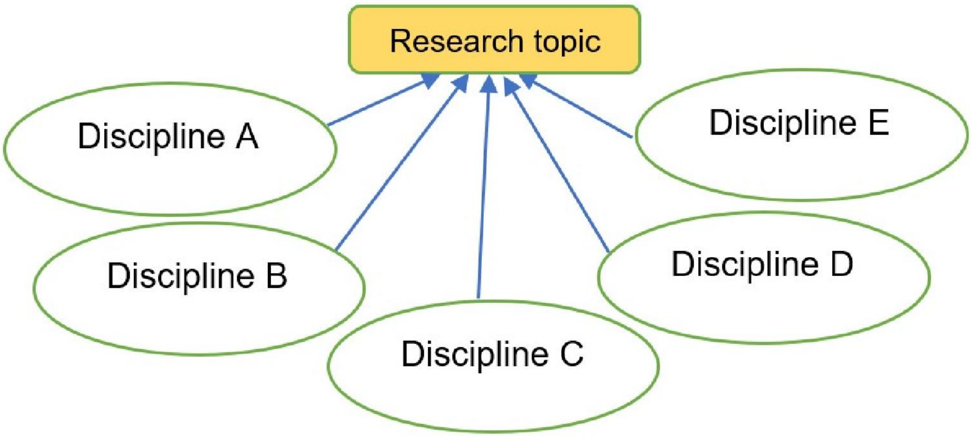

Figure 1: Transdisciplinary approach

3. Experimental study

In Ukraine, CT as a separate subject is not studied in primary school, and the development of relevant skills is built through an interdisciplinary approach and integration. According to the Concept of the New Ukrainian School, which has been implemented since 2017, the Standard of Primary Education provides for the formation of 10 equally important and interrelated key competencies that children acquire when studying different subjects at all stages of education. Their combination forms the elements of CT (Table 2).

Table 2
The relationship of components of CT with the key competencies of NUS

Key competence of NUS	Content	Components
Communication using the state (and native in case of difference) languages	Ability to express and interpret concepts, thoughts, feelings, facts and views orally and in writing	Abstraction, Decomposition, Generalization
Communication using foreign languages	Ability to properly understand a foreign language ...	Abstraction, Generalization
Mathematical competence	Culture of logical and algorithmic thinking. Ability to apply mathematical (numerical and geometric) methods to solve applied problems in various fields. Ability to understand and use simple mathematical models. Ability to build such models to solve problems	Abstraction, Algorithmic thinking, Automation, Decomposition, Debugging, Generalization
Basic competencies in natural sciences and technologies	... Ability to apply the scientific method, observe, analyze, formulate hypotheses, collect data, conduct experiments, analyze results.	Debugging, Algorithmic thinking, Automation, Decomposition, Generalization
Ability to learn throughout life	... effective management of resources and information flows, the ability to define learning goals and ways to achieve them ...	Abstraction, Automation, Decomposition, Debugging, Generalization
Initiative and entrepreneurship	Ability to generate new ideas and initiatives and implement them	Algorithmic thinking, Automation,

		Decomposition, Debugging
Social and civic competence	... Ability to work with others for results, to prevent and resolve conflicts, to reach compromises ...	Decomposition, Debugging
Awareness and self-expression in the culture	The ability to understand works of art, to form own artistic tastes, to express ideas, experiences and feelings through art ...	Abstraction, Decomposition, Generalization
Environmental literacy and healthy living	Ability to use natural resources wisely and rationally	Algorithmic thinking

Among the cross-cutting skills that are declared in NUS and those that are implemented through CT, are the skills: critical thinking; ability to logically justify the position; show initiative; ability to solve problems, assess risks and make decisions. The computer science program for primary school clearly identifies topics that cover the described component of digital competence - CT: Teams and performers (2nd grade), Algorithms and performers (3rd grade), Algorithms with branching and repetition (4th grade) (Table 3).

