8th Workshop on Cloud Technologies in Education: Report

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Abstract
This is an introductory text to a collection of selected papers from the 8th Workshop on Cloud Technologies in Education (CTE 2020) which was held in Kryvyi Rih, Ukraine, on the December 18, 2020. It consists of short introduction, papers' review and some observations about the event and its future.

Keywords
Adaptive Cloud Learning Platforms, Blended Learning, Blockchain in Education, Cloud-based AI Education Applications, Cloud-based E-learning Platforms, Tools and Services, Cloud-based Learning Environments, Competency-Based Education Platforms, Digital Transformation of Education, Educational Data Mining, Emotion AI, Immersive Technology Applications in Education, Mobile Learning, Smart Campus Technologies, Social Analytics in Education

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1. Introduction

1.1. CTE 2020: At a glance

Cloud **T**echnologies in **E**ducation (CTE) is a peer-reviewed international Computer Science workshop focusing on research advances, applications of cloud technology in education.

The Workshop occupies contributions in all aspects of educational technologies and cloud-based learning tools, platforms, paradigms and models, functioning programmes or papers relevant to modern engineering and technological decisions in the IT age.

CTE topics of interest since 2017 [1, 2, 3]:

- Adaptive Cloud Learning Platforms
- Blended Learning
- Blockchain in Education
- Cloud-based AI Education Applications
- Cloud-based E-learning Platforms, Tools and Services
- Cloud-based Learning Environments
- Competency-Based Education Platforms
- Digital Transformation of Education
- Educational Data Mining
- Emotion AI
- Immersive Technology Applications in Education
- Mobile Learning
- Smart Campus Technologies
- Social Analytics in Education

Figure 1: CTE 2020 logo

This volume represents the proceedings of the 8th Workshop on Cloud Technologies in Education (CTE 2020), held in Ukraine, Ukraine, on December 18, 2020. It comprises 31 contributed paper that were carefully peer-reviewed and selected from 52 submissions (https://notso.easyscience.education/cte/2020/). Each submission was reviewed by at least 3 program committee members. The accepted paper present the state-of-the-art overview of successful cases and provides guidelines for future research.

The volume is structured in seven parts, each presenting the contributions for a particular workshop session.

1.2. CTE 2020 Program Committee

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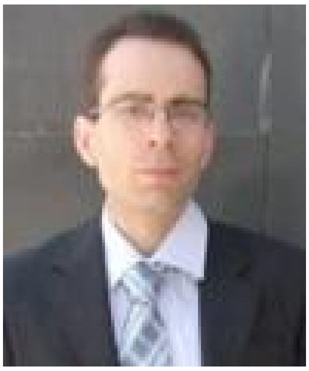

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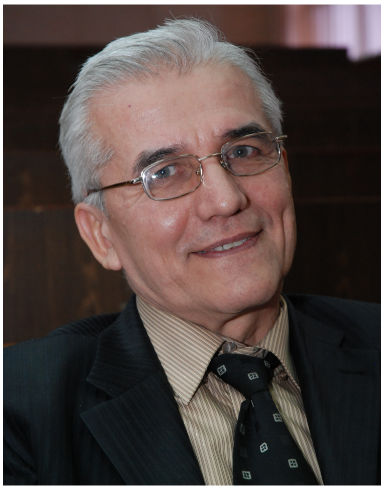

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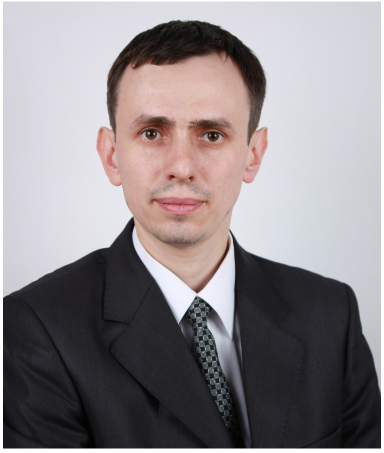

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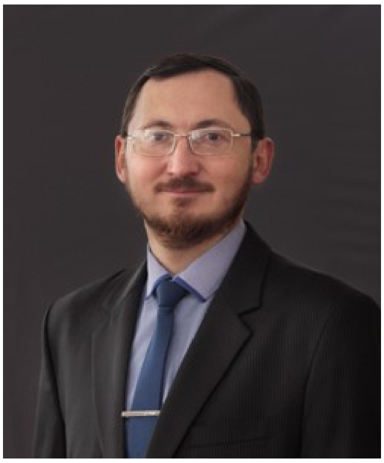

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2. Articles overview

2.1. Session 1: Digital Transformation of Education and Smart Campus Technologies

Andrey V. Pikilnyak, Nadia M. Stetsenko, Volodymyr P. Stetsenko, Tetiana V. Bondarenko and Halyna V. Tkachuk (figure 2) in the article "Comparative analysis of online dictionaries in the context of the digital transformation of education" [4] highlights further research by the authors, begun in [5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17]. This article is devoted to a comparative analysis of popular online dictionaries and an overview of the main tools of these resources to study a language. The use of dictionaries in learning a foreign language is an important step to understanding the language. The effectiveness of this process increases with the use of online dictionaries, which have a lot of tools for improving the educational process. Based on the Alexa Internet resource it was found the most popular online dictionaries: Cambridge Dictionary, Wordreference, Merriam–Webster, Wiktionary, TheFreeDictionary, Dictionary.com, Glosbe, Collins Dictionary, Longman Dictionary, Oxford Dictionary. As a result of the deep analysis of these online dictionaries, authors found out they have the next standard functions like the word explanations, transcription, audio pronounce, semantic connections, and examples of use. In propose dictionaries, authors also found out the additional tools of learning foreign languages (mostly English) that can be effective. In general, authors described sixteen functions of the online platforms for learning that can be useful in learning a foreign language. Authors have compiled a comparison table based on the next functions: machine translation, multilingualism, a video of pronunciation, an image of a word, discussion, collaborative edit, the rank of words, hints, learning tools, thesaurus, paid services, sharing content, hyperlinks in a definition, registration, lists of words, mobile version, etc. Based on the additional tools of online dictionaries authors created a diagram that shows the functionality of analyzed platforms.

Roman A. Tarasenko, Viktor B. Shapovalov, Stanislav A. Usenko (figure 3), Yevhenii B. Shapovalov, Iryna M. Savchenko, Yevhen Yu. Pashchenko and Adrian Paschke in the article "Comparison of ontology with non-ontology tools for educational research" [18] described the

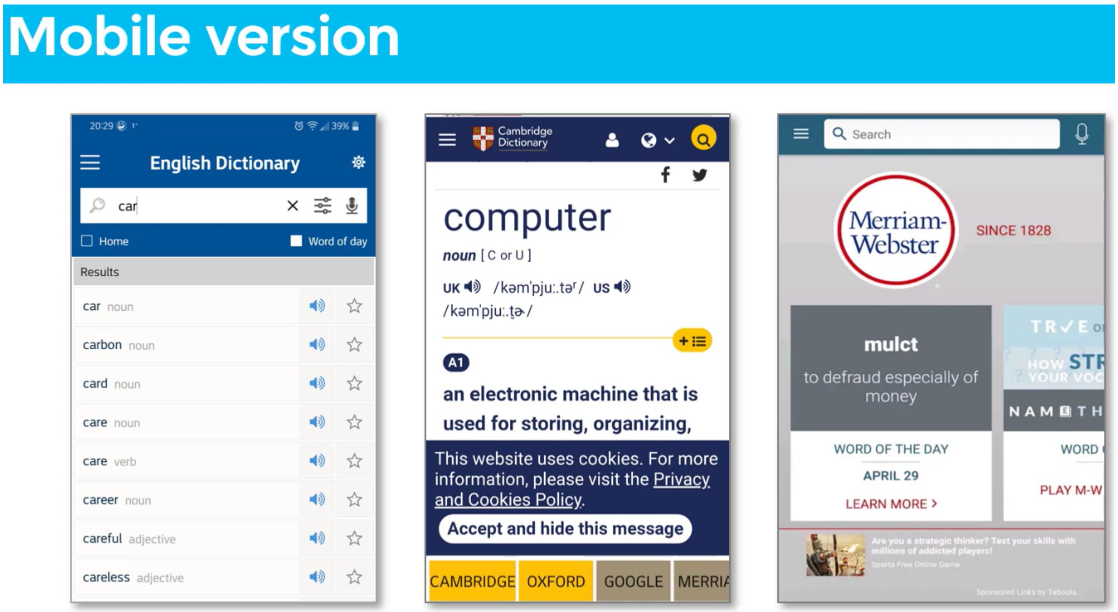

Figure 2: Presentation of paper [4].

usage of cognitive IT-platform Polyhedron to collect both existing informational ontology-based tools, and specially designed to complement a full-stack of instruments for digital support for scientific research. This article highlights further research by the authors, begun in [19, 20, 21, 22].

The article "A semantic structuring of educational research using ontologies" [23] by Yevhenii B. Shapovalov (figure 4), Viktor B. Shapovalov, Roman A. Tarasenko, Stanislav A. Usenko and Adrian Paschke is devoted to the presentation of the semantic interoperability of research and scientific results through an ontological taxonomy. To achieve this, the principles of systematization and structuration of the scientific/research results in scientometrics databases have been analysed. Authors use the existing cognitive IT platform Polyhedron and extend it with an ontology-based information model as main contribution. As a proof-of-concept we have modelled two ontological graphs, "Development of a rational way for utilization of methane tank waste at LLC Vasylkivska poultry farm" and "Development a method for utilization of methane tank effluent". Also, for a demonstration of the perspective of ontological systems for a systematization of research and scientific results, the "Hypothesis test system" ontological graph has created.

The article "Applying digital technologies for work management of young scientists' councils" [24] by Anna V. Iatsyshyn (figure 5), Iryna H. Hubeladze, Valeriia O. Kovach, Valentyna V. Kovalenko, Volodymyr O. Artemchuk, Maryna S. Dvornyk, Oleksandr O. Popov, Andrii V. Iatsyshyn and Arnold E. Kiv explores the features of the digital technologies' usage to organize the work of the Young Scientists' Councils and describes the best practices. The digital transformation of society and the quarantine restrictions caused by the COVID-19 pandemic have forced the use of various digital technologies for scientific communication, the organization

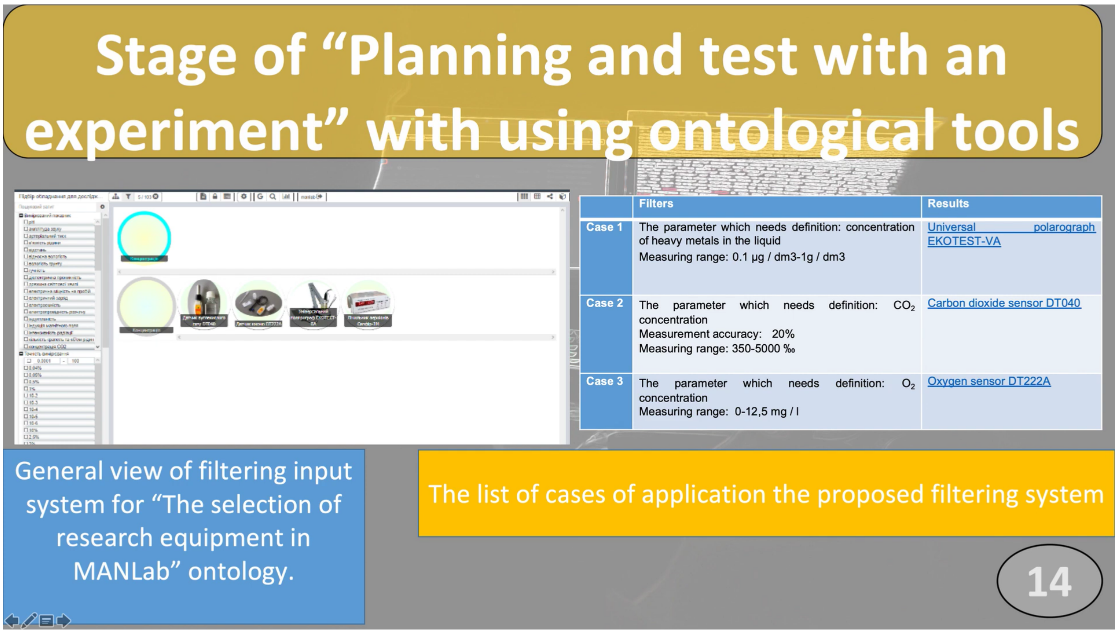

Figure 3: Presentation of paper [18].

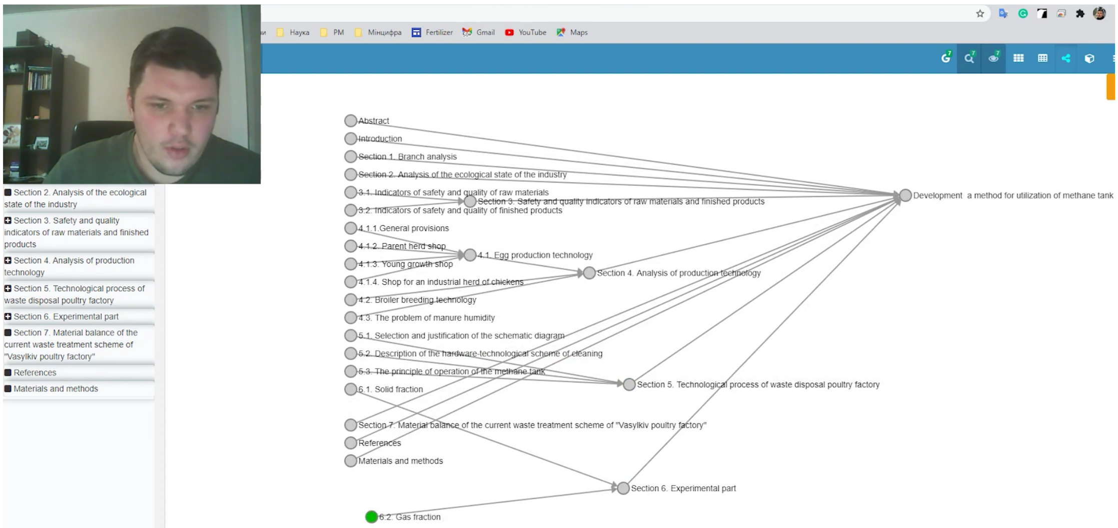

Figure 4: Presentation of paper [23].

of work for youth associations, and the training of students and Ph.D. students. An important role in increasing the prestige of scientific activity and encouraging talented young people to participate in scientific projects belongs to the Young Scientists' Councils, which are created at scientific institutions and higher education institutions. It is determined that the peculiarities of the work of Young Scientists' Councils are in providing conditions for further staff development of the institution in which they operate; contribution to the social, psychological and material support of young scientists and Ph.D. students; creating an environment for teamwork and collaborative partnership; development of leadership and organizational qualities; contribution to the development of digital competence. The advantages of using electronic social networks in higher education and research institutions are analyzed, namely: general popularity and free of charge; prompt exchange of messages and multimedia data; user-friendly interface; availability of event planning functions, sending invitations, setting reminders; support of synchronous and asynchronous communication between network participants; possibility of access from various devices; a powerful tool for organizing the learning process; possibility of organization and work of closed and open groups; advertising of various events, etc. Peculiarities of managing the activity of the Young Scientists' Council with the use of digital technologies are determined. The Young Scientists' Council is a social system, and therefore the management of this system refers to social management. The effectiveness of the digital technologies' usage to manage the activities of the Young Scientists' Council depends on the intensity and need for their use to implement organizational, presentation functions and to ensure constant communication. The areas to apply digital technologies for the work managing of Young Scientists' Councils are sorted as the presentation of activity; distribution of various information for young scientists; conducting questionnaires, surveys; organization and holding of scientific mass events; managing of thematic workgroups, holding of work meetings. It is generalized and described the experience of electronic social networks usage for organizing and conducting of scientific mass events. This article highlights further research by the authors, begun in [25, 26, 27, 28, 29, 30, 31, 32, 33, 34].

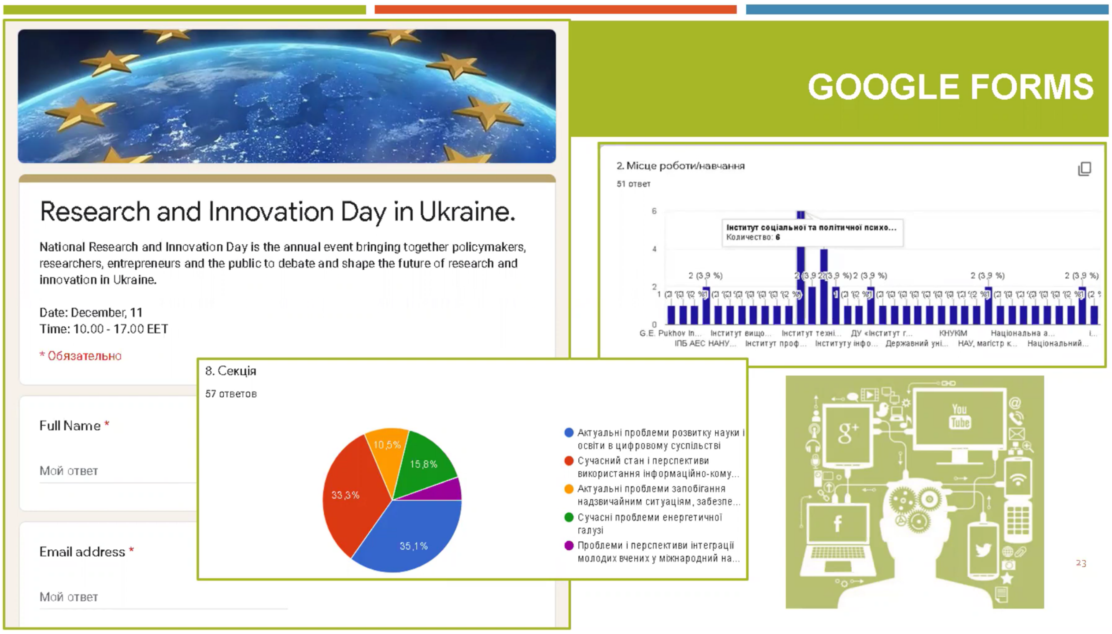

Figure 5: Presentation of paper [24].

The article "The use of cloud computing technology in professional training of future programmers" [35] by Kateryna P. Osadcha and Viacheslav V. Osadchyi (figure 6) provides a brief analysis of the current state of the study of cloud technologies by future software engineers at foreign and Ukrainian universities. The authors' experience in the application of cloud technologies in the training of future software engineers in Ukraine is presented. The application of cloud business automation systems, online services to monitor the implementation of the software projects, Google services for collaboration, planning and productivity while studying professional disciplines and carrying out diploma projects is described. Based on the survey conducted at Stackoverflow, the state of application of cloud technologies by software engineers around the world has been analyzed. The cloud technologies that are not studied at the analyzed universities of Ukraine and those that are not popular with software developers in the world, but studied at Ukrainian universities by future software engineers are outlined. Conclusions are made on the modernization of training programs for future software engineers. Topics for the study of cloud technologies by future software engineers in the content of professional disciplines are proposed. The article highlights further research by the authors, begun in [36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58].

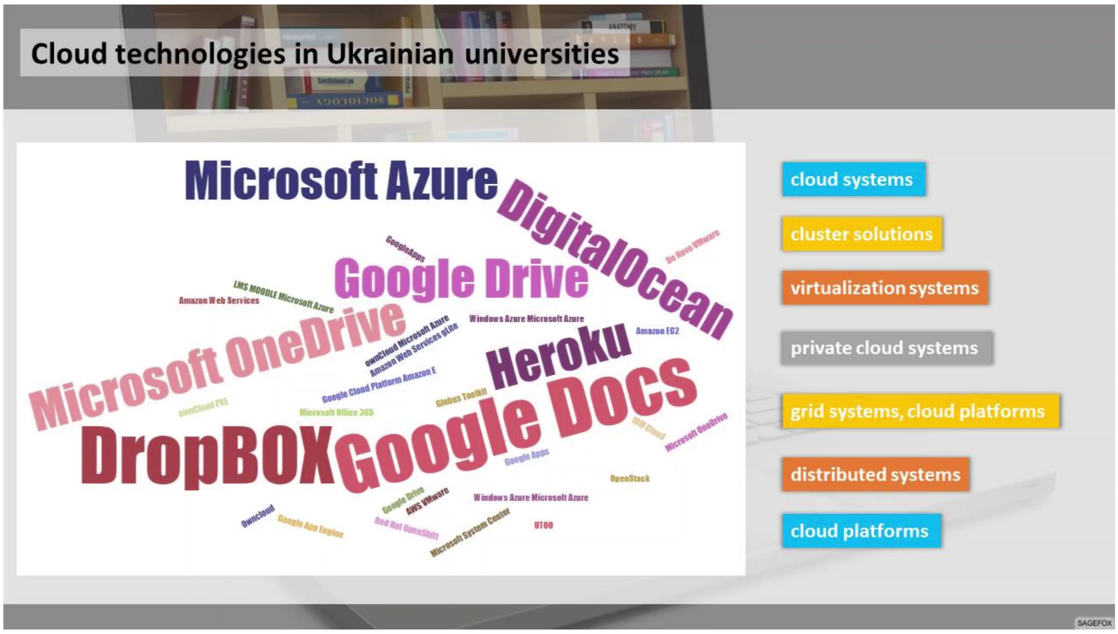

Figure 6: Presentation of paper [35].

The article "Some experience in maintenance of an academic cloud" [59] by Vasyl P. Oleksiuk (figure 7), Olesia R. Oleksiuk, Oleg M. Spirin, Nadiia R. Balyk and Yaroslav P. Vasylenko is devoted to the systematization of experience in the deployment, maintenance and servicing of the private academic cloud. The article contains model of the authors' cloud infrastructure. It was developed at Ternopil Volodymyr Hnatiuk National Pedagogical University (Ukraine) on the basis of the Apache CloudStack platform. The authors identify the main tasks for maintaining a private academic cloud. Here they are making changes to the cloud infrastructure; maintenance of virtual machines (VM) to determine the performance and migration of VM instances; work with VMs; backup of all cloud infrastructure. The analysis of productivity and providing students with computing resources is carried out. The main types of VM used in training are given. The number and characteristics of VM that can be served by a private academic cloud are calculated. Approaches and schemes for performing backup are analysed. Some theoretical and practical experience of using cloud services to perform backup has been studied. Several scripts have been developed for archiving the platform database and its repositories. They allow you to upload backups to the Google Drive cloud service. The performance of these scripts for the author's deployment of private cloud infrastructure was evaluated. The article highlights further research by the authors, begun in [60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75].

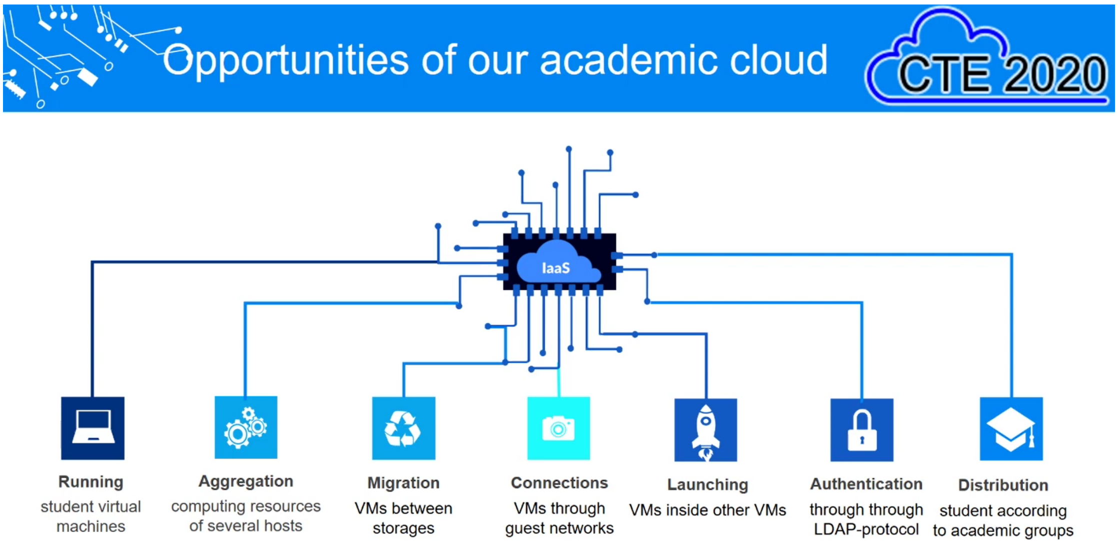

Figure 7: Presentation of paper [59].

The article "Digitalization of the educational process for the training of the pre-service teachers" [76] by Oksana V. Strutynska, Grygoriy M. Torbin, Mariia A. Umryk (figure 8) and Roman M. Vernydub considers the process of transition from informatization to digitalization in society, implementation of digital support for the educational process in the university, development of the digital educational environment for the training university teachers, and proposes the digital tools for such an environment. The authors propose several ways to improve the development level of digitalization of the educational environment in the university. This is to take into account the needs of the digital society and the modern generation of students, provide a high level of the digital literacy formation of university graduates and support the development of a new digital security system of the modern university. Aiming to design the digital educational environment for increasing the of educators' digital literacy level, the authors propose to develop and implement the following computer, multimedia and computer-based learning tools and equipment, which includes blended and distance learning classes, cloud technologies, tools of virtual and augmented reality, tools for gamification of the educational process, educational robotics, tools for learning 3D technologies, MOOCs. The article highlights further research by the authors, begun in [77].

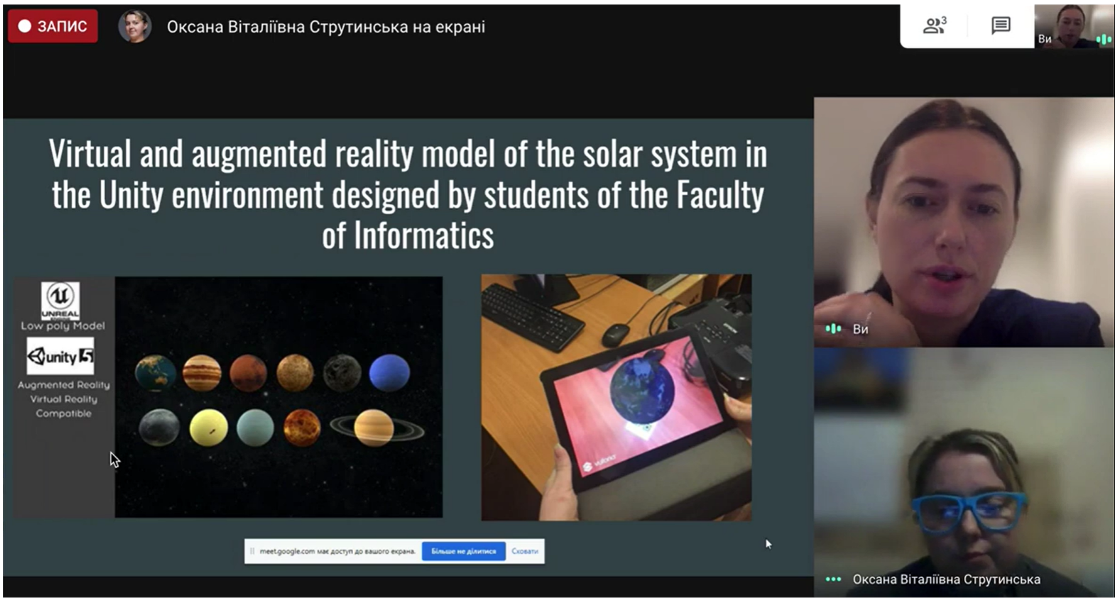

Figure 8: Presentation of paper [76].

The article "Ways to design a digital educational environment for K-12 education" [78] by Natalia V. Morze and Viktoriia O. Kucherovska (figure 9) is devoted to the description of the concept, components and ways of designing the digital educational environment of a K-12 education institution through the transformation of educational activities. The importance of developing an educational policy of an educational institution in the field of digital technology is described. Authors present the model and the ways of designing the digital educational environment of the K-12 education institution. The necessity of self-assessment of digital technologies usage in the educational process by all its participants is substantiated; the ways of application of the European tool SELFIE for carrying out such self-analysis are described. Based on the adaptation of all components of the tool SELFIE for Ukrainian education, the results of its usage at one of the secondary schools in Kyiv are presented. This article highlights further research by the authors, begun in [79, 80, 81, 82, 83].

2.2. Session 2: Mobile Learning

The article "Integration of chatbots into the system of professional training of Masters" [84] by Tetiana V. Shabelnyk, Serhii V. Krivenko, Nataliia Yu. Rotanova, Oksana F. Diachenko (figure 10), Iryna B. Tymofieieva and Arnold E. Kiv presents and describes innovative technologies of training in the professional training of Masters. For high-quality training of students of technical specialties, it becomes necessary to rethink the purpose, results of studying and means of teaching professional disciplines in modern educational conditions. The experience of implementing the chatbot tool in teaching the discipline "Mathematical modeling of socio-economic systems" in the educational and professional program 124 System Analysis is described. The characteristics of the generalized structure of the chatbot information system for investment

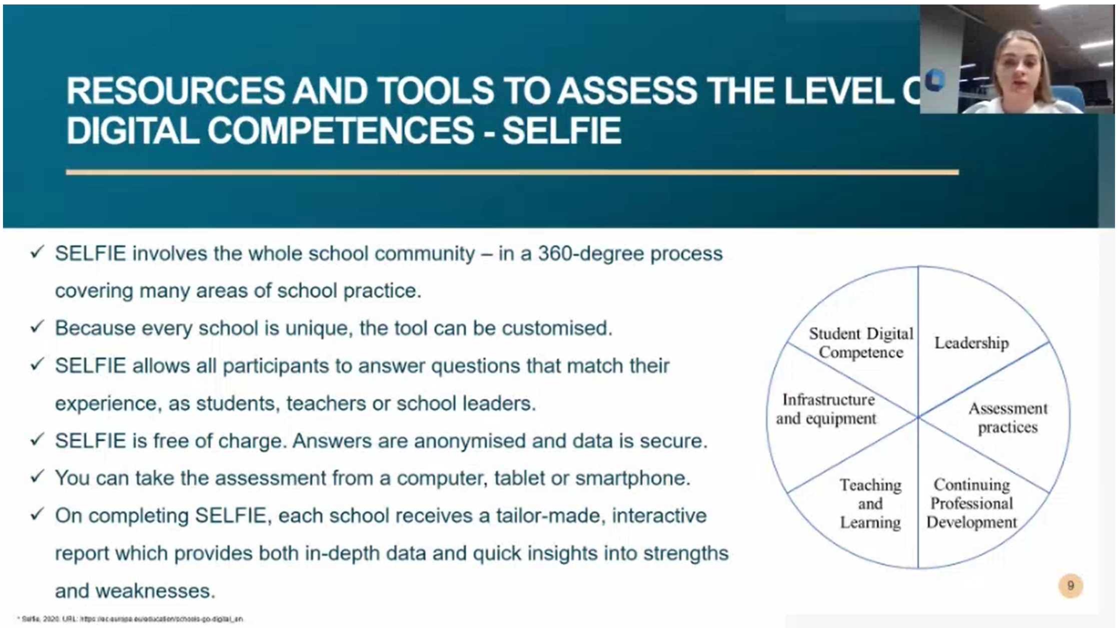

Figure 9: Presentation of paper [78].

analysis are presented and given: input information, information processing system, output information, which creates a closed cycle (system) of direct and feedback interaction. The information processing system is represented by accounting and analytical data management blocks. The investment analysis chatbot will help masters of the specialty system analysis to manage the investment process efficiently based on making the right decisions, understanding investment analysis in the extensive structure of financial management and optimizing risks in these systems using a working mobile application. Also, the chatbot will allow you to systematically assess the disadvantages and advantages of investment projects or the direction of activity of a system analyst, while increasing interest in performing practical tasks. A set of software for developing a chatbot integrated into training is installed: Kotlin programming, a library for network interaction Retrofit, receiving and transmitting data, linking processes using the HTTP API. Based on the results of the study, it is noted that the impact of integrating a chatbot into the training of Masters ensures the development of their professional activities, which gives them the opportunity to be competent specialists and contributes to the organization of high-quality training. This article highlights further research by the authors, begun in [85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100].

The article “Features of design of digital aids for training students with autistic disorders” [101] by Liudmyla I. Bilousova, Liudmyla E. Gryzun (figure 11) and Nataliia P. Volkova highlights further research by the authors, begun in [102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114]. In accordance with the aims of the paper, it is covered essential peculiarities of the design of digital aids for ASD-students. They are distinguished coming from the analysis of common learning and social difficulties inherent to the trainees with autistic disorders; needs for their speaking habits development; advantages of special digital support in terms of facilitating ASD-

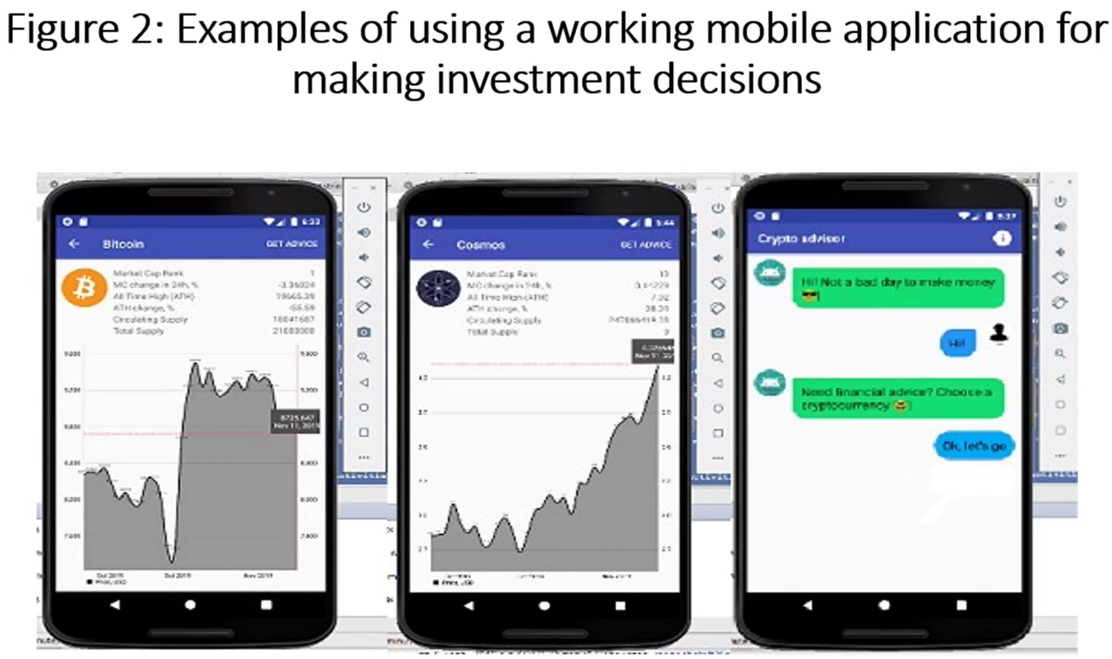

Figure 10: Presentation of paper [84].

students' training. The distinguished features essential in the process of the digital aids design are demonstrated on the example of the development of an e-simulator for young ASD-students' speech encouragement. The main stages of its design and functionality are characterised. It is emphasised in conclusion that the developed digital simulator due to its functionality helps to overcome a number of problems faced by young ASD-students.

2.3. Session 3: Blended Learning

The article "Implementation of future agricultural engineers' training technology in the informational and educational environment" [115] by Aleksandr D. Uchitel, Ilona V. Batsurovska, Nataliia A. Dotsenko (figure 12), Olena A. Gorbenko and Nataliia I. Kim highlights further research by the authors, begun in [116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130], and presents the implementation of future agricultural engineers' training technology in the informational and educational environment. To train future agricultural engineers, it is advisable to form tutorials for the study of each discipline in the conditions of informational and educational environment. Such tutorials are an assistance in mastering both theoretical material and course navigation, where interactive electronic learning tools are presented to perform tasks in the informational and educational environment. Higher education applicants perform such tasks directly in the classroom with the help of gadgets or personal computers. The final grade is formed from the scores obtained in the classroom and the rating of higher education applicants while studying in the informational and educational environment. The outlined approach is able to help in the quality of learning content. The use of interactive audiovisual online tools

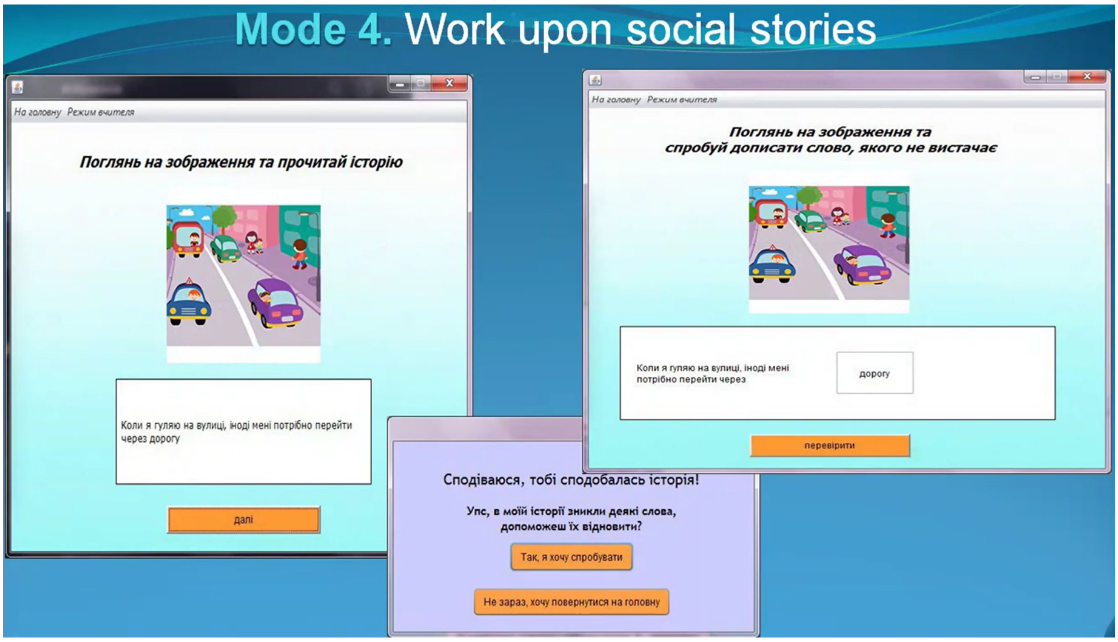

Figure 11: Presentation of paper [101].

allows to get acquainted with the theoretical, practical and experimental provisions clearly, it is important for the training of future agricultural engineers. At the end of the experiment, it can be argued that the developed technology increases the level of motivation and self-incentive to work in the informational and educational environment. The application of the presented technology provides an opportunity to combine the educational process in the classroom with learning in the informational and educational environment, forms analytical abilities and competencies in professional activity. The reliability of the obtained results was checked using the λ Kolmogorov-Smirnov criterion. It is determined that when using this technology in the educational process, the indicators in the experimental group increased, which displays the effectiveness of training bachelors in agricultural engineering in the conditions of informational and educational environment.