Table 3

Description of the components of CT, skills, abilities and requirements for the student

Components	Skills and abilities of the student	State requirements for student achievement
Abstraction Automation Decomposition	can formulate problems in such a way that it becomes possible to solve the problem with the help of a computer or other tools; analyze possible solutions	has an idea of the team, performers; sequence of actions; algorithms and performers of algorithms; composes and executes algorithms for performers to a certain situation in programming environments for children; understands the recording of algorithms in the form of blocks; determines the correct order of commands to the performer in a familiar algorithm; distinguishes false phrases; names opposing statements; is able to look for errors in the sequence of commands; combines items into a group on certain grounds, comes up with a name for the group; removes extra items from the group by attributes, recognizes items by these attributes and selects from the group
Generalization	can systematically collect data through experiments, interviews, surveys or literature studies	
Abstraction Decomposition	can evaluate the found information; understand and compare the found data	
Abstraction Decomposition	can display information in words, pictures, graphs, tables; choose the most efficient data representation	
Decomposition	can divide tasks into smaller tasks, a long list of tasks in subcategories	
Abstraction	can reduce complexity; compare two different concepts and connect them	
Algorithmic thinking Automation Generalization	can generate solutions using algorithmic considerations; automate decisions using algorithmic thinking; write a computer program; generalize the problem-solving process so that it can be applied to other problems	
Automation	can solve a problem or achieve a certain goal by compiling a series of algorithms; use computer resources to obtain a final solution	
Abstraction Decomposition Generalization	can make instructions, simulate the process of solving a problem or perform an experiment based on a specific model; summarize conclusions on problem solving and apply solutions to other problems	
Decomposition Generalization	can create a plan / schedule and assign tasks to team members during the project; allocate resources so that it is possible to use them simultaneously to achieve a common goal	

However, teachers try to focus on the formation of algorithmic thinking, which is only one component of computing, which leads to the need to focus on other elements. Specially created tasks with the use of electronic educational resources will allow to intuitively involve students not only in the development of algorithms, but also in the processes of decomposition, pattern detection, generalization and abstraction. In addition to these topics, CT can be formed in the study of other topics, with the following requirements for student achievement: chooses and uses the necessary tools of the graphic editor environment to create an image based on a sample and your own design; complements the missing data in simple diagrams, charts; seeks information in texts with false statements and proves the truth; is able to find the necessary information in the text and highlight part of the text; distinguishes and gives examples of devices for input and output of information (3-5) and more. Among the general results of primary school education in language, literature, mathematics and natural sciences can be distinguished components of CT (Table 4).

Table 4

Description of the components of CT in different fields of education*

Educational branch	General learning outcomes of the students	Components
linguistic and literacy	Highlights information	Abstraction
	Analyzes and interprets information and text	Decomposition
	Converts information	Algorithmic thinking
mathematical	Recognizes everyday situations that are solved by mathematical methods; evaluates the data of the problem situation, necessary and sufficient for its solution; analyzes the objects of the surrounding world and situations that arise in life	Abstraction
	Researches, analyzes, evaluates data and relationships between them to solve the problem of mathematical content	Debugging
	Predicts the outcome of a problem	Generalization
	Perceives and transforms information (heard, seen, read), builds an auxiliary model of the problem situation; develops strategies for solving problem situations; evaluates different ways to solve a problem situation, chooses a rational way to solve it; has computing skills, applies them in educational and practical situations	Algorithmic thinking
	Simulates the process of solving a problem situation and implements it	Generalization Algorithmic thinking
	Recognizes geometric shapes by their essential features; uses algebraic concepts to solve a problem situation; explores problems	Decomposition
natural	Identifies and formulates research problems; defines the purpose of the study, puts forward a hypothesis; groups and classifies objects	Decomposition
	Plans research	Algorithmic thinking
	Analyzes and substantiates research results, formulates conclusions	Generalization
	Converts information from one form to another; identifies relationships in nature and takes them into account in its activities; identifies the problem by correlating new facts with previous experience; critically evaluates the problem	Abstraction
	Generates new ideas to solve the problem	Debugging

* Created by the authors based on the analysis of educational programs

During the research, we interviewed more than 60 respondents who participated in the education of schoolchildren in NUS programs. Among the respondents, 77% were computer science teachers at NUS, more than 21% were primary school teachers (Fig. 2). The survey was conducted in all regions of Ukraine through a survey form, which is posted in groups of primary school teachers on social networks.

The sample covered the vast majority of teachers with more than 10 years of experience, which indicates that teachers have sufficient experience of practical work in school (Fig. 2).