The article "Blended learning in the context of digitalization" [131] by Tatyana B. Bykova (figure 13), Mykola V. Ivashchenko, Darja A. Kassim and Vasyl I. Kovalchuk highlights further research by the authors, begun in [132, 133, 134, 135, 136]. The realities of digitalization require changes in strategies for choosing educational technologies. The modern educational process is not possible without the use of digital technologies. Digital technologies have led to the arising and development of blended learning. However, its effectiveness is determined not only by technology. The human factor receives special attention in this direction. Analysis of the World Development Report 2016: Digital Dividends allows us to identify digital competence as a necessary condition for the successful use of digital technologies, and hence blended learning. Learning interactions designing in the process of implementing blended learning requires timely diagnosis of the level of digital competence. A popular tool for this is the Digital Competence

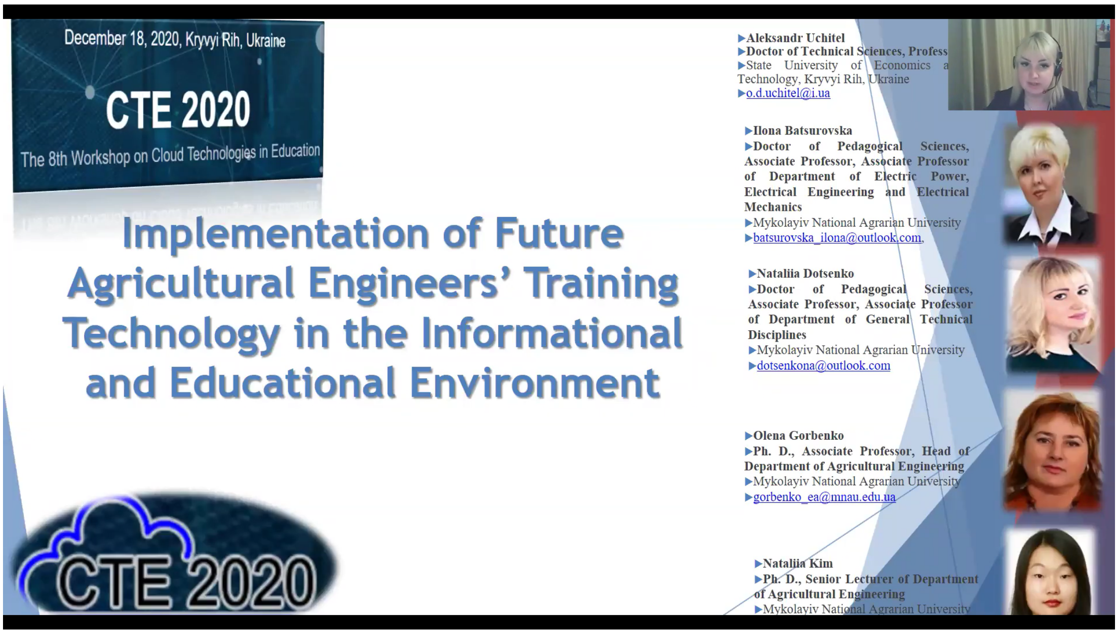

Figure 12: Presentation of paper [115].

Framework for Citizens. To clarify the peculiarities of its use was made an analysis of the experimental implementation results of blended learning in the industrial training in sewing for intended masters. During the research, it was revealed that the most important digital competence areas for the variable learning establishment in the training of future professionals are Information and data literacy, Communication and collaboration and Problem solving. In addition, competence for area Problem solving conduce to increase the level of competence for all other areas. The level of digital competence of the subjects mainly coincide to the characteristics of basic and secondary levels. The obtained data clarified the reasons for the difficulties, decrease motivation and cognitive activity that occur among students using distance courses-resources learning designed for blended learning. Thus, the use of the Digital Competence Framework for Citizens at the initial stage of implementing blended learning can make a rational choice of strategies for combining face-to-face and distance learning technologies.

The article "Strengthening of e-learning at the leading Ukrainian pedagogical universities in the time of COVID-19 pandemic" [137] by Halina I. Falfushynska (figure 14), Bogdan B. Buyak, Hryhorii V. Tereshchuk, Grygoriy M. Torbin and Mykhailo M. Kasianchuk highlights further research by the authors, begun in [138, 139]. Distance education has become the mandatory component of higher education establishments all over the world including Ukraine regarding COVID-19 lockdown and intentions of Universities to render valuable knowledge and provide safe educational experience for students. The present study aimed to explore the student's and academic staff's attitude towards e-learning and the most complicated challenges regarding online learning and distance education. Authors findings disclosed that the online learning using Zoom, Moodle, Google Meet, BigBlueButton and Cisco has become quite popular among the students and academic staff in Ukraine in time of the lockdown period and beyond. Based on

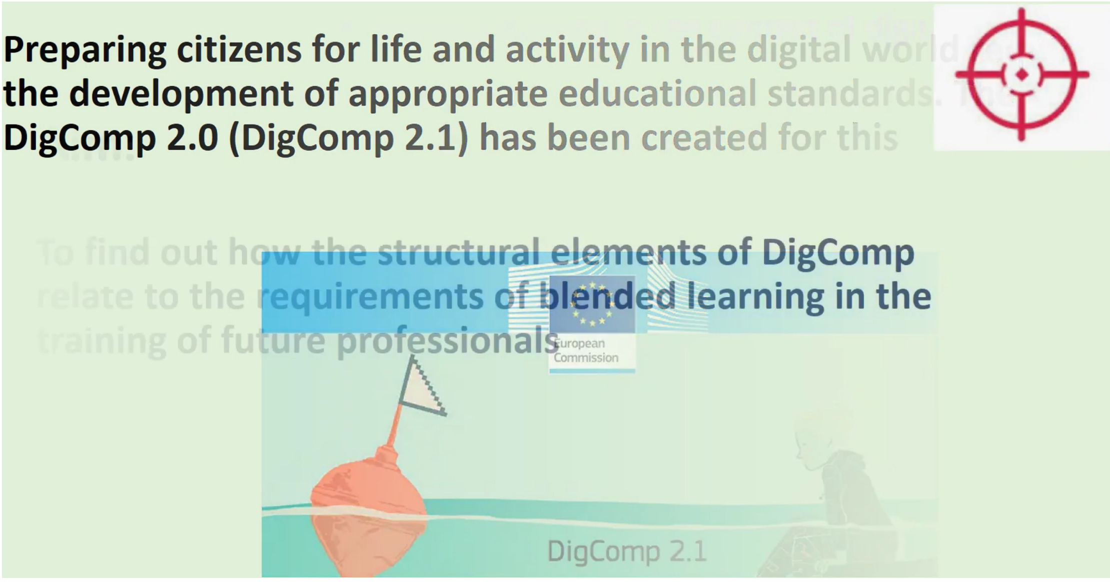

Figure 13: Presentation of paper [131].

the Principal Component Analysis data processing we can conclude that students' satisfaction and positive e-learning perception are in a good correlation with quality of e-learning resources and set of apps which are used while e-learning and distance education. Also, education style, methods, and manner predict willingness of students to self-study. The self-motivation, time-management, lack of practice, digital alienation, positive attitude towards ICT, and instruction strategy belong to the most important challenges of COVID-19 lockdown based on the students and academic staff interviews. Online learning on daily purpose should be used in the favor of strengthening of classical higher education rather than replacing the former. Blended education is the best alternative to face-to-face education, because the communication with mentor in a live environmental even virtual should have ushered the learners to complete online learning and improve its results.

The article "Operation system features and cloud services for lecturer work" [140] by Lesya V. Bulatetska (figure 15), Vitaliy V. Bulatetskyi, Tetyana O. Hryshanovych, Yulia S. Pavlenko, Tetyana I. Cheprasova and Andrey V. Pikilnyak proposes a conception of setup and use of teacher's or lecturer's workspace using common software and hardware products. The research object is a system built by using operating system capabilities in conjunction with office suite and public cloud service, as a foundation for teacher's digital workspace. Research is made on how to set up, scale, and operate such a system, by studying the experience of national and foreign scientists and teachers, and using our own experience in educational processes, and working with operating systems and cloud services. As a result, we got a system which is easy to set up, learn, and apply by teachers without significant experience working remote education systems, and could be used for initial learning of remote education principles. It could be used as an initial step before migrating to specialized remote education systems. In the future, the system itself could be improved by adding additional objects into the system and a

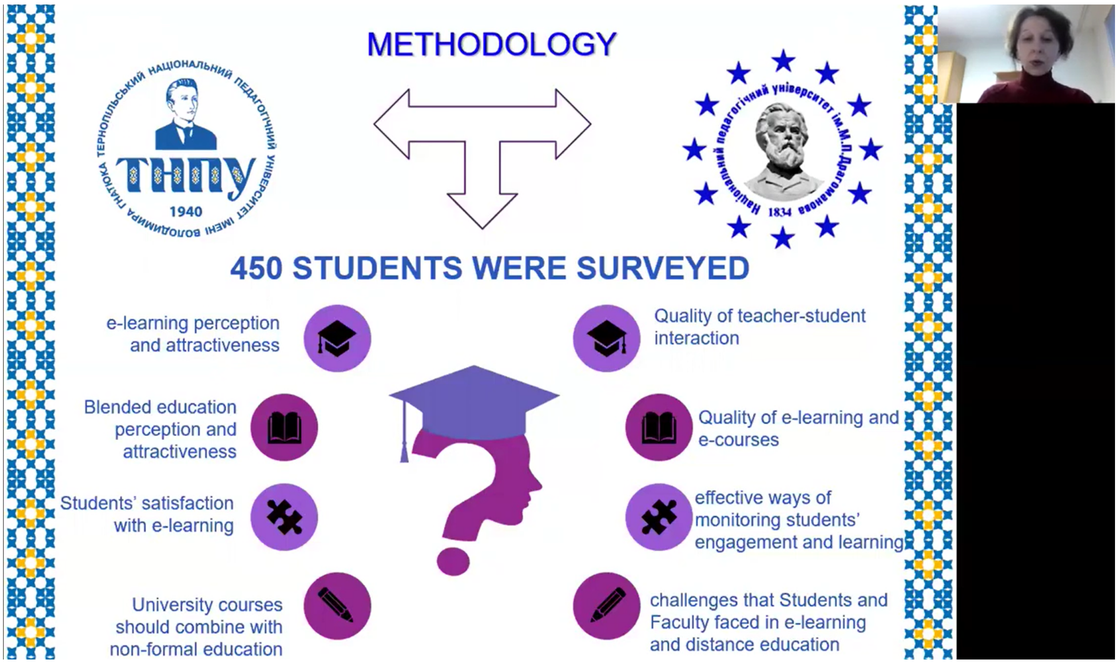

Figure 14: Presentation of paper [137].

higher integration level between objects and external subjects.

Online Faculty Development Programs/Webinars are the two buzzing words, which have become viral next to corona among the teaching fraternity during the lockdown period of pandemic situation caused by COVID-19. The article "Research on efficacy of webinars organized for faculty during lockdown of COVID-19" [141] by Krishna Chythanya Nagaraju (figure 16), Karanam Madhavi and Jandhyala N. Murthy intends to throw light on, the reason for the outbreak of FDPs/Webinars, their efficiency and the attitude of the participating faculty during the lockdown period from 16th March to 15th June 20. Information is gathered through an online survey having 31 research questions answered by 683 participants across India. The new found tool of online teaching has become the accepted norm and the urge to lead the bandwagon by each and every stakeholder in the education sector resulted in a sudden spurt of webinars and FDPs in such a short period. Study observed that global reach at no cost plus freedom of working from home spurred many faculty to experiment this mode and 40% from them have been found to be juggling with many courses simultaneously for certificate sake only, 45.1% attended on mandatory instructions and 38% have not even initiated the work. Quizzes and Polls during sessions besides assignments were found to be suitable active learning mechanisms to improve the efficacy of the online knowledge transfer methods.

The article "Cloud resources use for students' project activities" [142] by Nataliia V. Valko (figure 17) and Viacheslav V. Osadchyi and Vladyslav S. Kruhlyk highlights further research by the authors, begun in [143, 144, 145, 146]. The modern educational system proclaims learning aimed at acquiring practical skills and based on the activity approach. Educational research projects are the necessary component of curricula in physics, computer science,

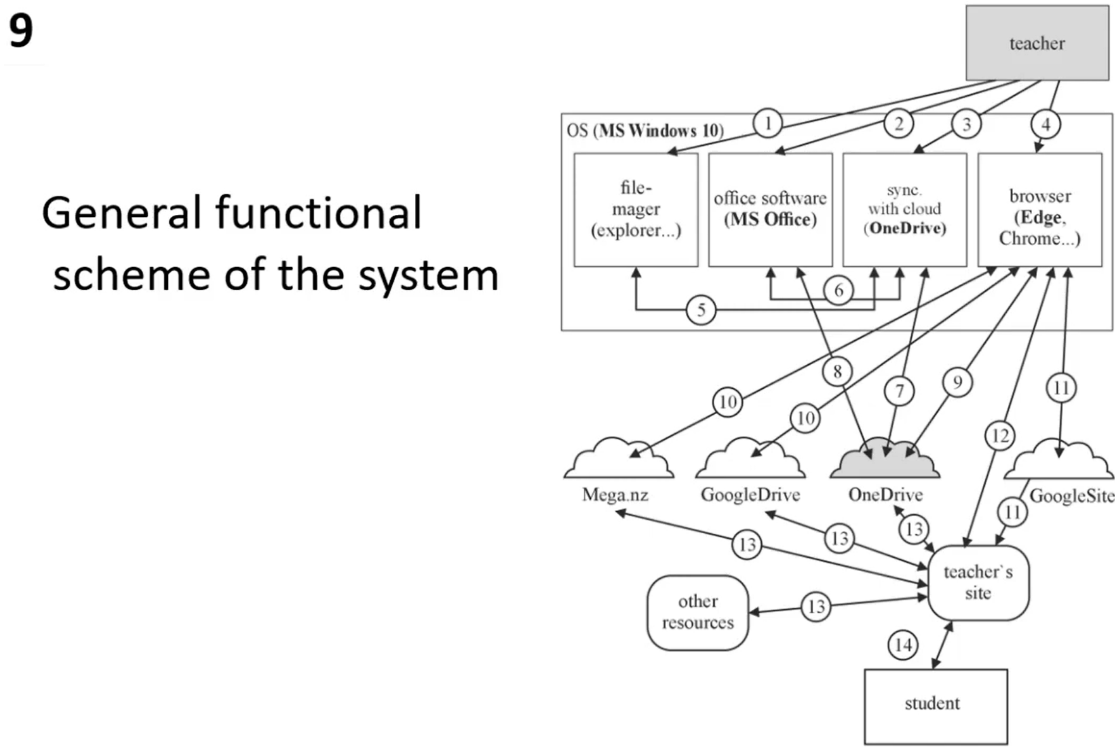

Figure 15: Presentation of paper [140].

biology and chemistry. There is a problem of specialized equipment and facilities using for the implementation of such projects in distance learning. Therefore, the issue of cloud resources using for distance learning organization in robotics is relevant. The article presents a brief overview of the current state of projects development in Ukrainian schools and approaches used in foreign educational institutions in teaching robotics distantly. The article describes the stages of robotics projects development such as organizational, communicative, project work, summarizing. The peculiarities of the stages in distance learning and the possibilities of cloud technologies in robotics are also considered. The authors' experience in projects developing in this environment for students and future teachers is described.

The training of pre-service mathematics teachers is a complex process due to the specifics of the field. Informatization of education affects all the areas, and pre-service mathematics teachers can not be left out. The article "The support of the process of training pre-service mathematics teachers by means of cloud services" [147] by Vladyslav Ye. Velychko and Elena H. Fedorenko and Nataliia V. Kaidan (figure 18), Vladimir N. Soloviev and Olga V. Bondarenko is devoted to the problem of supporting the process of professional training of pre-service mathematics teachers by means of cloud services. Examples of the use of cloud technologies are given. The analysis of a survey of pre-service mathematics teachers on the use of information and communication technologies in the training process is done. This article highlights further research by the authors, begun in [148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160,

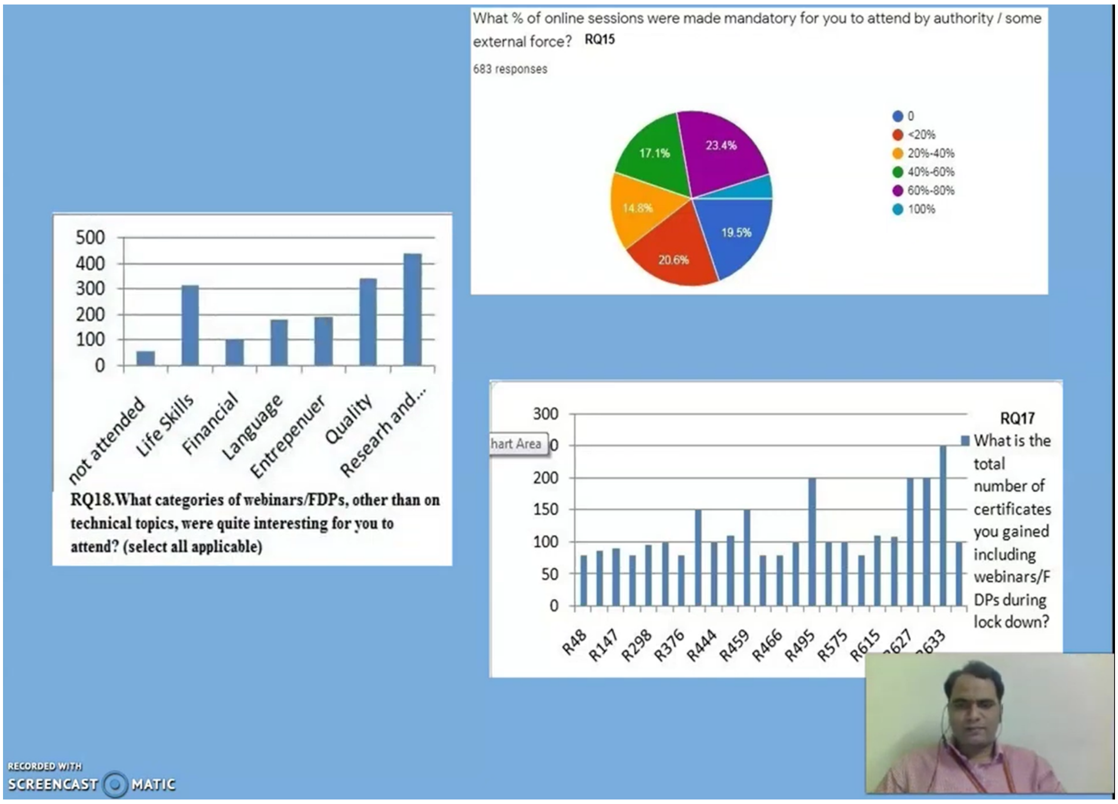

Figure 16: Presentation of paper [141].

161, 162, 163, 164, 165].

2.4. Session 4: Competency-Based Education Platforms

The matter of building an optimal model of managing the online platform "Higher School Mathematics Teacher" is considered in the article "Management of online platform development and support process" by Kateryna V. Vlasenko, Sergii V. Volkov (figure 19), Iryna V. Lovianova, Olena O. Chumak, Irina V. Sitak and Dmytro Ye. Bobyliev [166]. This article highlights further research by the authors, begun in [167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178]. The existing researches on the management of online platform development and support process have been analyzed in this paper. The model developers described the process of building an online platform according to the Software Development Lifecycle rules. The researchers described an online course platform creation and functioning process that corresponds to a five-stage pedagogical ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) of online course preparation. The research describes the roles and objectives of online platform team members. These results allowed the authors of the article to model the organizational structure of online platform management. The method of survey among the team members of the online platform "Higher School Mathematics Teacher" and its participants was

Figure 17: Presentation of paper [142].

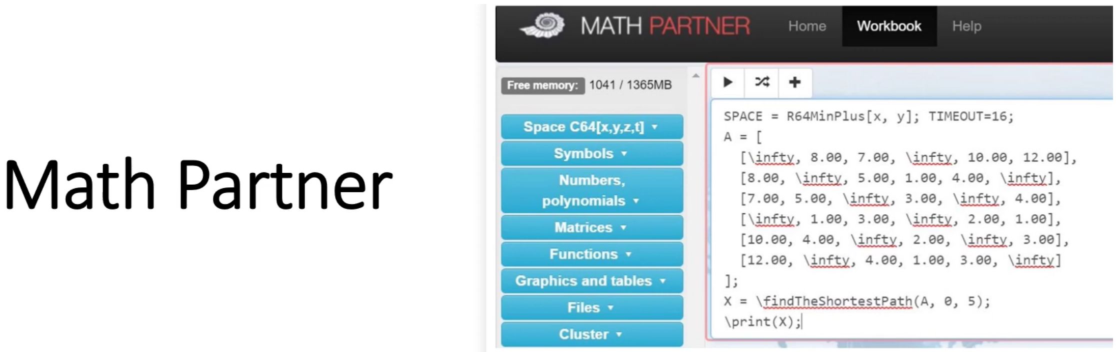

Figure 18: Presentation of paper [147].

used to prove the efficiency of the offered model. The results allowed us to confirm the actuality of the research in the management of educational platforms, the convenience of teamwork in online platform management, and successful model implementation.

Researches and publications on using Google Classroom web service for lecturers of higher educational establishments under pandemic conditions are analysed in the article "The potential of Google Classroom web service for lecturers of higher educational establishments under pandemic conditions" [179] by Leila Yu. Sultanova, Oksana P. Tsiuniak, Liudmyla O. Milto, Maryna O. Zheludenko (figure 20), Lyudmyla M. Lyktei, Larisa M. Petrenko and Aleksandr D. Uchitel. The current state of higher education under pandemic conditions is characterised. Features of Google Classroom web service have been identified. The methodical development

Figure 19: Presentation of paper [166].

for lecturers of higher educational establishments “Potential of using Google Classroom web service” is described. Criteria and levels of using Google Classroom web service are defined. Initial diagnostic of the levels of using Google Classroom web service was conducted. During the diagnostic was revealed that most respondents have insufficient levels of theoretical knowledge and practical skills. In order to increase the level of using Google Classroom web service, the methodological development was implemented. As a result, positive dynamics in the levels of theoretical knowledge and practical skills of using Google Classroom web service was revealed. The effectiveness of the obtained results was confirmed by Fisher’s criterion. This article highlights further research by the authors, begun in [180, 181].

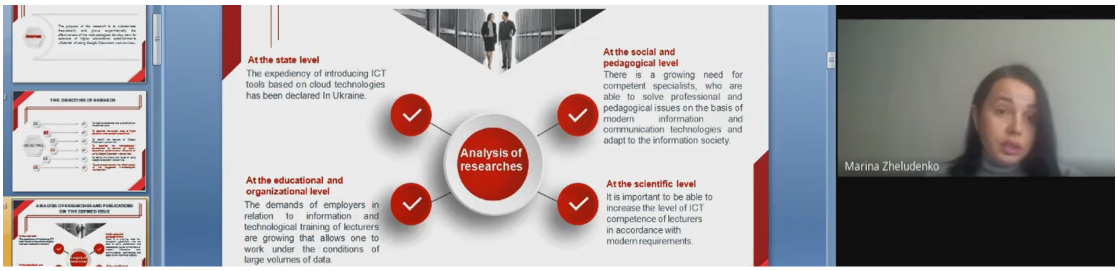

Figure 20: Presentation of paper [179].

The article “Formation of informational and digital competence of secondary school students in laboratory work in physics” [182] by Oleksandr O. Martyniuk (figure 21), Oleksandr S. Martyniuk and Ivan O. Muzyka deals with the formation of informational and digital competence of high school students. First and foremost, the existing digitalization strategies for society already approved in the world and in Ukraine, including the implementation of STEM education and the Digital Agenda, are considered. On the other hand, attention is paid to the inconsistency of the level of ownership and frequency of use of digital technologies with the requirements of these initiatives. The concept of informational and digital competence is analyzed in detail. Existing publications identify key components, skills and competencies required to achieve this competence. A survey is conducted to better understand the current situation. One of the tasks is to determine the level of use of digital information in the classroom by teachers and in students' preparation at home. The second task was to show how developing students' informational and digital competence can be done by active introduction of existing software and hardware in the educational process in physics, in particular, a laboratory workshop. The example of laboratory work carried out in educational institutions shows how modern software can be used to analyze the movement of bodies and determine the physical characteristics of this movement. The concrete ways of performing laboratory work, analyzing its results and drawing conclusions are given. It is in the combination of existing teaching practices with modern gadgets, specialized and general programs that the basic way of forming informational and digital competence is seen. Further ways of modernization and improvement of described methods for increasing the level of information and digital competence are proposed. This article highlights further research by the authors, begun in [183, 184, 185, 186, 187].

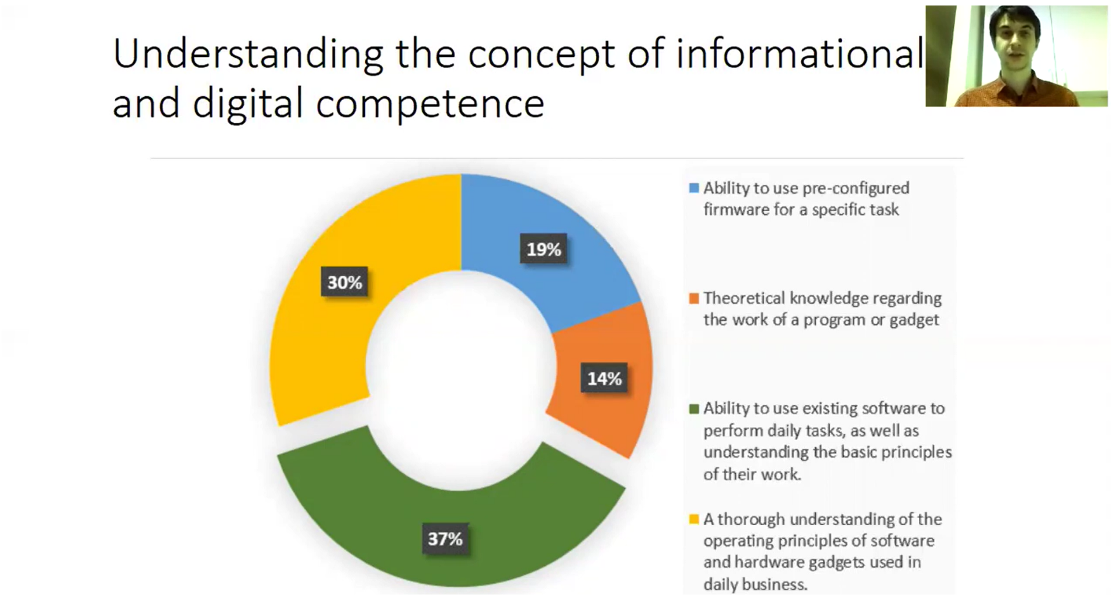

Figure 21: Presentation of paper [182].

2.5. Session 5: Adaptive Cloud Learning Platforms

The article "The selection of cloud services for ER-diagrams construction in IT specialists databases teaching" [188] by Tetiana A. Vakaliuk (figure 22), Olha V. Korotun and Serhiy O.

Semerikov highlights further research by the authors, begun in [189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211]. One of the main aspects of studying databases in higher education institutions by future IT specialists is database design and software product development. This, in turn, is the most important problem of the developer's interaction with the customer. To facilitate the process of database design, ER-diagrams are used, which are based on the concepts of "Entity" and "Relationship". An ER diagram allows you to present a database in the form of visual graphical objects that define a specific subject area. The article considers the available cloud services for the construction of ER-diagrams for learning databases of future IT specialists and their selection the method expert evaluation. For this purpose, the criteria and indicators for the selection of cloud services for the construction of ER-diagrams of databases by future information technology specialists have been determined. As a result, it was found that the cloud services Dbdesigner.net and Lucidchart are the most convenient to learn. It is determined that for a teacher of a higher education institution the use of cloud services is an opportunity to use licensed software in education without additional costs.

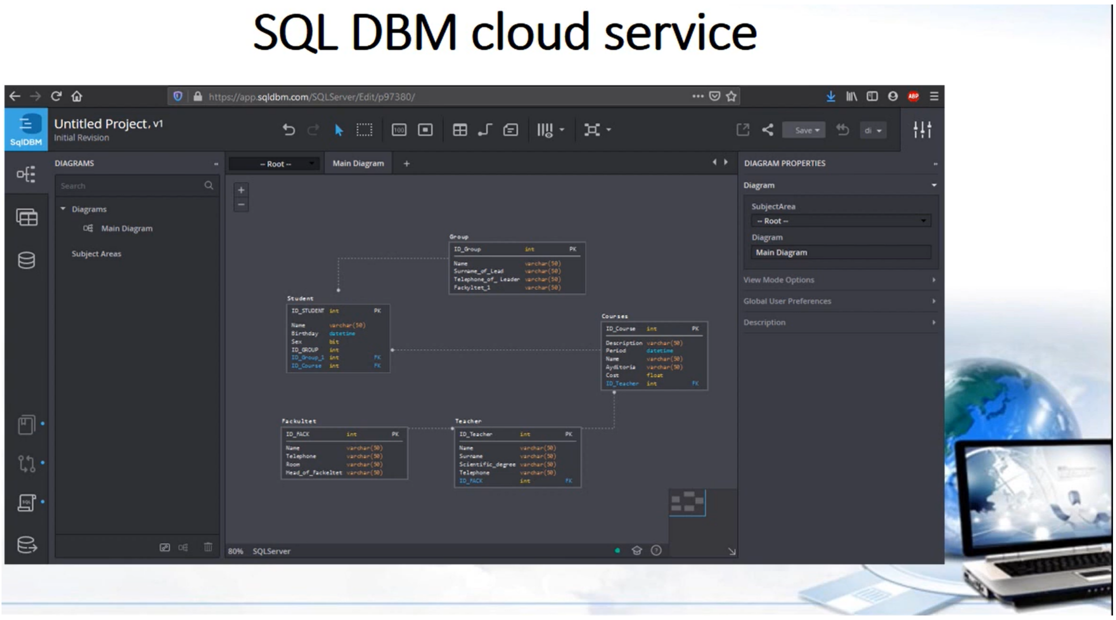

Figure 22: Presentation of paper [188].

The article "Approaches to the choice of tools for adaptive learning based on highlighted selection criteria" [212] by Yaroslava B. Sikora (figure 23), Olena Yu. Usata, Oleksandr O. Mosiiuk, Dmytrii S. Verbivskyi and Ekaterina O. Shmeltser substantiates the relevance of adaptive learning of students in the modern information society, reveals the essence of such concepts as "adaptability" and "adaptive learning system". It is determined that a necessary condition for adaptive education is the criterion of an adaptive learning environment that provides opportunities for advanced education, development of key competencies, formation of a flexible personality that is able to respond to different changes, effectively solve different problems and achieve results. The authors focus on the technical aspect of adaptive learning. Different classifications of adaptability are analyzed. The approach to the choice of adaptive learning tools based on the characteristics of the product quality model stated by the standard ISO / IEC 25010 is described. The following criteria for the selecting adaptive learning tools are functional compliance, compatibility, practicality, and support. By means of expert assessment method there were identified and selected the most important tools of adaptive learning, namely: Acrobatiq, Fishtree, Knewton (now Wiliy), Lumen, Realize it, Smart Sparrow (now Pearson). Comparative tables for each of the selected tools of adaptive learning according to the indicators of certain criteria are given. This article highlights further research by the authors, begun in [213, 214, 215, 216, 217, 218, 219].

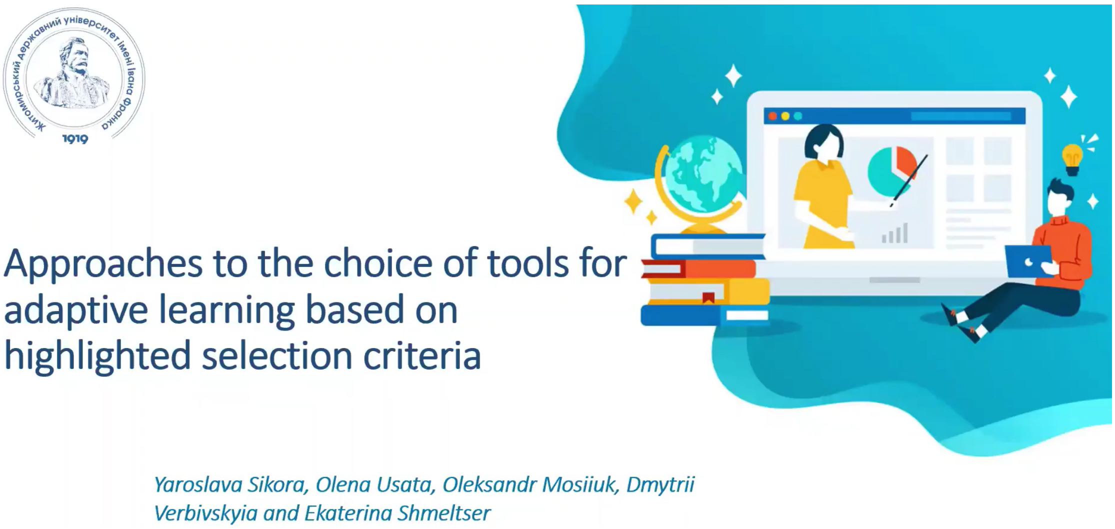

Figure 23: Presentation of paper [212].

The article "Computerized adaptive testing in educational electronic environment of maritime higher education institutions" [220] by Olena S. Diahyleva, Igor V. Gritsuk, Olena Y. Kononova and Alona Y. Yurzhenko (figure 24) is devoted to the organization of modern learning process, namely the use of innovative technologies – computerized adaptive testing in educational electronic environment of maritime higher education institutions. This article highlights further research by the authors, begun in [221]. The example of educational electronic environment is presented in the article on LMS Moodle. The provided new technological and methodological opportunities are a priority in the developed methods of control and testing of knowledge, skills and abilities of students. Comparative characteristic of using computerized adaptive testing in educational electronic environment is given in the article according to different criteria: the role of tests in the learning process; methods of training; equipment; presence of the problems in educational process; level of its control and learning outcomes. The paper also presents examples of activities to form communicative competency of future maritime professionals. Types of adaptive tests are listed in the paper. The research activities were done by second year cadets of ship engineering department of Maritime College of Kherson State Maritime Academy. The experiment was devoted to the formation of communicative competence with the help of electronic environment of maritime higher education institution. The results of experiment proved positive impact of computerized adaptive testing on communicative competence of future ship engineers. Further investigation of adaptive testing can also be done for learning system of maritime education establishments using simulation technologies of virtual, augmented and mixed realities.

Figure 24: Presentation of paper [220].

The ways of providing comprehensive efficiency increase in communication facilities of the academic space are given by Tetyana V. Neroda, Lidia V. Slipchyshyn (figure 25) and Ivan O. Muzyka in the article "Adaptive toolkit of branch-oriented workshop environment for enlargement the cloud-based e-learning media platform" [222] with regard to stipulated methods of managing distributed network resources. Selected the user interfaces types are distinguished according to user actions in the studied subject area, which made it possible to justify and hierarchically organize the categories of adaptive toolkit of the branch-oriented workshop environment by the classes of components declared in the project, which are closely related to the scheme of learning experiment and are basic means for simulating transients. The analytical models of classes of components of the virtual laboratory stand are compiled, the elements of which represent the properties and methods for visualization and further processing of interacting instances of the basic locations of the subject area, while ensuring system stability and controllability by clear distribution of functionality. Finally, the unification of component set template properties of the subject area is implemented, which greatly extending the targeted destination of virtual platform and increasing number of educational disciplines of academic course covered by the designed media resource. The results of the pedagogical verification showed an increase in the students' performance in mastering the subject area by means of presented branch-oriented workshop environment.

2.6. Session 6: Cloud-based AI Education Applications

Rasmus Munk (figure 26), David Marchant and Brian Vinter in the paper "Cloud enabling educational platforms with corc" [223] is shown how teaching platforms at educational institutions can utilize cloud platforms to scale a particular service, or gain access to compute instances

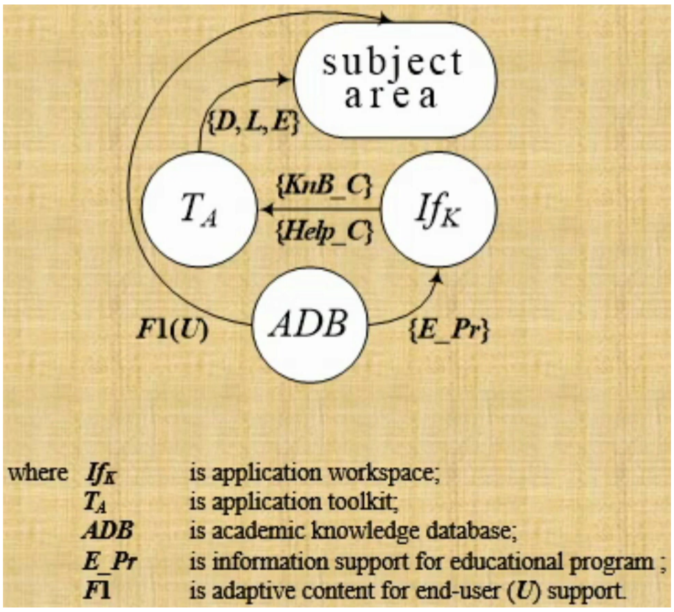

Figure 25: Presentation of paper [222].

with accelerator capability such as GPUs. Specifically at the University of Copenhagen (UCPH), it is demonstrated how the internal JupyterHub service, named Data Analysis Gateway (DAG), could utilize compute resources in the Oracle Cloud Infrastructure (OCI). This is achieved by utilizing the introduced Cloud Orchestrator (corc) framework, in conjunction with the novel JupyterHub spawner named MultipleSpawner. Through this combination, we are able to dynamically orchestrate, authenticate, configure, and access interactive Jupyter Notebooks in the OCI with user defined hardware capabilities. These capabilities include settings such as the minimum amount of CPU cores, memory and GPUs the particular orchestrated resources must have. This enables teachers and students at educational institutions such as UCPH to gain easy access to the required capabilities for a particular course. In addition, we lay out how this groundwork, will enable us to establish a Grid of Clouds between multiple trusted institutions. This enables the exchange of surplus computational resources that could be employed across their organisational boundaries.

The article "Methodology of formation of modeling skills based on a constructive approach (on the example of GeoGebra)" [224] by Marina G. Drushlyak (figure 27), Olena V. Semenikhina, Volodymyr V. Proshkin, Serhii Ya. Kharchenko and Tetyana D. Lukashova highlights further research by the authors, begun in [225, 226, 227, 228, 229, 230, 231]. Author's methodology of forming modeling skills involves 4 steps: Step 1 – the teacher step by step constructs the curve by means of cloud based service GeoGebra; Step 2 – the teacher offers a description-definition of the curve and provides a ready-made algorithm by which students model the curve independently in GeoGebra; Step 3 – the teacher offers an algorithm for constructing a curve model, and students need to characterize the properties of the curve or give its definition based on the results, Step 4 – students are offered definitions of curves that they have to model in

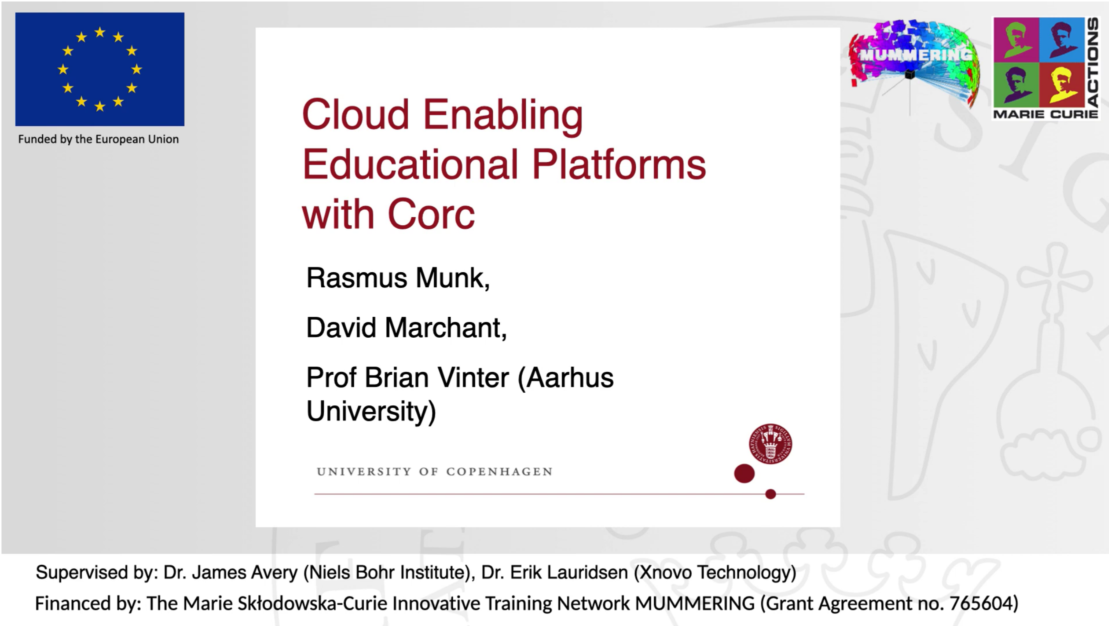

Figure 26: Presentation of paper [223].

GeoGebra). An example of realization of the author's methodology is given, the pedagogical experiment on proof of its effectiveness is described.