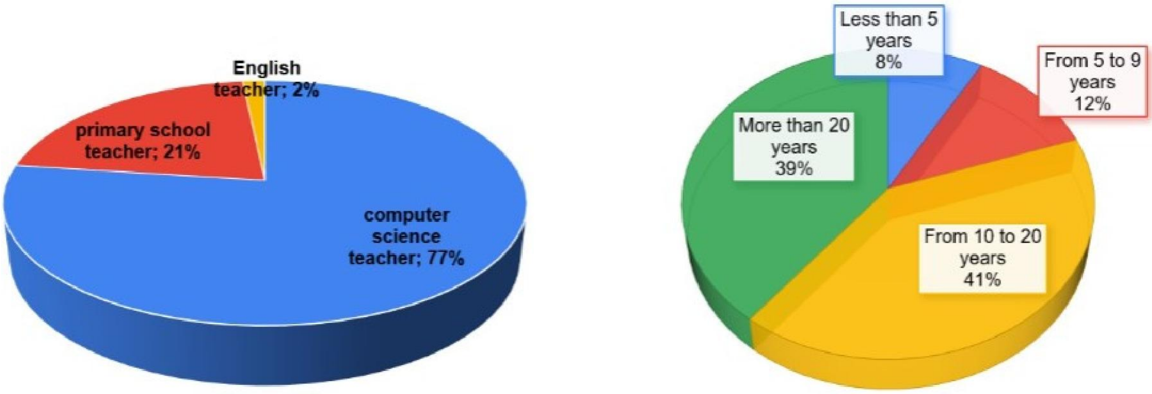

Figure 2: Contingent of respondents and Work experience of respondents

Most respondents have a false impression of the essence of the concept of "computational thinking", namely as a method of forming students' computing skills (Fig. 3)

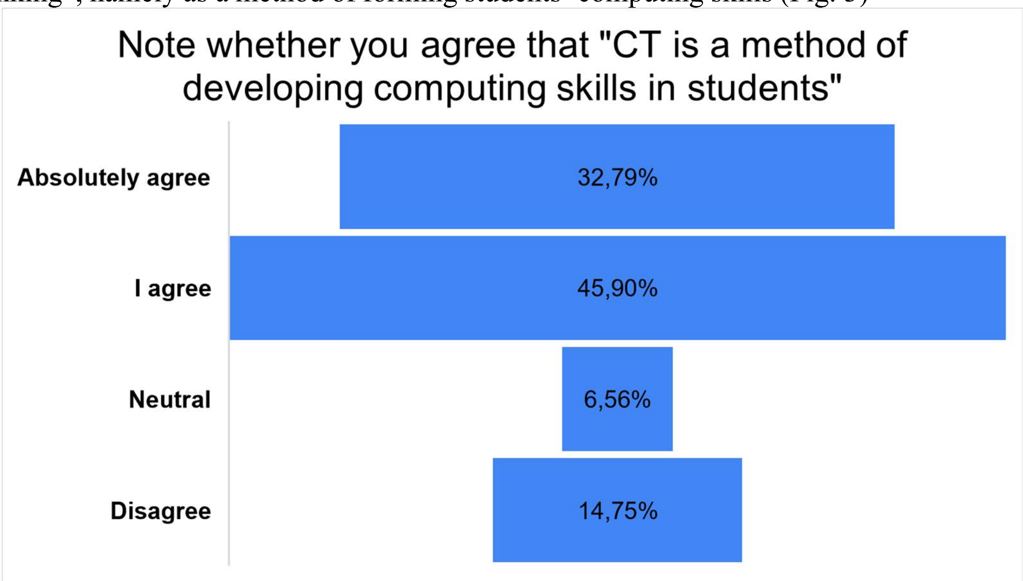

Figure 3: The choice of respondents to determine the CT

More than 88% of respondents said that they offer students tasks to identify and formulate a real problem. At the same time, most often it happens in computer science lessons, almost half less - in mathematics lessons, and even less - in the integrated lesson "I explore the world", which combines natural, social, civic, health education (Fig. 4).