2.7. Session 7: Educational Data Mining and Social Analytics in Education

The article "The learning process simulation based on differential equations of fractional orders" [232] by Oleksii P. Chornyi, Larysa V. Herasymenko and Victor V. Busher (figure 28) is an integrated study conducted to develop a learning model which would make it possible to identify the students' changes of knowledge, abilities and skills acquisition over time as well as the formation of special features of their individual background. Authors have justified the application of the cybernetic model based on fractional equations for the description and evaluation of the student's learning process. Learning is dealt as a transformation of young people's knowledge, abilities and skills into a complex background, which envisages its implementation in the future professional activity. The advantage of the suggested model is better approximation characteristics which allow the consideration of a wide range of factors affecting the learning process including the youth's neurodynamic and psychological nature. The research has employed both mathematical modeling methods and psychodiagnostic techniques (surveys, questionnaires). As a result of the findings, students who assimilate the content of teaching information and form personal experience in different ways have compiled different groups; the learning curve constructed on the basis of the heterogeneous differential equation of second order with integer powers has been compared with the set of models with equations of fractional order of aperiodic and fractional power components. The prospect of the issue to explore is the improvement of the suggested model considering special characteristics of

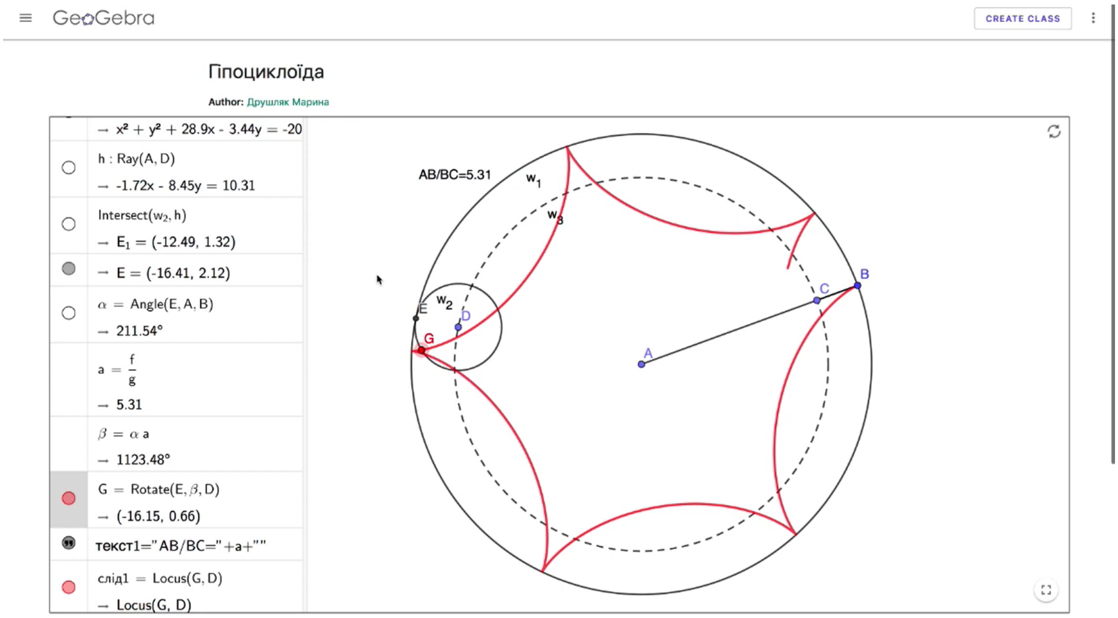

Figure 27: Presentation of paper [224].

cognitive processes aimed at the formation of an individual path of the student's learning.

author=, title=,

The article "Cloud technologies and learning analytics: web application for PISA results analysis and visualization" [233] by Mariia S. Mazorchuk (figure 29), Tetyana S. Vakulenko, Anna O. Bychko, Olena H. Kuzminska and Oleksandr V. Prokhorov analyzes the ways to apply Learning Analytics, Cloud Technologies, and Big Data in the field of education on the international level. This paper provides examples of international analytical researches and cloud technologies used to process the results of those researches. It considers the PISA research methodology and related tools, including the IDB Analyzer application, free R intsvy environment for processing statistical data, and cloud-based web application PISA Data Explorer. The paper justifies the necessity of creating a stand-alone web application that supports Ukrainian localization and provides Ukrainian researchers with rapid access to well-structured PISA data. In particular, such an application should provide for data across the factorial features and indicators applied at the country level and demonstrate the Ukrainian indicators compared to the other countries' results. This paper includes a description of the application core functionalities, architecture, and technologies used for development. The proposed solution leverages the shiny package available with R environment that allows implementing both the UI and server sides of the application. The technical implementation is a proven solution that allows for simplifying the access to PISA data for Ukrainian researchers and helping them utilize the calculation results on the key features without having to apply tools for processing statistical data. This article highlights further research by the authors, begun in [234, 235, 236].

In order for the learning process to always retain personal value for the learner, it is necessary that his or her motivation be maintained through an awareness of his or her purpose and goals.

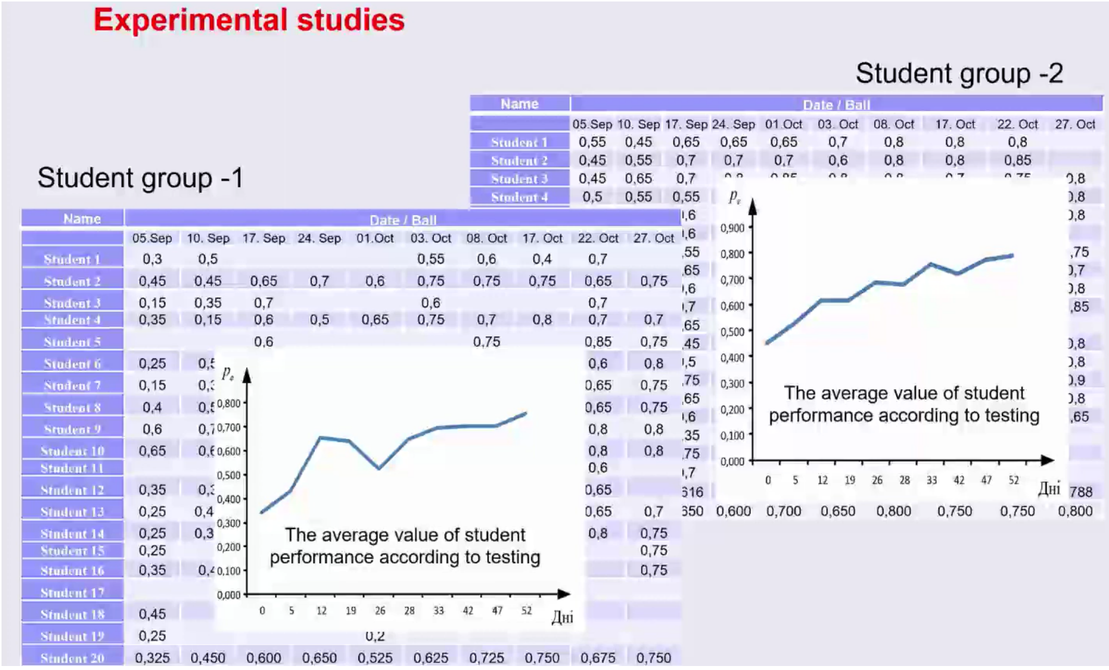

Figure 28: Presentation of paper [232].

The article “Computer simulation of processes that influence adolescent learning motivation” [237] by Larysa O. Kondratenko, Hanna T. Samoylenko, Arnold E. Kiv, Anna V. Selivanova (figure 30), Oleg I. Pursky, Tetyana O. Filimonova and Iryna O. Buchatska presents a local model (at the individual object level) of enhancing external motivation, which give to determine students’ efforts to get rewards. The concept of this model based on describing the behavior of agents (in our case students). The characteristics of the phenomenon in the motivation of learning at different stages of adolescent development are analyzed. The problem of computer modeling of educational processes with the help of agent modeling on the example of studying student motivation is considered. Internal and external factors that may strengthen or weaken the adolescent’s motivation to study have been studied. The expediency of using information technologies of agent modeling to study the dynamics of strengthening or weakening student motivation is substantiated. Using the AnyLogic Cloud computing environment the change of dynamics of strengthening of motivation of teenagers on an example of model of strengthening of external motivation is defined. This article highlights further research by the authors, begun in [238, 239, 240, 241].

The article “Simulation of intellectual system for evaluation of multilevel test tasks on the basis of fuzzy logic” [242] by Ivan M. Tsidylo (figure 31) and Serhiy O. Semerikov and Tetiana I. Gargula and Hanna V. Solonetska and Yaroslav P. Zamora and Andrey V. Pikilnyak highlights further research by the authors, begun in [243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268]. This article describes the stages of modeling an intelligent system for evaluating multilevel test tasks based on fuzzy logic in the MATLAB application package, namely the Fuzzy Logic Toolbox. The analysis of

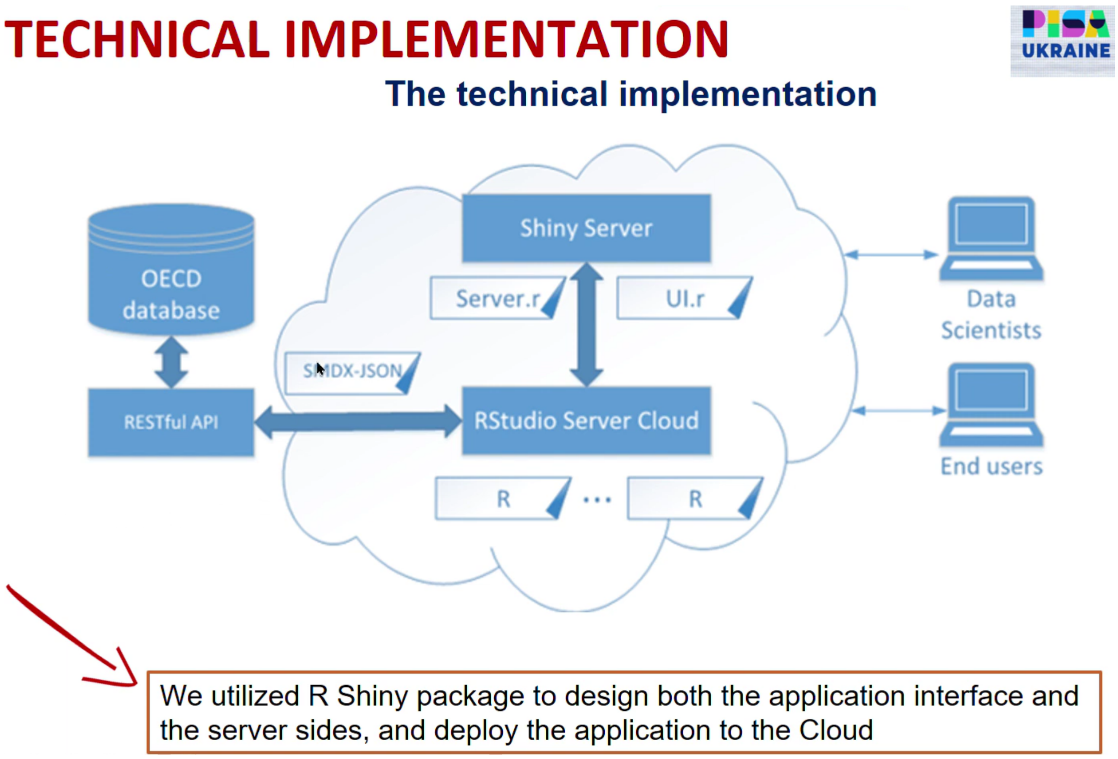

Figure 29: Presentation of paper [233].

existing approaches to fuzzy assessment of test methods, their advantages and disadvantages is given. The considered methods for assessing students are presented in the general case by two methods: using fuzzy sets and corresponding membership functions; fuzzy estimation method and generalized fuzzy estimation method. In the present work, the Sugeno production model is used as the closest to the natural language. This closeness allows for closer interaction with a subject area expert and build well-understood, easily interpreted inference systems. The structure of a fuzzy system, functions and mechanisms of model building are described. The system is presented in the form of a block diagram of fuzzy logical nodes and consists of four input variables, corresponding to the levels of knowledge assimilation and one initial one. The surface of the response of a fuzzy system reflects the dependence of the final grade on the level of difficulty of the task and the degree of correctness of the task. The structure and functions of the fuzzy system are indicated. The modeled in this way intelligent system for assessing multilevel test tasks based on fuzzy logic makes it possible to take into account the fuzzy characteristics of the test: the level of difficulty of the task, which can be assessed as “easy”, “average", “above average”, “difficult”; the degree of correctness of the task, which can be assessed as “correct”, “partially correct”, “rather correct”, “incorrect”; time allotted for the execution of a test task or test, which can be assessed as “short”, “medium”, “long”, “very long”; the percentage of correctly completed tasks, which can be assessed as “small”, “medium”, “large”, “very large”; the final mark for the test, which can be assessed as “poor”, “satisfactory”, “good”, “excellent”, which

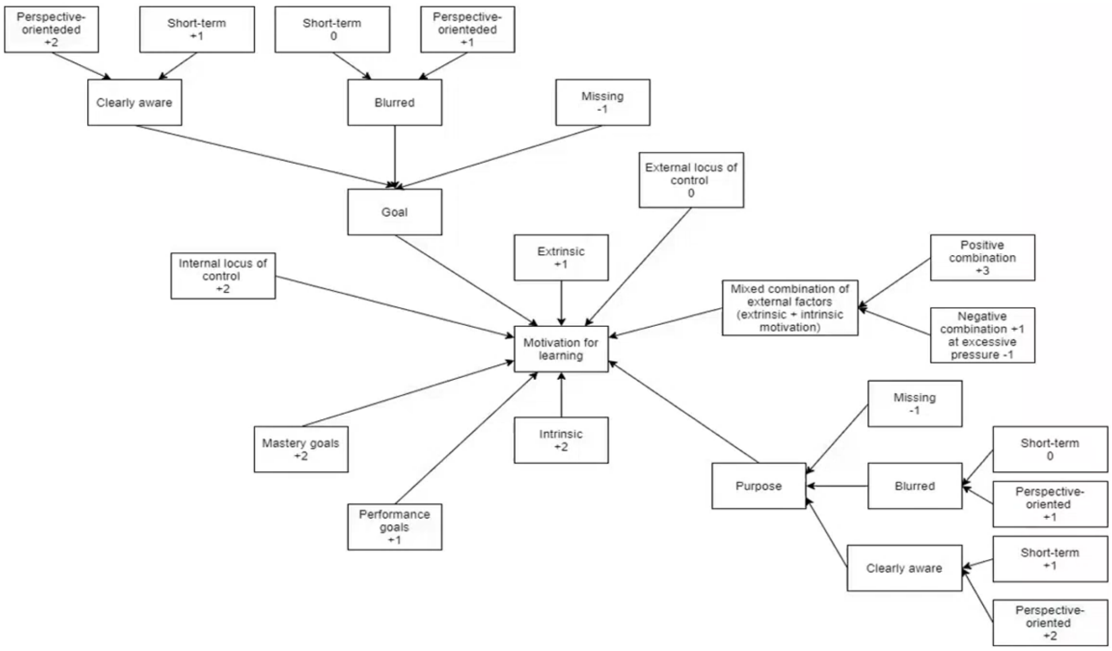

Figure 30: Presentation of paper [237].

are included in the assessment. This approach ensures the maximum consideration of answers to questions of all levels of complexity by formulating a base of inference rules and selection of weighting coefficients when deriving the final estimate. The robustness of the system is achieved by using Gaussian membership functions. The testing of the controller on the test sample brings the functional suitability of the developed model.

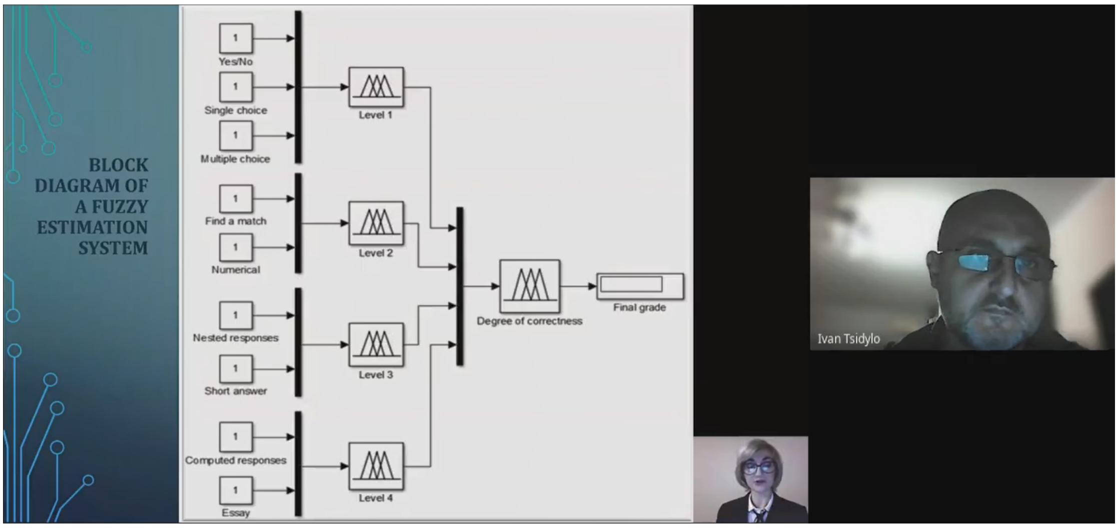

Figure 31: Presentation of paper [242].

The article “Peculiarities of cloud computing use in the process of the first-year students’ adaptive potential development” [269] by Hanna B. Varina (figure 32), Viacheslav V. Osadchyi, Kateryna P. Osadcha, Svetlana V. Shevchenko and Svitlana H. Lytvynova highlights further research by the authors, begun in [270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281]. Technologies based on cloud computing is one of the demanded and actively developing areas of the modern information world. Cloud computing refers to an innovative technology that allows you to combine IT resources of various hardware platforms into a single whole and provide the user with access to them via a local network or the global Internet. Cloud services from various providers offer users access to their resources via the Internet via free or shareware cloud applications, the hardware and software requirements of which do not imply that the user has high-performance and resource-consuming computers. Cloud technologies represent a new way of organizing the educational process and offers an alternative to traditional methods of organizing the educational process, creates an opportunity for personal learning, collective teaching, interactive classes, and the organization of psychological support. The scientific article is devoted to the problem of integrating cloud technologies not only in the process of training highly qualified specialists, but also in the formation of professionally important personality traits. The article describes the experience of introducing cloud technologies into the process of forming the adaptive potential of students in conditions of social constraints caused by the COVID-19 pandemic.

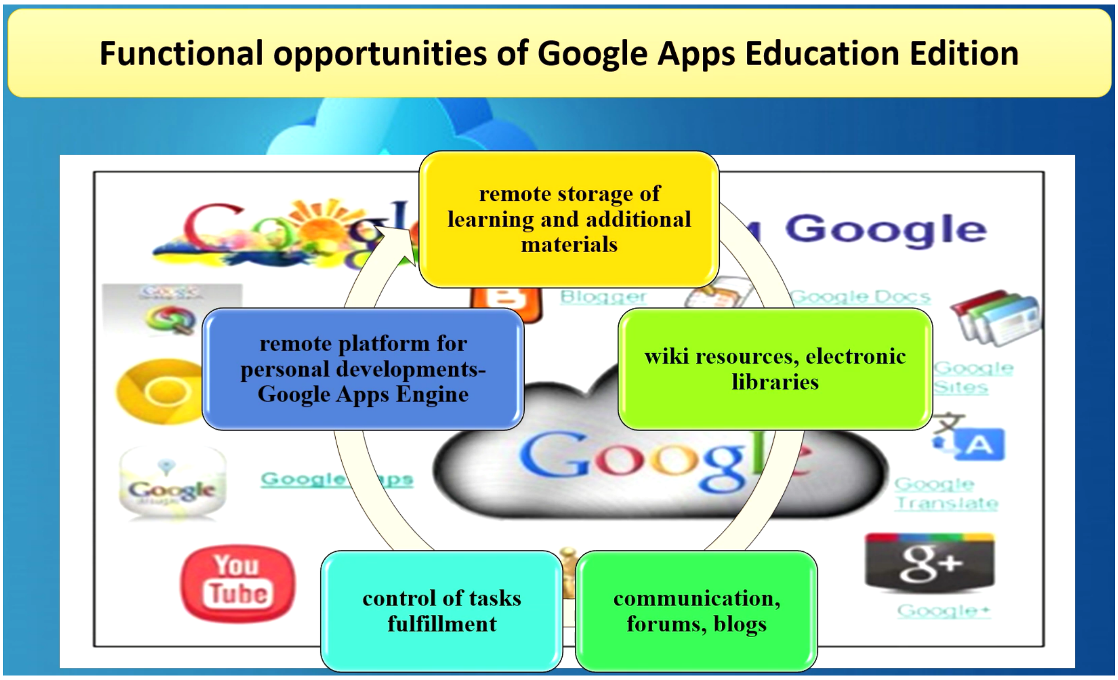

Figure 32: Presentation of paper [269].