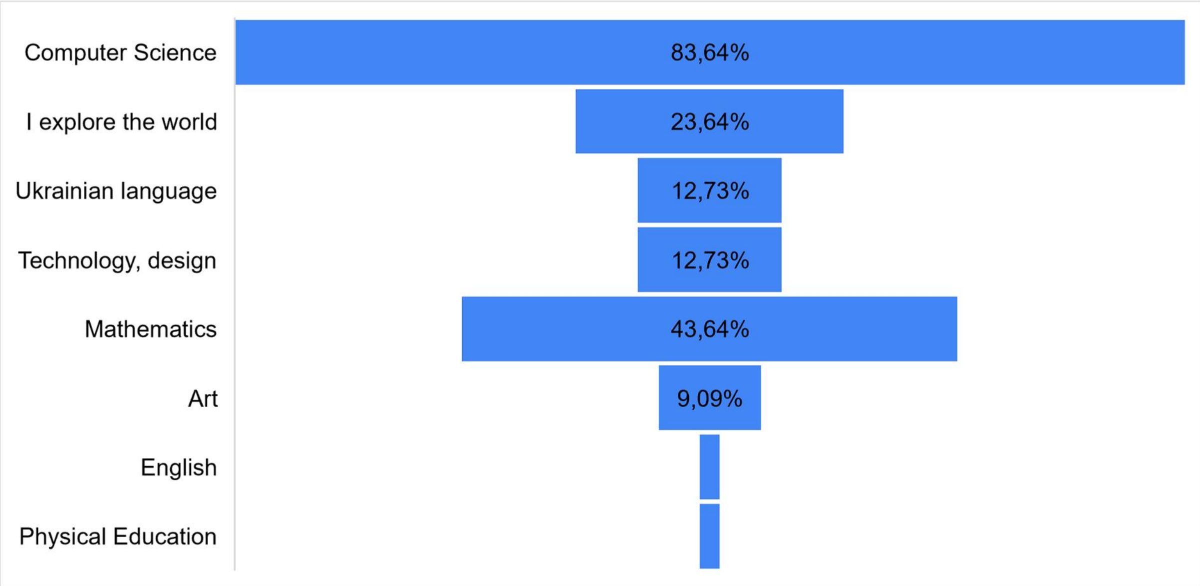

Figure 4: The choice of respondents to solve real problems with the students during the lessons

Almost 41% of teachers indicate that they offer students problem questions every day; most often respondents say that their students perform their own experiments several times a week, in 30% of respondents students never or very rarely work with data in different experiments, in 41% of cases students once a month, or even less often record the process and result of the experiment, 50% offer tasks for the formation of assumptions in solving a specific problem (Fig. 5).

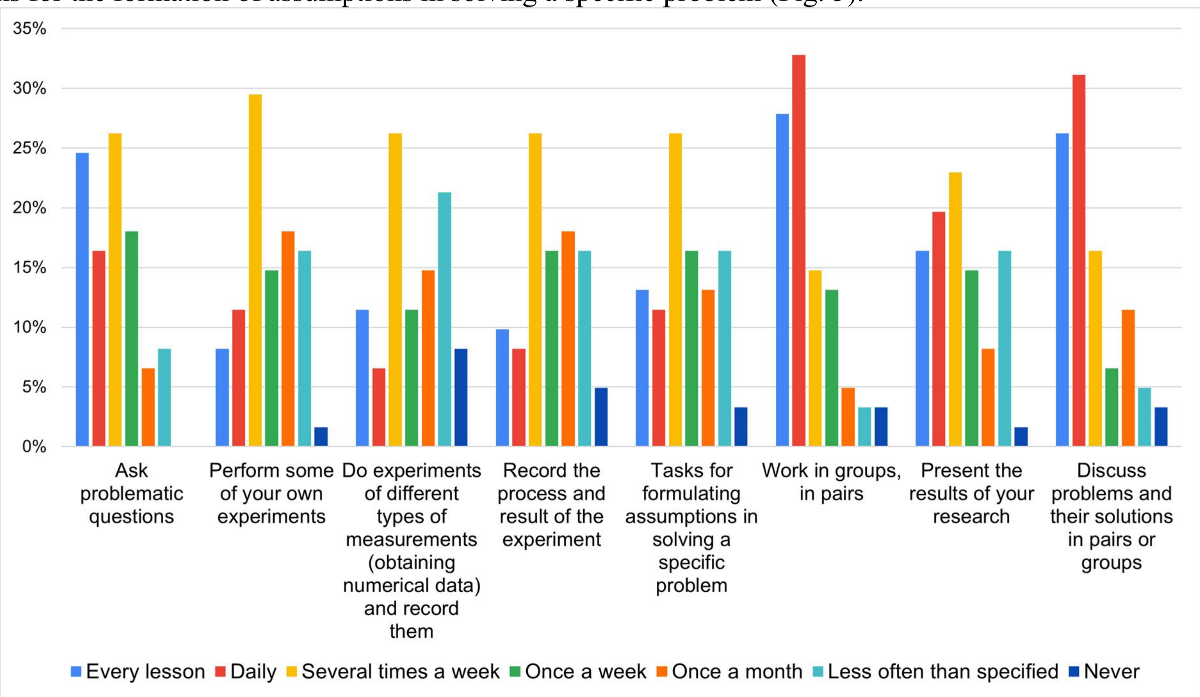

Figure 5: Respondents' choice of lessons activities

When assessing their own level of CT, the vast majority of respondents rated them at a high or close to it level (Fig. 6).

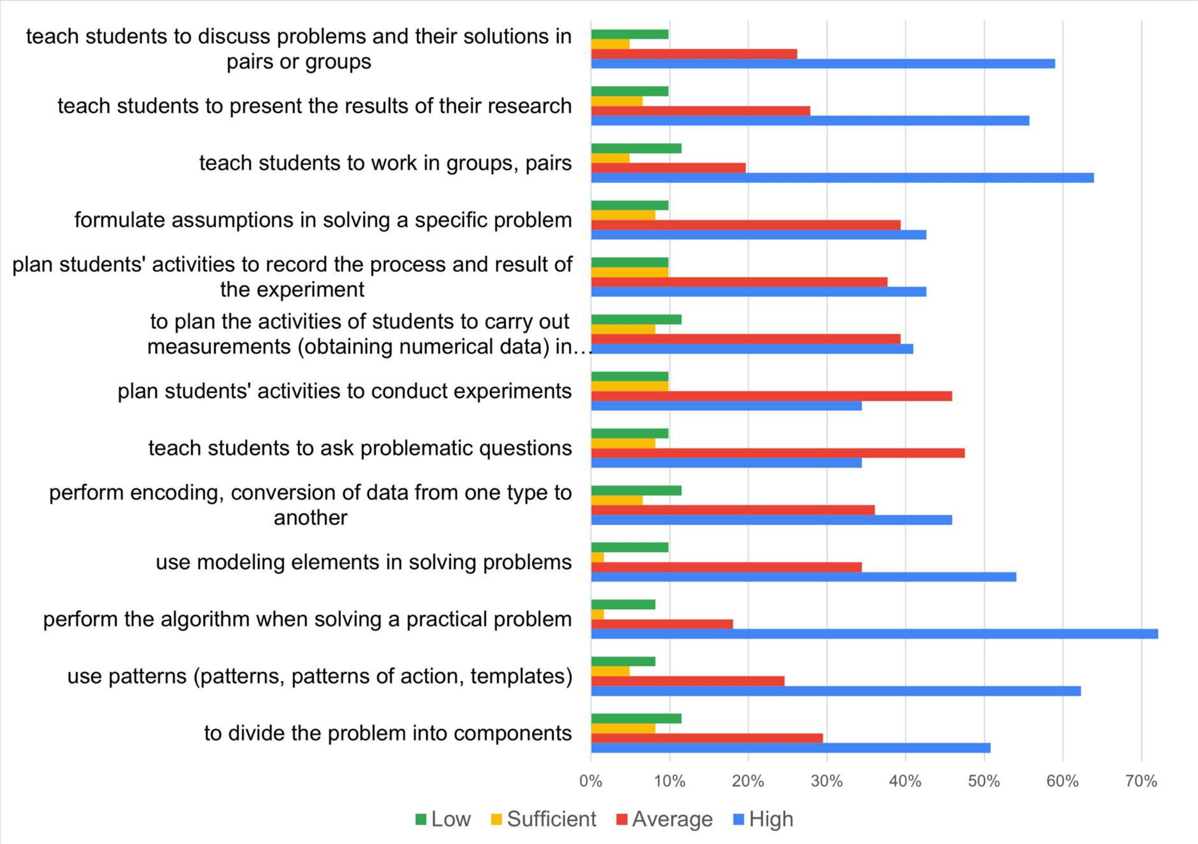

Figure 6: Respondents' choice of skills they possess

The most difficult for teachers is the process of teaching students to divide the task into components (decomposition), plan their activities during experiments (algorithmic thinking), ask problem questions (abstraction, decomposition), use elements of modeling in solving problems (abstraction, generalization), formulate assumptions when solving a specific problem (Debugging). The results of the teacher survey are extrapolated to the formation of students' end-to-end skills, some of which are components of CT. The evaluation took place in 2019 as part of a comprehensive study of the effectiveness of NUS implementation (link). According to the results of the study of skills of primary school students, the lowest results were found in the development of critical and systematic thinking skills - 42% of students have low and medium levels, only 7% - high level (Fig. 7).