3. Conclusion

8th Workshop on Cloud Technologies in Education (CTE 2020) was organized by Kryvyi Rih National University (with support of the rector Mykola I. Stupnik) in collaboration with Kryvyi Rih State Pedagogical University (with support of the rector Yaroslav V. Shramko), Institute of Information Technologies and Learning Tools of the NAES of Ukraine (with support of the director Valeriy Yu. Bykov) and University of Educational Management (with support of the vice-rector for research and digitalization Oleg M. Spirin).

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Comparative analysis of online dictionaries in the context of the digital transformation of education

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Abstract
The article is devoted to a comparative analysis of popular online dictionaries and an overview of the main tools of these resources to study a language. The use of dictionaries in learning a foreign language is an important step to understanding the language. The effectiveness of this process increases with the use of online dictionaries, which have a lot of tools for improving the educational process. Based on the Alexa Internet resource it was found the most popular online dictionaries: Cambridge Dictionary, Wordreference, Merriam–Webster, Wiktionary, TheFreeDictionary, Dictionary.com, Glosbe, Collins Dictionary, Longman Dictionary, Oxford Dictionary. As a result of the deep analysis of these online dictionaries, we found out they have the next standard functions like the word explanations, transcription, audio pronounce, semantic connections, and examples of use. In propose dictionaries, we also found out the additional tools of learning foreign languages (mostly English) that can be effective. In general, we described sixteen functions of the online platforms for learning that can be useful in learning a foreign language. We have compiled a comparison table based on the next functions: machine translation, multilingualism, a video of pronunciation, an image of a word, discussion, collaborative edit, the rank of words, hints, learning tools, thesaurus, paid services, sharing content, hyperlinks in a definition, registration, lists of words, mobile version, etc. Based on the additional tools of online dictionaries we created a diagram that shows the functionality of analyzed platforms.

Keywords
online dictionary, electronic dictionary, English, education, tools of English learning

1. Introduction

The problem of digitalization of education is a topical theme for discussions [1]. The solution to these problems will contribute to the creation of conditions for the update of forms, tools, systems, technologies, and methods of teaching disciplines and the sharing of knowledge. Digital transformation as a global trend of the modern world contributes to the integration of Ukrainian education into the European Education Area [2, 3, 4, 5]. The change of paper-based data into electronic-based is an indisputable example of the digital transformation in education that is still in the process.

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In general, use of dictionaries for learning and interpretation of terms is relevant in the study of foreign languages. When using a dictionary, the students can expand their vocabulary, to find the meaning of a word, to build an associative series of terms, to improve the pronunciation, to avoid monotony in learning English.

The digitalization of education has created the conditions for the transformation of paper dictionaries into electronic-based [6] and the development of electronic tools for teaching a foreign language in general [7, 8, 9, 10, 11, 12]. When digital technologies began to develop the previously existing monopoly on knowledge has disappeared. Now everyone can use the knowledge and create it. This provides the main trends in education – free access to education and using open resources [13, 14].

In many developed countries, paper dictionaries were replaced by online counterparts that become an integral element of the educational process. To increase its competitiveness publish houses like Longman, Cambridge, Chambers, Oxford made electronic versions of many printed publications and develop online services for English education. Nowadays these platforms are sources of learning information and include a lot of educational functions. Of course, online dictionaries more functionality than paper-based. They can have functions like to search, listen to the pronunciation, view examples including multimedia, get professional advice, make your own word list, etc.

2. Related works

An analysis of recent research and publications indicate that the problem of online dictionaries in the context of the digital transformation of education is attracting the attention of a lot of researchers. Ranka Stanković, Cvetana Krstev, Biljana Lazić and Mihailo Škorić have considered transformation electronic dictionaries - from file system to based lexical database [15]; Rastislav Metruk researched the use of electronic dictionaries for pronunciation practice by university students [16]; Anna Dziemianko investigated on the usefulness of paper and electronic dictionaries [17]; Sameer Naser Olimat found out the positive and negative impact of technology and information revolution on compiling the dictionary [18]; Robert Lew researched and classified the online dictionaries of English [19]; Amy Chi gave a review of Longman Dictionary of Contemporary English (6th edition) and found out whether the dictionary satisfies the needs and expectations of the users [20]. Christian M. Meyer and Iryna Gurevych explored the possibilities of collaborative lexicography by using Wiktionary [21]; Dikshit Kumar, Agam Kumar, Man Singh, Archana Patel and Sarika Jain clarified the difference between all existing online dictionaries and thesauruses by using an effective parameter [22]; Rezaei Mojtaba and Davoudi Mohammad found out the influence of electronic dictionaries on vocabulary knowledge extension [23]; Dmytro Pryimak found out the main mistakes of online dictionaries in the context of incomplete information, providing incorrect translations, and using incorrect lexical and grammatical constructions [24]; Ilona Kostikova highlighted the theoretical underpinnings of the efficiency of using electronic dictionaries at English lessons [25].

The above-mentioned authors have made a significant contribution to the theory and practice of using online dictionaries to learn a foreign language. The works mention individual dictionary resources, describe their functions, but we do not find a comparative analysis of online dictionaries. Thus, the main purpose of our research is a comparative analysis of online dictionaries and education tools for learning a foreign (mostly English) language on these platforms.

3. Analysis of functionalities online platforms of dictionaries

In our research, we use the term is "`online dictionary`", because the systems presented in this article are positioned themselves as dictionaries. In addition, the main function of these systems is the translation of words. However, analysis of their functionality indicates that they are not just online dictionaries, but platforms in which various tools for learning a foreign language are implemented. So, we use also term is "`online platform`".

The key condition for the digitalization of education is a demand for education digital technologies and their use by users. We found out the demand for online dictionaries by users and selected 10 ranking online dictionaries. The measuring was by using the Alexa Internet resource (table 1). The rank is calculated using a combination of average daily visitors to this site and pageviews on this site over the past 3 months. The site with the highest combination of visitors and pageviews is ranked number 1. This table shows the Alexa Rank trend for this site over a trailing 90 days. The most popular are the Cambridge Dictionary, Wordreference, Merriam–Webster, Wiktionary, TheFreeDictionary.com, etc.

Table 1
The estimate of the site's popularity (Alexa Rank at 11.10.2020)

Name	Address	Rank
Cambridge Dictionary	dictionary.cambridge.org	350
Wordreference	wordreference.com	518
Merriam–Webster	www.merriam–webster.com	605
Wiktionary	www.wiktionary.org	707
TheFreeDictionary.com	www.thefreedictionary.com	771
Dictionary.com	www.dictionary.com	791
Collins Dictionary	www.collinsdictionary.com	2313
Glosbe	glosbe.com	2606
Longman Dictionary	www.ldoceonline.com	3173
Oxford Learner's Dictionary	www.oxfordlearnersdictionaries.com	3908

To detect the features of the use of online dictionaries in the study of a foreign language, we made a comparative analysis of their education functions (table 2).

We didn't analyze positions like the definition of a word, the transcription, audio pronounce of the word, the example of semantic connections, and example of use, as they are standard functions and implemented on all online translation platforms. Let's review the functions of the online platforms for learning that can be useful in learning a foreign language.

Translator. Provides for the presence on the site of a machine translation system (like Google's free service for translate). This system allows translating words instantly, phrases of a certain volume. For example, the Cambridge Dictionary machine translation system translates up to 160 characters and the Collins Dictionary up to 5.000 characters. In the Collins Dictionary,

Table 2
The functions of the online platforms for learning a foreign language (1 Cambridge; 2 Wordreference; 3 Merriam–Webster; 4 Wiktionary; 5 TheFreeDictionary; 6 Dictionary.com; 7 Glosbe; 8 Collins; 9 Longman; 10 Oxford).

Functions	1	2	3	4	5	6	7	8	9	10
Translator	+	−	−	−	−	−	−	+	−	−
Multilingual support	+	+	−	+	+	−	+	+	+	−
Video of pronunciation	−	−	−	−	−	−	−	+	−	−
Image of a word	+−	−	+	+	+	−	−	−	−	+
Discussion	−	+	−	+	+	−	−	−	−	−
Collaborative edit	−	−	−	+	−	−	+	−	−	−
Rank of words	−	−	−	−	−	−	−	+	−	+
Hints	+	+	+	+	+	+	−	+	+	+
Learning tools	+	−	+	−	+	+	−	+	+	+
Thesaurus	+	−	+	+	+	+	−	+	−	−
Paid services	−	−	+−	−	+−	−	−	−	−	+
Content Sharing	+	−	+	−	+	−	−	+	+	−
Hyperlinks	+−	+	−	+−	+	+−	−	+−	+−	−
Registration	+	+−	+	+	+	+	+	+	+	+
Lists of words	+	−	+	−	+	−	−	−	−	+−
Mobile version	+	+	+	+	+	+	+	+	+	+
Rank of Mobile version	4.2	4.5	4.5	3.1	4.8	4.6	4.4	4.3	4.5	4.3

the translator also has the function of recording a voice with a microphone. It is possible to translate what the user says. Both online platforms have the ability to automatically detect a language. As for translation languages, the Collins Dictionary provides translation of a larger number of languages, including Ukrainian, while in the Cambridge Dictionary this number is much smaller. Also, the Collins Dictionary transforms all words into hyperlinks, which give the possibility to follow each word and see translate it.

Multilingual support. Only three online dictionaries don't have multilingual function. These sites work exclusively for English-speaking audiences and are used to understand and learn English. But the sites, who have this function implemented it in different ways. For example, in the Cambridge Dictionary, this function is used only to translate a word, not to explain it. For example, if the system searches the word "`car`" from English to Polish, then the result is only a translation of this word into Polish. The explanation and grammar will be displayed in English.

In the Collins Dictionary translated word is accompanied by translate in other languages. There is also an example of pronunciation in the selected language and English. It is possible to listen to the searched word in different languages (figure 1).

Video of pronunciation. This function allows users to hear and to see the pronunciation of the searched word. Video pronunciation is available only in the Collins Dictionary. Video pronunciation is a video that shows how to pronounce some words. This feature is helpful because it is the best way to learn the right pronunciation [26].

Image of a word. The learning effect of using a picture of a word can be shown with the

Figure 1: Example of multilingual function in the Collins Dictionary.

expression "`A picture is worth a thousand words`" [27]. The illustrate of meanings is the best way to reach the result by associative. It allows you to create an associative lines and remember a word better. This creates equal opportunities for students with different perceptions of information. Some of the students work with visual information better, others with sound one, and combining these forms can improve the learning effect. Not all online dictionary platforms have this function, and some of them have this feature only when searching for the word without translating into another language. That is when the multilingual function is not used.

Discussion. This function allows users to discuss different topics. In particular, Wordreference and TheFreeDictionary have a public forum that allows users to consult about the possible translation and use of the words, its correct grammatical part, and speech pronunciation. To take part in the forum user needs to have an account.

This function is also implemented on the Wiktionary site, but it works by a non-traditional way. It is possible to discuss each page of Wiktionary, including the found words (figure 2). You don't need to create a new topic to start discussions. The discussion page is being edited and supplemented with a new comment. Using this function requires knowledge of the markup language Wiki.

Collaborative edit. Provides the ability to free edit the content of the dictionary, add new terms, change, and improve existing ones. The best example of a collaboratively built resource is Wikipedia, which has positioned as the largest encyclopedia on the world wide web. The content of collaboratively created resources is repeatedly changed before a consensus

Figure 2: Example of discussion on the Wiktionary site.

is achieved. Having the history of edit we can research the evolution of a definition. It's impossible for expert-built dictionaries because there aren't any edit history nor the discussion. Now collaboratively constructed language resources are rivaling expert-built lexicons. The collaborative construction process of these resources is driven by what is called the "Wisdom of Crowds" phenomenon or collective intelligence [21]. This is one of the main ideas of using Web 2.0 and cloud technologies [28].

Only Wikitionary and The Glosby dictionary have this function. Wiktionary is a multilingual collaborative online dictionary that is edited by users and volunteers from all world. The name "Wiktionary" is a combination of two terms "wiki" and "dictionary". Now the dictionary has about 6.432.000 articles. In the Glosby dictionary, the user can add their own translation or example of the word, edit the description of this concept.

The rank of words. This function involves assigning a word to a specific group. The word can be ranked by the place, value, complexity, importance, authority, level, the degree.

For example, the Longman Dictionary marks all the words by special symbols: W1, W2, and W3 for words that are in the top 1000, 2000, and 3000 most frequent words in written English, and S1, S2, and S3 for the top 1000, 2000 and 3000 most frequent words in spoken English. Nowadays, many learner's dictionaries include information about the most frequent words in English, but Longman dictionaries are the only ones to highlight the differences between spoken and written frequency [20].

The Oxford Dictionary analyzes words according to the Common European Framework of Reference. CEFR describes language ability on a six-point scale, from A1 for beginners, up to C2 for those who have mastered a language.

The Collins Dictionary analyzes words by the frequency of use. That is indicated by the dark red or light red circles. For example, if a word has four dark red circles the rank is named "very common".

Hints. It is an information navigational tool. It provides for the possibility to use the search method based on hints. When the user typing a word, the hint showing him different variants of a word. For example, if a user typed the word "`car`", the hint proposes variants like "`car accident`", "`alarm`", "`car boot`", etc. Hints save time because during the search user doesn't need to remember the correct writing of the word. The system will offer similar words to the first letters.

Learning tools. Some resources position themselves not only as online dictionaries but also as resources for learning English. Such dictionaries have grammar exercises, quizzes education resources, videos, blogs, courses for studying English, etc.

For example, Cambridge and Collins's dictionaries have a separate section on grammar. Users can get clear grammar explanations with hundreds of examples of how grammar is used in natural written and spoken English.

Longman's dictionary has exercises in vocabulary, grammar, learning synonyms, idioms for users of intermediate and high levels. There are rubrics "`Word of the day`", "`Hot topics`", "`Mail`", "`Pictures of the day`" etc. It has a lot of quizzes of a different type. There are the next types of quizzes: collocations, synonyms, phrases, phrasal verbs, prepositions.

TheFreeDictionary.com proposes graphic quizzes. One of the interesting games to activate the passive vocabulary is "`Hangman`" (figure 3). The task is simple: you need to guess the word by the number of letters and type it in the field. If the word is not guessed, the dictionary still displays the correct answer and a link by which learners can see the full dictionary article for that word.

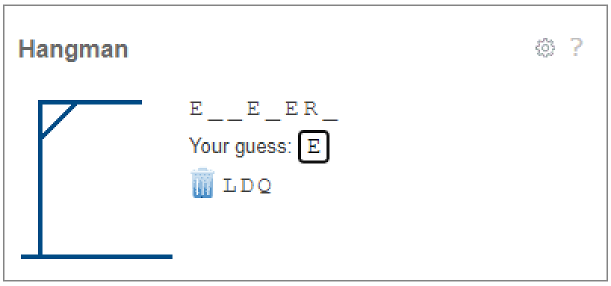

Figure 3: The quizzes Hangman on TheFreeDictionary.com.

Thesaurus. Thesaurus is a service of reference work for finding synonyms and sometimes antonyms of words. For example, Dictionary.com uses the structural principle of the thesaurus, which finds its lexicographic reflection at the macrostructural level. Words that belong to certain areas of knowledge are located on a thematic basis and have examples of their correct use in the text. For each user-defined word, the system generates lexicographic materials and presents a sample of more than 15 dictionaries.

The subject of the definition in the online dictionary is a word that includes a selection of synonyms, idioms, antonyms, examples of use, grammatical relations to another word (figure 4). The origin, development, and primary meaning of the lexical unit are also explained in the dictionary.

Paid services. These services are used as an opportunity to market and sell extra content, such as paper books, training courses, content that might be richer lexicographic data, and language testing materials, etc. All dictionaries would normally be free for use. It is difficult to demarcate clearly between free content and paid, as revenue to the publisher can take different forms. For example, personal pay-per-view or subscription-based access. Or online access to

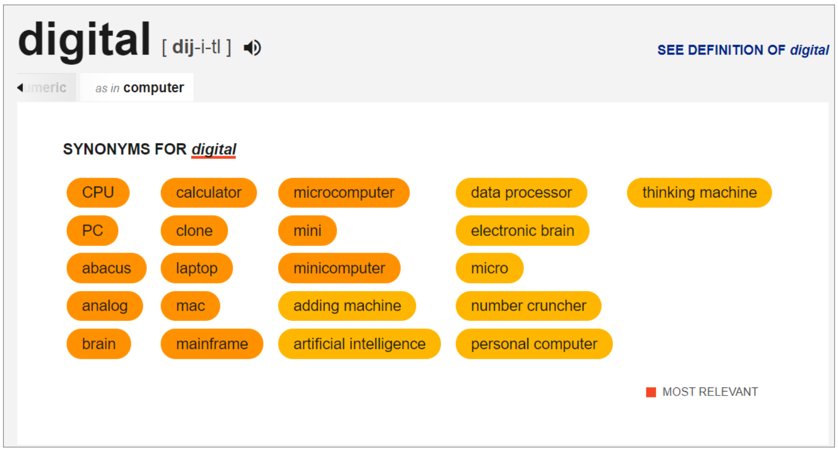

Figure 4: Example of synonyms of the word “digital” on Dictionary.com.

paid content of dictionary is offered only for buyers of paper editions [19].

Paid services are available in the Oxford Dictionary. The dictionary has premium tools to develop pronunciation and speaking skills, to plan, write, and review your work. For teachers: videos, lesson plans, and activities for use in class.

Some publishers need advertisements to cover the costs of producing and maintaining online dictionary content. This is a rather popular model of using resources at the moment. TheFree-Dictionary.com and Merriam–Webster doesn’t have a paid content, but uses advertising. For example, you can make monthly payments of 2.99 dollars or 19.99 dollars per year to disable advertising on TheFreeDictionary.com.

Content sharing. This is a key function to use the knowledge on the Internet. Today, almost every active student uses social networks. Therefore, a tool for content sharing is a great opportunity to share knowledge. This tool can be used by a teacher for homework. For example, the teacher shares some words in a special group of social networks. The homework of students is an analysis of these resources. Table 2 shows that not all dictionary systems have the function of sharing information on social networks.

Hyperlinks. A hyperlink is an ability for a user quickly to jump to an unknown word without spending time searching for it. Some dictionaries don’t have a hyperlink for each word at the definition. These resources have a mark with plus and minus (table 2), which indicates that not all words of the content have hyperlinks. There are also cases where all words have hyperlinks except prepositions and articles.

Registration. Almost all dictionaries have a registration function except for Wordreference, which allows you to register only on the forum. Most sites offer more features after registration. After registration, there are adding words to list, editing content, adding the user’s own terms, participating in quizzes with fixing the result, creating interactive tools (such as flashcards with words), etc. For example, TheFreeDictionary.com gives users the opportunity to set their own learning goals, compete with other participants, receive awards for best results, etc.

Lists of words. The function of adding and forming word lists allows the user to return to the studied material, repeat it, and train. Only 3 online dictionaries have this function. In the case of the Oxford Learner's Dictionaries, this feature is only available after activating a premium account.

Mobile version. The mobile version is the best way to attract more users to use the online platform. In addition, it provides an opportunity to improve a platform with a focus on user feedback and their needs. Most users, especially young people, use mobile phones to get quick access to resources anywhere and anytime. Table 2 shows the availability of the mobile version and the rating of an app among users. Some dictionaries are available in the free version, but others offer to buy the full-text dictionary.

We have also highlighted the function that is specific to an individual platform.

The function of finding similar texts. This function based on content from the Internet and available in the dictionary of Glosbe. The search result can be sorted depending on the expediency of lexical information from different source databases and dictionaries. This feature of the online resource is the main advantage for users who are not native English speakers and are looking for user services to create their own dictionary. From a technical point of view, by entering a certain word or phrase, you can get an example of the use of a word in the native language and a foreign version of its use.

Taking into account table 2, we created a diagram that clearly shows the functionality of the platforms (figure 5).