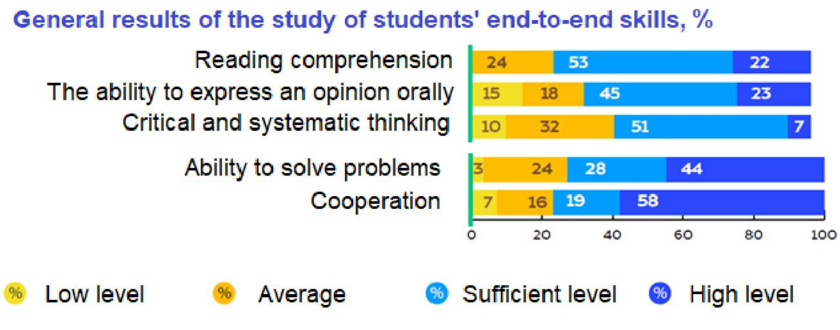

Figure 7: General results of the study of students' skills

Students' ability to think critically and systematically was assessed by performing two competency tasks. The first of them involved the division of statements into true, false and doubtful, the second - a systematic presentation of reliable information and data. The ability to think critically and systematically is developed in students the worst: 7% of groups of students found all the false statements in the task and the ability to structure information and its systematic presentation; 51% of groups of students coped with the tasks quite successfully, at the same time made several mistakes;

10% of student groups did not show signs of critical and systematic thinking; The ability of students to solve problems was determined on the basis of observations of the problem in terms of content and form of presentation of the results of their work and the effectiveness of solving two problems. We analyzed the syllabi of academic disciplines and educational programs in the specialty 013 “Primary Education” of five universities that are in the top 10 (link) among pedagogical universities of Ukraine on the corresponding sites (https://npu.edu.ua, http://tnpu.edu.ua,http://pdpu.edu.ua/b, http://uipa.edu.ua/ua/). None of the programs involves the study of CT as a separate subject. In the syllabuses of courses in academic methods of teaching mathematics, computer science and other disciplines in primary school there are no topics that directly address the issues of CT or its components. Fragmentarily, the syllabi of the courses provide for the formation of future teachers’ skills in the formation of compulsory learning outcomes, in accordance with the CURRENT Standard of Primary Education and the Concept of the New Ukrainian School. Thus, the formal component of teacher training for the formation of CT in students is incomplete. A Google search query for the phrase “computational thinking + training” provided access to information on 9 trainings conducted as part of the project of the EU program Erasmus + №586098-EPP-1-2017-1-UA-EPA “Modernization of Pedagogical Higher Education by Innovative Teaching Instruments” (MoPED), International Seminar” Introduction to Computational Thinking”, organized by the Institute of Information Technology and Teaching Aids of the National Academy of Pedagogical Sciences of Ukraine with the participation of Joseph Kush, Professor, Dukein University, Pittsburgh, USA) (link) and several local events for educators. This indicates that in the segment of non-formal education, measures to train teachers in CT cover a critically small circle of educators. The fact that teachers need such training and tools for its formation of the components of CT in the classroom is also evidenced by the results of our survey (Fig. 8).