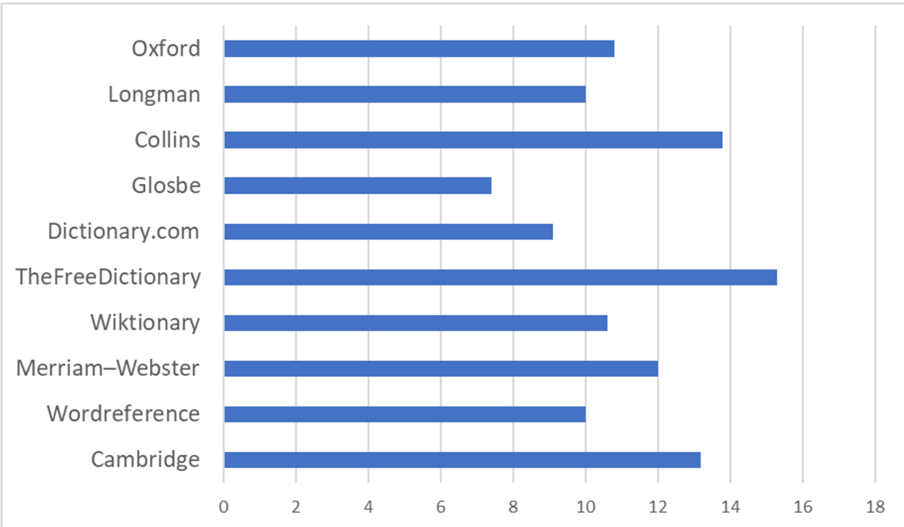

Figure 5: Diagram of the functionality of online platforms.

For the calculation, we evaluated each function 1 point (+). If the function is partially implemented (±), we evaluated it 0.5 points. We also did not take into our calculation the indicator of "`paid services`", as this function is not available to everyone. And we included a mobile version rating to take into account users' opinions.

We see that the most functional was found out the platform TheFreeDictionary. It has not only a wide range of educational functions but also the highest rating among users.

The lowest rating was found out in the dictionary of Glosbe, it has only 3 educational functions

– multilingual support, co-editing, and registration. According to table 1, you can see also that the rating of this platform is low.

4. Conclusions

One of the steps towards the digital transformation of education is to provide students with digital educational content and to provision digital interaction and cooperation between students and teachers. Platforms of online dictionaries are a means of organizing digital activities and student interaction. They provide both independent activities of students in the educational environment and collaborative activities by tools of online dictionaries.

In this paper, we have analyzed the 10 most popular online dictionaries. This analysis shows that each platform has traditional and additional tools that can implement certain educational functions in the study of a foreign language.

Nowadays, online dictionaries can not only help to improve the vocabulary but also increase the level of grammar, practice pronunciation, develop writing skills, and more. Thanks to the learning tools function, which most platforms have, students can implement the next types of English activities: listening, reading, writing.

Particularly useful for writing training is participation in co-writing articles (collaborative edit tools) and discussion topics (discussion tools).

The only exception of these activities is speech, which cannot be formed in an artificial environment like an online dictionary. This activity involves the presence of the person and the relevant language situation.

This article showed that online dictionaries differ in many aspects: purpose, tools, technological environment, levels of the structuring of interfaces, forms of information presentation, opportunities for registered users, etc. The analysis of the functions of online dictionaries makes it possible to track the combination of information and lexicography technologies in online interpretation. It promotes better orientation in modern English-language discourse, illustrates and explains the evolution of society, shows its linguistic realities in a particular time period. Described dictionaries can be both an additional and the main source of linguistic information offered during the study of foreign languages.

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Comparison of ontology with non-ontology tools for educational research

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Abstract
Providing complex digital support for scientific research is an urgent problem that requires the creation of useful tools. Cognitive IT-platform Polyhedron has used to collect both existing informational ontology-based tools, and specially designed to complement a full-stack of instruments for digital support for scientific research. Ontological tools have generated using the Polyhedron converter using data from Google sheets. Tools "Search systems", "Hypothesis test system", "Centre for collective use", "The selection of methods", "The selection of research equipment", "Sources recommended by Ministry of Education and Science of Ukraine", "Scopus sources", "The promising developments of The National Academy of Sciences of Ukraine" were created and structured in the centralized ontology. A comparison of each tool to existing classic web-based analogue provided and described.

Keywords
cognitive IT-platform Polyhedron, ontology, ontology tool, system, scientific method, scientific tool

1. Introduction

Nowadays, to increase the convenience and efficiency of data processing, the active digital transformation of all of the areas of human activity [1, 2, 3, 4, 5, 6] is underway.

The scientific method is a way that researchers used for many years. However, until now, there are no approaches that can support the research process in educational research. For example, in Crus et al. [7] work, the research process considered as only three cyclical stages: Composition, Execution, and Analysis. But in this article, the term "scientific method" has used

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according to one of the most popular versions. The scientific method can be presented by the set of stages [8] that are shown as a simple algorithmic scheme in figure 1.

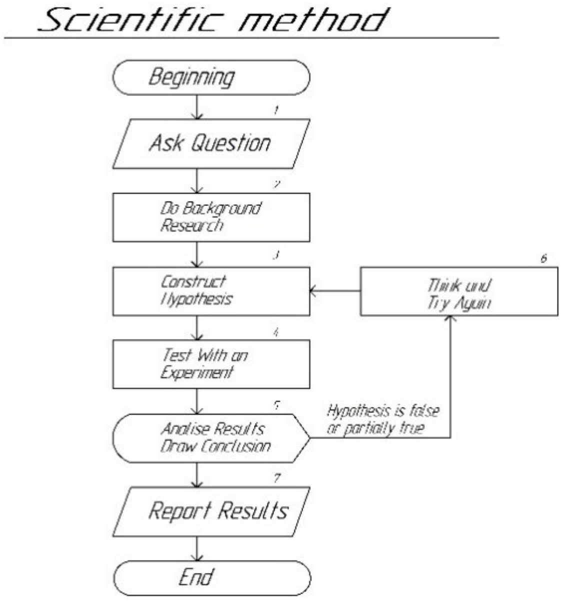


Figure 1: Algorithmic scheme stages of the scientific method.

The scientific method is often used in the educational process. Quite often, teachers require to research to complete an essay. There are various school competitions of scientific works such as the competition of scientific articles of the Junior Academy of Sciences of Ukraine, international competitions, those provided by international programs and other [9].

Often it is difficult for students and pupils to perform a scientific method and therefore, to simplify it, several authors suggested the use of ontological systems [10, 7, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21]. But they did not use on all stages of scientific methods used during educational researches.

It is possible to use a digital ontological-based approach to improve structuration, interactivity. Smith [20] believed in the effect that the authoring and maintenance and evaluation of scientific ontologies is an incremental, empirical, cumulative, and collaborative (i.e., precisely, scientific) activity that must be carried out by experts in the relevant scientific domains. Ontologies has used to sovling of practical oriented problems based on formalization of the contexts [22] and for creation of repositories [23].

In this article, an "ontological tool" is a term, that means some software or web system, that consists of nodes with specific data and provide solving of some problem during educational research. The node from which all branches go is called the parent or root. The top from which no ribs protrude is called a leaf. The other nodes are called child nodes. If there are no additional branches in the graph from the parent node, then this ontology is called simple. Also, a characteristic feature of ontologies systems is that multiple ontologies can be filled with concepts of various levels of complexity [10].

Ontologies have been using to visualize the results of the already performed experiment.

In Crus et al. [7] work, an ontological system named "Open proVenance" was developed. The root node in their ontology is the name of the experiment, from which withdraws names and surnames of specific performers and their role in the study, and the leaf node is a specific measured indicator, and its value (for example, pH 1). The system is based on the "Open proVenance" Model and the Unified Foundational Ontology. This ontological system can be useful only on the "Test with an Experiment" stage of the scientific method.

To create the structure of the all research process, an ontological system called "Elements of a common ontology of scientific experiments" (EXPO) [7] had developed. The root node in such application is the name of the research with its metadata (hypothesis, goal, conclusion etc.), from which depart factors (the child nodes) that may affect the experiment and its result. The leaf node is a specific scientific experiment, and its attributes indicate its name (a precision measurement of the mass of the top quark). EXPO based on the W3C standard ontology language OWL-DL. This ontological system can be useful only at the stage of "Test with an Experiment" and "Analyse results and Conclude" of the scientific method.

Ontology constructor MoKi [11, 12] developed for creating a structured ontology from Wikipedia articles and devoted to providing a literature review. The user can present the creation of their ontologies based on the Wiki articles he needs during the literature review. However, in any ontology created using Moki, there no root node, and all of them are looped. Nodes in Moki are a Wiki article connected to the other child node (other wiki articles). Moki is multiplatform and supports various ontological generators (Amine, Protégé, etc.).

It can be useful in the "Do Background Research" stage of educational researchers. At the same time, it is limiting by the Wikipedia database.

There are also more specific ontological systems designed for the scientific method. For example, an ontological database "Gene Ontology" [20] had developed and designed to obtain detailed information about genes. The root node in such application is called the gene classifier from which branch the filters (child nodes) used by geneticists (e.g. biological process, cellular component, molecular function, and others). The leaf node is a specific gene with its name (e.g. ABIN2-NFKB1-MAP3K8) and attributes which are keys semantic characteristics that describe the gene (e.g. Definition, Gene products, Synonyms, Ontology ID space, and others). The system based on the Open Biomedical Ontologies repository. It can be useful on the "Do Background Research" and "Analyse results and Draw conclusion" stages, but can be helpful only for the specialists in the genetic field.

All these ontological systems will be useful only at certain separate stages of scientific method such as "Do background research", "Construct Hypothesis" and "Report Results", and in most cases only for specialists in separate fields. So, none of the ontological systems previously proposed couldn't offer a universal and complex method to provide digital cloud-based support of educational researches. Also, all these systems haven't integrated. That means, all these systems cannot fully interact with each other's ontologies. Users must choose between them or feel discomfort memorizing and switching between them. The results of the comparison of ontological systems in the scientific methods have shown in table 1.

Besides, a common disadvantage of all considered systems [7, 10, 11, 13, 14, 20, 21, 12, 15, 16, 17, 18, 19] is unsuitability for use by pupils and novice researchers due to the complexity of using. For example, "Open proVenance" requires using both nodes and classes, which requires additional specific knowledge and additional time to create an ontology.

Table 1
The results of the comparison of scientific ontological systems

Name of ontology instrument	Root node	Leaf node	Was built on	Using on scientific method stages	Authors
Open proVenance Ontologyt	Name of the experiment	Measured indicator its value	Open Provenance Model and the Unified Foundational Ontology	Report the results of experiment and test the experiment	Sergio Manuel Serra Crus, Maria Luiza Machado Campos and Marta Mattoso
MoKi	There no initial node and all of them are looped	Wiki article in ontological form	Multiplatform and supports various ontological generators	Report the results and test the experiment	Alessio Bosca, Matteo Casu, Mauro Dragoni and Andi Rexha
EXPO	The name of the experiment with its metadata	A specific scientific experiment	Based on the W3C standard ontology language OWL-DL	Test with on Experiment and Analise results of experiment	Larisa N. Soldatova, Ross D. King
Gene Ontology	The gene classifier	Gene with their name	Based on the Open Biomedical Ontologies repositorys	Report the results and test the experiment	Barry Smith

So, it seems relevant to provide digital support of educational researchers provided by the scientific method using uncomplicated and understandable tools. Unlike observed systems, tools developed using IT-platform Polyhedron are simple to use, and it is possible to create all primary instruments in one environment.

This paper aims to develop the system of the most common ontology-based tools used by pupils during educational researches using the scientific method characterized by advantages compare to non-ontological-based tools. To provide it, IT-platform Polyhedron has used due to its simplicity. These functions can provide semantic web, systematization, internal and external searches [24] and transdisciplinary support.

This system is multi-agent, and internal sources can be used as agents. In such a way, IT-platform Polyhedron allows to provide of transdisciplinary and interactivity of educational research[24, 25]. In the environment of the Polyhedron platform, the construction of all chains of the process transdisciplinary integrated interaction is ensured [26].

Besides, cognitive IT-platform Polyhedron has all advantages of the ontological information representation [27, 28, 29]. The ontological interface has provided by the procedure of activation of multiple binary taxonomy relationships. It is an intelligent means of user interaction with an ontology-based information system [26].

The cognitive IT platform Polyhedron platform can provide the digitalization of the scientific method in the learning process. Also, this system can be useful for the education process in general by creating a centralized Information web-oriented educational environment [24, 30]. All proposed instruments can be used together with different modern educational and scientific methods like an augmented reality [31, 32, 33, 34], and distance learning [35, 36].

2. Materials and methods

For creating digital instruments, the sheets with data have loaded to editor4, the part of the cognitive IT platform Polyhedron. After that, the generation of the graph nodes with its characteristics have carried out. To provide information storage and exchange Google sheets were used to store data, with their further conversion into the .xls and .csv Excel sheets (see figure 2).

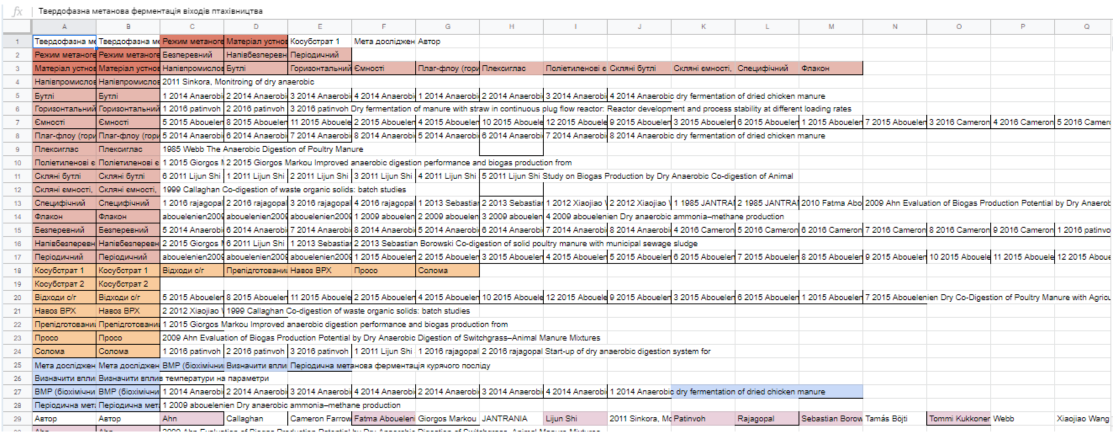


Figure 2: Google sheet with data.

The obtained documents have used to create the ontological structure .xml and to fill the ontology graphs with semantic and numeric information for ranking or filtering. Some of the instruments to the web-oriented educational environment is using artificial intellectual features of the cognitive IT platform Polyhedron to provide additional semantic characteristics.

The received documents have used to create an ontology structure (.xls) and to fill the ontology graphs of ranking and filtering. To provide it, they were downloaded in editor4, the part of the cognitive IT platform Polyhedron. After that, the graph generation and the inputting of semantic characteristics to each vertex have carried out. Ontological edges have formed using predicate equations which described in previous work [26].

For the development of some ontological tools, specific “audit” and “ranking” [37, 38, 39] instruments have used. Both of them based on “Alternative” module, which has described in previous works [40]. To use “Alternative” a module has been created nodes of the graph with semantic data grouped in semantic classes that will be ranking criteria. IT platform Polyhedron is an innovative complex of programmatic information and methodological knowledge management tools, which is using ontological management approaches to corporate information resources. Users are considered as the source for new knowledge, for transferring it in the form of their knowledge through the tool IT platform Polyhedron, which is the only integrated point of access – "the single window" – to the information and applications of the system to provide interactive interaction with users. A key benefit of this system is the context-based method of data processing and structuring based on semantic relations.

IT Platform Polyhedron allows users creating a system or graph, read, update a system or graph, delete a system or graph and update the system configurations or graph configurations. All these sections we can split into several different subsections that are named: customization, data creation, information searching, data processing, data structuration, data validation, data isolation, data visualization and data deletion. Every different user has a different role in IT Platform Polyhedron. The Expert can create graphs, delete graphs, add metadata, edit metadata. Thus, the Expert is responsible for creating term fields and filling them with data for further processing in the Polyhedron IT platform. The IT Platform Polyhedron administrator performs specialized functions – the formation of a public library of ontologies and the system administration of transdisciplinary representation. The Young researcher can only read the necessary data, for individual purpose. UML different types of users functions diagram is shown in figure 3.

2.1. Criterion of the searching systems comprising

Search systems and scientometrics bases have compared with each other and the cognitive IT platform Polyhedron search system according to the following criteria: "Content integration", "Lack of advertising", "Interoperability with scientific and a patent search", "Data security" and "Data Availability", "Indexing of educational programs".

Search systems which in response to the user's query, provides all types of data (links, graphical results, semantic characteristics) meet the criterion of "Content integration", and those of them. Search systems which characterized by the lack of advertising met the criterion of "Lack of advertising". Search systems that provide results in the form of articles and patents have considered to meet the criterion "Interoperability with scientific and a patent search". Search systems which do not find any malicious programs and viruses, meet the criterion of "Data security". Search systems which don't have no one restrictions on access to information (for example, the fee for access or a mandatory registration) meet the criterion of "Data Availability". Search systems that can use data directly from educational programs and integrated with them has been evaluated as meet the criterion "Indexing of educational programs".

2.2. Criterion of the research tool systems comprising

Proposed ontology-information solutions have compared with their web-oriented analogue criteria (except search systems) according to the following criteria: "Customization potential", "Multifunctionality of information processing", "Data structuration", "Availability of adaptive interface", "Data validation", "Multi-user support", "Data isolation".

"Customization potential" criterion has used to evaluate possibility of the simply interaction with the system to provide adaptive analysis. Criterion "Multifunctionality of information processing" to evaluate possibility of the systems to provide data processing using few algorithms in same time. If all information is structured, easy to read, and perceived by the user the systems

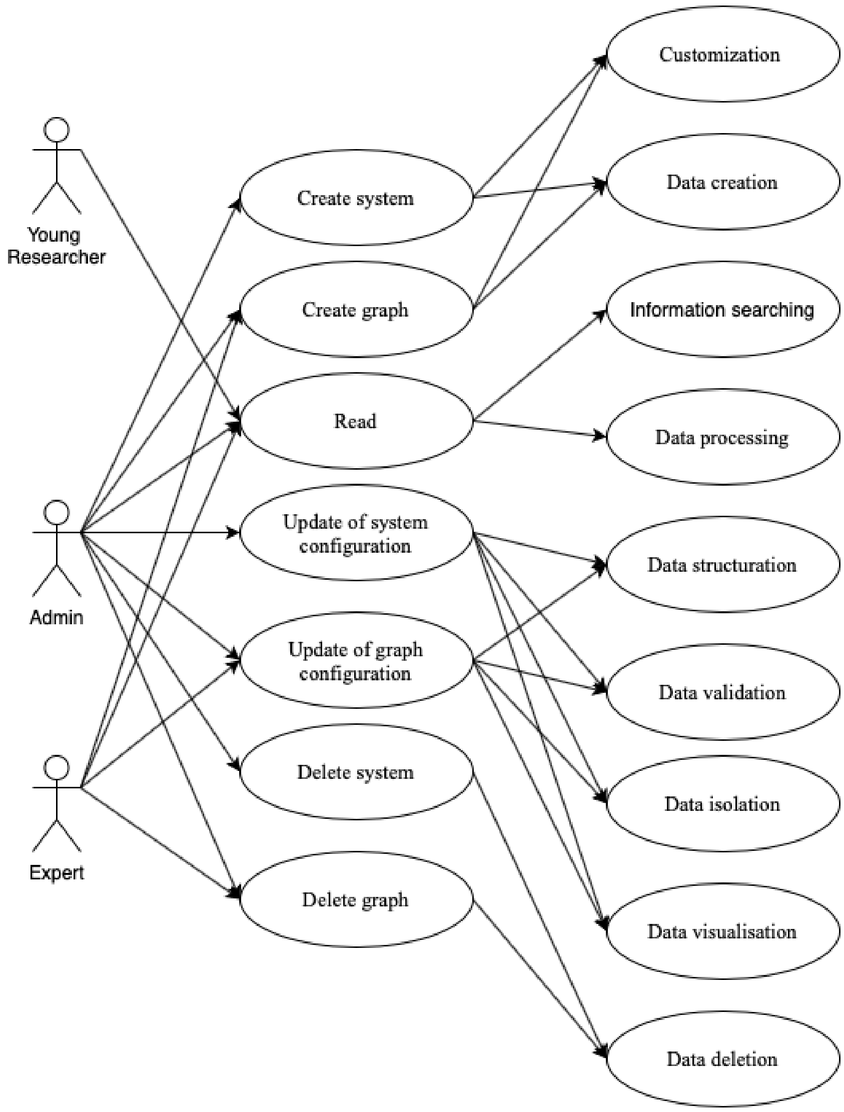


Figure 3: UML different types of user's functions diagram.

has been evaluated as meet criterion "Data structuration". The criterion "Availability of adaptive interface" means that the system will be convenient in use for any circle of users, regardless of their computer literacy level. "Data validation" criterion has used to evaluate functionality of data validation by experts (on the absence of inaccurate or incorrect information on the resource and its coresponding to the actucal stadarts; for example, educational programs and national standard such as on the names of chemical compounds used during educational process (DSTU 2439:2018). The criterion "Multi-user support" indicates that the document in the system can be changed at one time by multiple users. "Data isolation" criterion means that system can provide access rights to information according to user roles and publish in the search only those results that relate to the user and his interests. "Multi-user support" criterion has used to evaluate the possibility of the systems to provide access management to information changing according to user roles and publish in the search only those results that relate to the user and his interests.