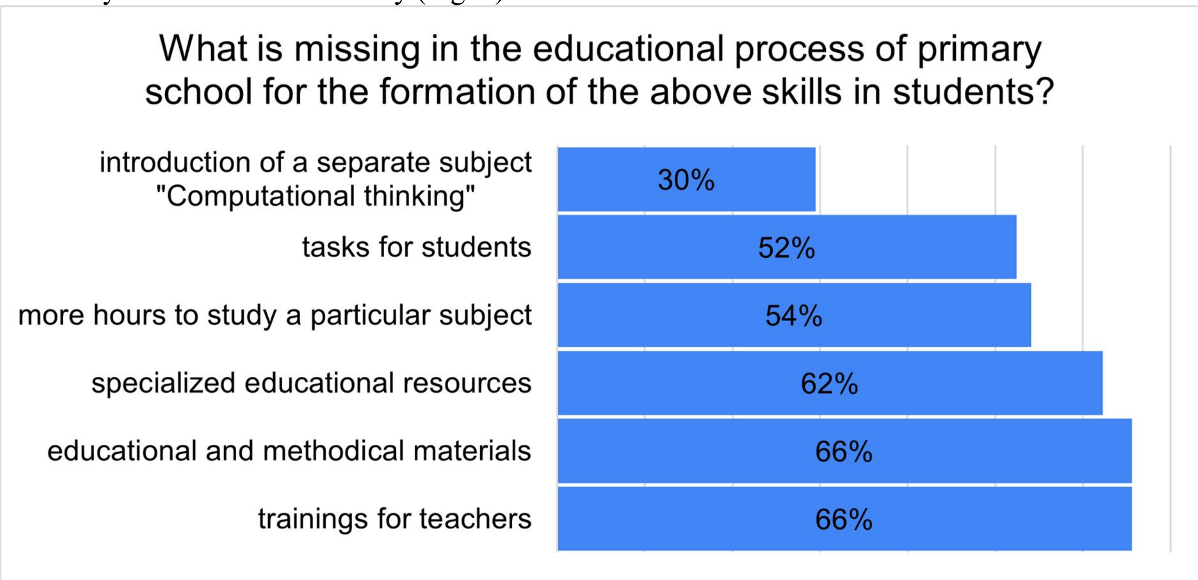

Figure 8: Respondents’ answers to the needs for the formaming CT

There are no professional communities and specialized sites on CT in the Ukrainian segment of the Internet. For example, as in the UK (https://community.computingatschool.org.uk/door), the Computationalthinking initiative from Wolfram Research (https://www.computationalthinking.org), the virtual educational environment (Computational thinking in education), community of researchers (https://digitalpromise.org). In this regard, there is a need to create a platform for educators to support informal education on CT.

Components of such a platform can be, for example, a digital library:

- Sites with information about CT
    - Computational thinking https://www.computationalthinking.org
    - K–12 Computer Science Framework https://k12cs.org/computational-thinking
    - Computational thinking https://dystosvita.gnomio.com...

  - ISTE Computational thinking in education https://www.iste.org/areas-of-focus/computational-thinking
- Resources for teachers with ready-made developments
  - Google for Education. Exploring Computational Thinking resources https://edu.google.com/resources/programs/exploring-computational-thinking
  - Computing at School https://community.computingatschool.org.uk/resources/landing
  - Barefoot Computing primary classroom resources https://www.bare-footcomputing.org/primary-computing-resources
  - Computer Science without a computer https://csunplugged.org/en
  - Programamos https://programamos.es
  - Raspberry Pi https://projects.raspberrypi.org/en
- E-resources with exercises
  - Blockly https://blockly.games
  - Compus https://compus.deusto.es
  - Code https://code.org
  - Bebras https://www.bebras.org
  - Coder Dojo https://coderdojo.com/resources
  - Code Club https://www.codeclubworld.org/projects
- Resources for creating your own exercises with CT
  - Kodetu http://kodetu.org
  - MakeWord https://makeworld.eu
  - LearningApps https://learningapps.org
  - Puzzle designer http://pazlyonline.com/konstruktor.html, https://www.jigsawplanet.com
  - Rebus designer http://rebus1.com/ua/index.php
  - Tinkercad https://www.tinkercad.com
  - Studystack https://www.studystack.com
- Integrated coding environments
  - Scratch https://scratch.mit.edu
  - Alice https://www.alice.org
  - Greenfoot https://www.greenfoot.org/door
  - Agentsheets https://agentsheets.com
- Robotics and circuitry
  - Lego WeDo, Mindstorms
  - Arduino LilyPad
  - BBC micro:bit
  - Bee-Bot
  - Makeblock
  - Makeymakey

In the Ukrainian educational space, not only such open educational resources should be created to help teachers, but first of all it is expedient to develop a concept of teaching teachers and future teachers CT and provide ways and means to develop appropriate skills in primary school students. As an initial step we can consider the introduction of the subject ”Computational Thinking” due to the selective component, and over time in substantiating and experimenting with the content of learning and ways of integration with the basics of science through solving certain integrated competency problems - a separate subject, especially in primary school. In the Ukrainian educational space, not only such open educational resources should be created to help teachers, but first of all it is expedient to develop a concept of teaching teachers and future teachers CT, provide ways and means to develop appropriate skills in primary school students, increase the digital competence of students and teachers [22]. As an initial step we can consider the introduction of the subject ”Computational Thinking” due to the selective component, and over time in substantiating and experimenting with the content of learning and ways of integration with the basics of science through solving certain integrated competency problems – a separate subject, especially in primary school.

4. Conclusions

Preparing teachers to teach CT is an important task of all components of teacher education: formal, informal and informal. In Ukraine, despite the widespread inclusion of components of CT in state educational standards, in particular in the Standard of Primary Education, the issue of development of resources for such training is insufficiently resolved. The analysis of the survey showed teachers' misunderstanding of the concept of CT, their unwillingness to form CT in students and interest in learning about approaches that could help with the implementation of CT, unwillingness to use special digital resources. In particular, teachers' requests, learning outcomes of students according to the concept of NUS, educational university programs and resources to support non-formal and informal education allows to build a model of the concept of development of CT in primary school (Fig. 9).

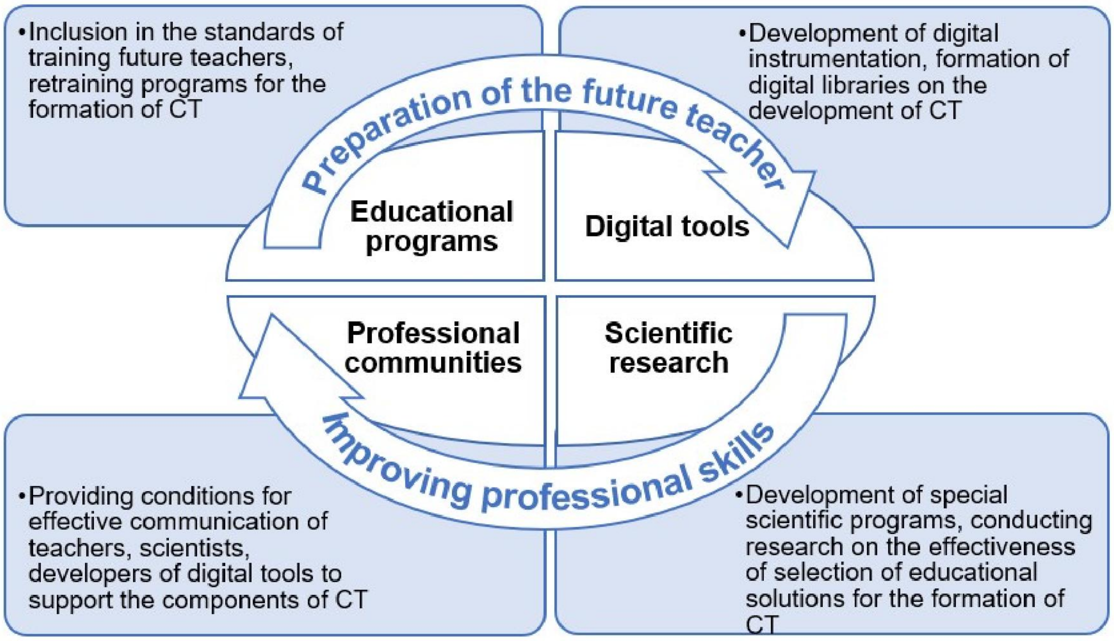

Figure 9: Conceptual model of teacher preparation for teaching CT

To implement this concept, you need to provide the following steps: comprehensive integration (Integrate CT across all levels of compulsory education); systematic rollout (Adopt a holistis approach for introducting CT into compulsory education); consolidated understanding (Develop a shared understanding of CN and the relationship with 21st century skills); support policy (foster broad engagement and optimize impact). It is expedient in the system of advanced training of primary school teachers to provide trainings on the development of CT of students based on the use of digital tools and a corresponding elective course in educational programs of future primary school teachers, which would help increase their digital competence. Such programs should include the following sections and an appropriate system of tasks that meet the standard of primary education and are based on competency-based learning and integration of knowledge based on a transdisciplinary approach: decomposition, identification of patterns in various subject areas, generalization and abstraction, development of algorithms and coding. This approach is one of the main in the implementation of STEAM education, including the use of digital technologies. These digital resources for the formation of CT should be included in training programs.

Prospects for further research include research and description of specialized digital resources for the formation of CT students, preparation of training programs for teachers, development of a database of tasks with CT.

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