3. Scientific method with using ontological tools

3.1. The general concept of ontological-based model based on Polyhedron

An ontology-based solution has developed to simplify the process of educational researches using the scientific method. Such ontological solutions were: “Search systems ranking”, “Search systems”, “Hypothesis test system”, “Centre for collective use”, “The selection of methods”, “The selection of research equipment”, “Sources recommended by the Ministry of Education and Science of Ukraine”, “Scopus sources”, “The promising developments of National Academy of Sciences of Ukraine”.

For systematization, simplification, and providing of a single ecosystem, these tools have compiled into the single simple ontology named “Scientific method”. It is structured according to the stages of the scientific method as “Do Background Research”, “Construct Hypothesis”, “Test with an Experiment”, “Analise results and Draw conclusion”, “Report Results” (see figure 4). The “Ask questions” stage skipped because no software required at this stage. Each of the nodes contains links to ontological tools, that can be used at an appropriate stage. The next part of the article will devote to the analysis of these tools.

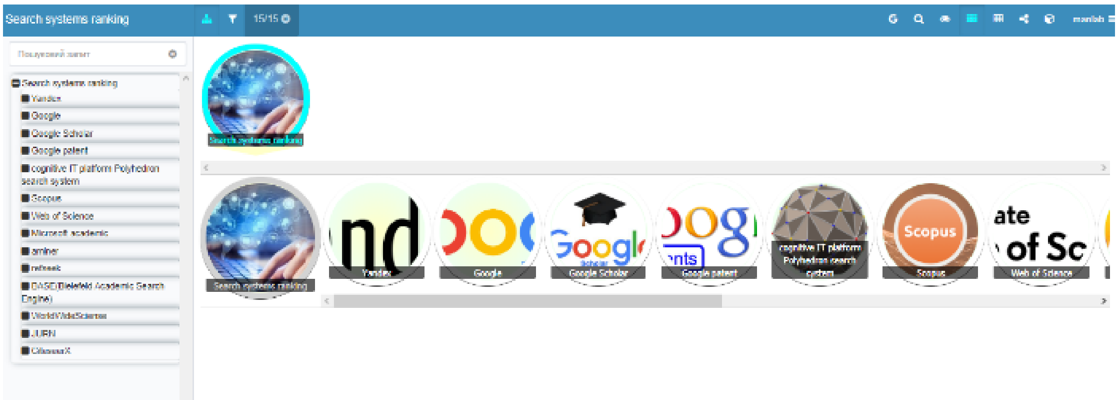


Figure 4: The general view of the ontology-based model.

3.2. Stage “Do background research” of educational researches

Tools like search sites (Google, Bing, Yahoo, etc.) and scientometric databases (Scopus, Web of Science, CiteseerX, Microsoft academic, a miner, refseek, BASE (Bielefeld Academic Search Engine), WorldWideSciense, JURN, Google scholar, and Google patent and others) have represented in the “Do Background Research” ontological node. Each child node were a specific search system or a scientometrics database with a link to it. The general view of “Search systems” ontology has presented in figure 5.

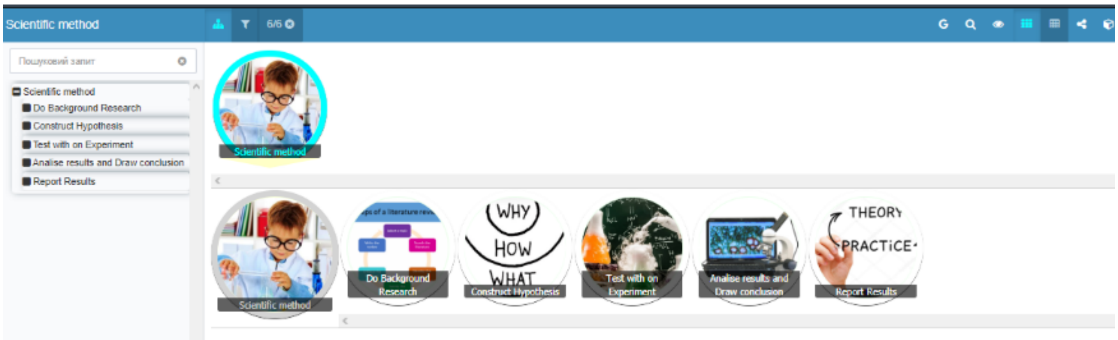


Figure 5: General view of the "Search systems" ontology.

The advantage of the cognitive IT platform Polyhedron internal search function is using an algorithm, which conducted between the ontological graph with nodes. Additionally, this algorithm can provide isolation and validation of information based on experts' decisions called internal search. That led to extended security and an increase in searching for material quality. This is significantly important in conditions of developing science society, that led to dynamic changes of the standards, as was with names of chemical substances of substance in Ukraine last year. The proposed in this article system also has its search engine (internal and external) described in previous works [24].

Scopus, Web of Science, CiteseerX, Microsoft academic, aminer, refseek, BASE (Bielefeld Academic Search Engine), WorldWideSciense, JURN, Google Scholar, Google patent have evaluated as particularly meet the criterion "The content integration". Scopus, Web of Science, CiteseerX have assessed partly, because they provide only necessary information about article and their metadata.

Scopus, Web of Science, CiteseerX, Microsoft academic, aminer, refseek, BASE (Bielefeld Academic Search Engine), WorldWideSciense, JURN, Google Scholar, Google patent have evaluated as partly meet the criterion "Interoperability with scientific and a patent search", because they provide search only among between scientific publications or patents in the one time. Google has evaluated as partly meet the criterion "Interoperability with scientific and a patent search" partly because it publishes results of search not only in the form of scientific publications and patents.

Scopus, Web of Science, CiteseerX, Microsoft academic, aminer, refseek, BASE (Bielefeld Academic Search Engine), WorldWideSciense, JURN, Google Scholar, Google patent have evaluated as partly meet the criterion "Data security" and "Data Availability", because some search results require a fee for full access to information or mandatory registration on the website.

Google has evaluated as partly meet the criterion "Indexing of educational programs", because it publishes search results primarily in the form of links on normative documents containing educational programs. The search systems have compared to each other. The results of the comparison are shown in table 2.

Thus, the comparison has found that the Polyhedron search system is more appropriate to use because it fully meets all the criteria. Also, has been found and confirmed that the Google search is more suitable for daily search and external literature review, as it meets such criterion:

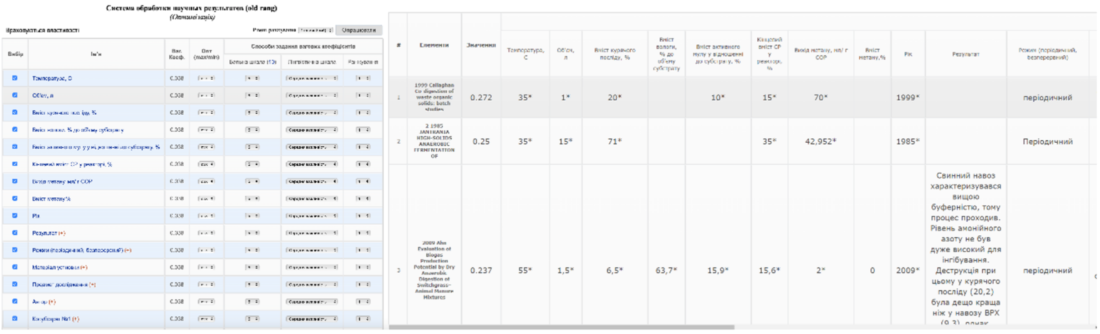
Table 2
The result of the comparison search system

Search system and scientometrics bases name	Content integration	Lack of advertising	Interoperability with scientific and a patent search	Data security	Data availability	Indexing of educational programs
Polyhedron search system	Yes	Yes	Yes	Yes	Yes	Yes
Scopus	Partly	Yes	Partly	Partly	Partly	No
Web of Science	Partly	Yes	Partly	Partly	Partly	No
CiteseerX	Partly	Yes	Partly	Partly	Partly	No
Microsoft academic	Partly	Yes	Partly	Partly	Partly	No
aminer	Partly	Yes	Partly	Partly	Partly	No
refseek	Partly	Yes	Partly	Partly	Partly	No
BASE (Bielefeld Academic Search Engine)	Partly	Yes	Partly	Partly	Partly	No
WorldWideSciense	Partly	Yes	Partly	Partly	Partly	No
JURN	Partly	Yes	Partly	Partly	Partly	No
Google Scholar	Partly	Yes	Partly	Partly	Partly	No
Google patent	Partly	Yes	Partly	Partly	Partly	No
Google	Yes	No	Partly	No	No	Partly

"Content integration", but do not meet criteria: "Lack of advertising", "Data security" and " Data availability", and only partly meet criteria: "Interoperability with scientific and a patent search", "Indexing of educational programs". The rest of the considered systems are suitable only for in-depth scientific research because they meet the criterion "Lack of advertising" and partly meet by the following criteria "Content integration", "Interoperability with scientific and a patent search", "Data security" and "Data availability".

Therefore, the usage of ranking system can be more relevant, comparing to existing approaches (searching systems). The ranking system expect preparation of numeric data from scientific papers(reports). It is possible due to the experimental papers includes the same information, for example, different works in the field of anaerobic digestion. All research papers about anaerobic digestion include data processing parameters such as temperature, type of substrate, reactor volume, moisture content, initial pH, parameters, characterises of the efficiency of the process, biogas yield, methane content, average pH during the process, destruction process etc [41]. An example of the ranking system on numeric data analysis of educational researches is shown in figure 6.

The proposed approach involves the use of an ontology for the management of specialized literature using other functions of the Polyhedron platform such as filtering (according to the parameters created by the user), ranking, and audit (if the user needs it).



a) b)

Figure 6: An example of input (a) and result interfaces of the ranking system on numeric data analysis of educational researches

3.3. Stage of “Constructing Hypotheses” with using ontological tools

There is only one ontological tool “Hypothesis test system” for testing of hypotheses status only this tool has represented in the “Construct Hypothesis” node. The Polyhedron platform has an instrument to compare the hypotheses of several works. The instrument is a simple ontology, where already have tested predictions from the scientific researches are semantic characteristics of each node. Next, the audit function of the Polyhedron platform described in previous works [37, 38, 39] find the affinity of the semantics and highlight by red colour those of hypothesis which already tested. An example of the results of such an audit is presented in figure 7.

3.4. Stage of “Planning and test with an experiment” with using ontological tools

At the stage of “Test with an Experiment” specific ontological tools have developed and represented in the general ontology as: “Centre for collective use”, “The selection of methods”, “The selection of research equipment”. In Ukraine, it is possible to provide an experiment using tools located in centres of collective use of the National Academy of Science. To simplify the process of selecting the equipment, the web-based tool “Centre for collective use” has been created. However, to simplify the interface and make it more useful, ontology with the same data but with extended functionality have created. The leaf nodes of this ontology are analysis devices. Visual comparison of ontological and non-ontological tools “Centre for collective use” is presented in figure 8.

Non-ontology system “Centre for collective use” has several shortcomings, both visual and functional which are obsolescence and inconvenience of the interface, inconvenient navigation in the system, and the complete absence of a filtering system. These factors make the application unsuitable for the selection of equipment during the process of planning of the experiment.

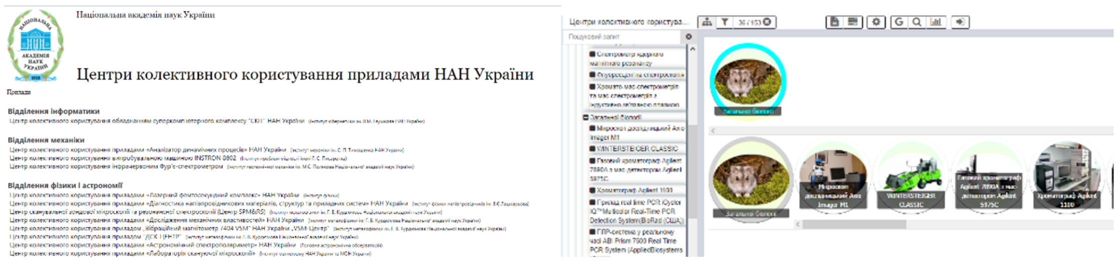
The proposed ontological-based tool “Centre for collective use” is having not only an up-to-date interface but also several advantages. One of the key features is a stable semantic link and the ability of the system to combine all of the innovative applications of digitalization of the educational and research process. Also, have created an ontological-based system “Centres

Hypothesis testing system
(Аудит)

Враховуються властивості

#	Показники	Одиниця виміру	ДСТУ	Зразки		
				supposition 1	supposition 2	supposition 3
Abstract						
1	Object of study	Object of study	Chlorella vulgaris		Chlorella vulgaris	
2	Subject of study	Subject of study	Cultivation of Chlorella vulgaris microalgae on effluents obtained after methane fermentation.		Cultivation of Chlorella vulgaris microalgae on effluents obtained after methane fermentation.	
3	The aim of the study	The aim of the study	Developing a method of growing Chlorella Vulgaris in effluents after methane fermentation.		Developing a method of growing Chlorella Vulgaris in effluents after methane fermentation.	
4	Practical value	Practical value	The results of this work will contribute to the spread of biogas technologies. This approach makes it possible to increase the economic benefits from the utilization of bird droppings by converting the anaerobic digestion effluents into microalgae that have a wide range of applications.		The results of this work will contribute to the spread of biogas technologies. This approach makes it possible to increase the economic benefits from the utilization of bird droppings by converting the anaerobic digestion effluents into microalgae that have a wide range of applications.	
5	Scientific novelty	Scientific novelty	A method of utilization of methane tank effluent using microalgae is proposed. Cultures of Chlorella Vulgaris were adapted to the methane tank effluent.		A method of utilization of methane tank effluent using microalgae is proposed. Cultures of Chlorella Vulgaris were adapted to the methane tank effluent.	
6	Keywords	Keywords	microalgae		Chlorella Vulgaris	
7	Hypothesis	Hypothesis	The effluent obtained after anaerobic digestion can be used as a nutrient medium for microalgae Chlorella Vulgaris.	The effluent obtained after anaerobic digestion can be used as a nutrient medium for microalgae Spirulina Platensis.	The effluent obtained after anaerobic digestion can be used as a nutrient medium for microalgae Chlorella Vulgaris.	The effluent obtained after anaerobic digestion can not used it as a nutrient medium for microalgae Chlorella Vulgaris.

Figure 7: General view of the audit results in the "Hypothesis test system" ontology.



a) b)

Figure 8: General view systems for the selection of equipment in centre of collective usage during planning the experiment in the non-ontology-based (a) and (b) ontological-based system.

of collective use" is conveniently classifying scientific equipment by departments of science it belongs to. This feature was realized as non-user-friendly in traditional web-based tool.

Besides, the "Centre for collective use" use in the cognitive IT platform Polyhedron platform has several useful filters, unlike web-based tool. These filters are "the sphere of science", "section of National Academy of Science of Ukraine institution belongs to", "Location", "object of study", and "measured parameter". All these filters will be especially useful for novice researchers.

These two systems have compared each other. The result of the comparison is shown in table 3.

Table 3
The result of the comparison of two ontological-based with non-ontology-based systems for the selection of equipment in "Centre of collective usage".

Criterion name	Non-ontology "Centre for collective use"	Ontological-based system "Centre for collective use"
Customization potential	No	Yes
Multifunctionality of information processing	No	Yes
Data structuration	No	Yes
Availability of adaptive interface	No	Yes
Data validation	Yes	Yes
Multi-user support	No	Yes
Data isolation	No	Yes

As a result of the comparison, it has found that the "Centre for collective use" in the cognitive IT platform Polyhedron is more appropriate to use, because it fully meets all the criteria. It has established that the non-ontology-based version of the "Centre for collective use" is undesirable for use because it doesn't meet the following criteria: "Customization potential", "Multifunctionality of information processing", "Data structuration", "Availability of adaptive interface".

There are many potential cases of using "Centre for collective use" in the cognitive IT platform Polyhedron. For example, the user needs to find a device that is located in Kyiv, and which investigates atomic particles. As a result of the user request, the device is the Isochronous cyclotron U-240 of the Institute of Nuclear Physics, which is located on Nauki Avenue. This and some other examples of applications are shown in table 4.

Table 4
The list of examples of using the proposed filtering system

	Filters	Results
Case 1	*Location: Kyiv* The object of study: Atomic particles	cyclotron U-240
Case 1	*Location: Kyiv* Purpose: Analysis of X-ray spectra	Module for CEM INCAPenteFETx3
Case 3	*Location: Lviv* Purpose: Microscopic examinations	Scanning electron microscope EVO 40XVP

In the laboratory MANLab of the National Center of Junior Academy of Science centre of collective usage of the research equipment devoted to the research education has been created. The same approach to simplify (using the ontology) the selection of the equipment called "Selection of equipment in MANLab" has been developed. Leaf node in this ontology is separate equipment located in MANLab. The filters such as the parameter which needs definition, "Measurement accuracy", "Measuring range" "The parameter which needs definition" will be useful for selection. The General view of filtering input system for "The selection of research equipment in MANLab" ontology is shown in figure 9

Hypothesis testing system
(Аудит)

Враховуються властивості

#	Показники	Одиниця виміру	ДСТУ	Зразки		
				supposition 1	supposition 2	supposition 3
Abstract						
1	Object of study	Object of study	Chlorella vulgaris		Chlorella vulgaris	
2	Subject of study	Subject of study	Cultivation of Chlorella vulgaris microalgae on effluents obtained after methane fermentation.		Cultivation of Chlorella vulgaris microalgae on effluents obtained after methane fermentation.	
3	The aim of the study	The aim of the study	Developing a method of growing Chlorella Vulgaris in effluents after methane fermentation.		Developing a method of growing Chlorella Vulgaris in effluents after methane fermentation.	
4	Practical value	Practical value	The results of this work will contribute to the spread of biogas technologies. This approach makes it possible to increase the economic benefits from the utilization of bird droppings by converting the anaerobic digestion effluents into microalgae that have a wide range of applications.		The results of this work will contribute to the spread of biogas technologies. This approach makes it possible to increase the economic benefits from the utilization of bird droppings by converting the anaerobic digestion effluents into microalgae that have a wide range of applications.	
5	Scientific novelty	Scientific novelty	A method of utilization of methane tank effluent using microalgae is proposed. Cultures of Chlorella Vulgaris were adapted to the methane tank effluent.		A method of utilization of methane tank effluent using microalgae is proposed. Cultures of Chlorella Vulgaris were adapted to the methane tank effluent.	
6	Keywords	Keywords	microalgae		Chlorella Vulgaris	
7	Hypothesis	Hypothesis	The effluent obtained after anaerobic digestion can be used as a nutrient medium for microalgae Chlorella Vulgaris.	The effluent obtained after anaerobic digestion can be used as a nutrient medium for microalgae Spirulina Platensis.	The effluent obtained after anaerobic digestion can be used as a nutrient medium for microalgae Chlorella Vulgaris.	The effluent obtained after anaerobic digestion can not used it as a nutrient medium for microalgae Chlorella Vulgaris.

Figure 9: General view of filtering input system for "The selection of research equipment in MANLab" ontology.

Novice researchers can easily find the equipment in both, Centers of collective usage in National Academy of Science and Junior Academy of Science. For example, the researcher needs to provide the information about the content of heavy metals in the water, and it is already known that the content is high. The system can provide both ranking and filtering for solving the tasks. Any of these instruments will propose to use for this task the Universal polarograph EKOTEST-VA. By Choosing of this instrument, novice researchers will be able to use the links on manlab.inohst.com.ua web-page with detailed information on the equipment. The list of cases of application the proposed filtering system is presented in table 5. The General view of filtering input system for "The selection of methods" ontology is shown in figure 10.

The other routine tasks that need to be solved during the planing of the experiment ("Test with an experiment stage) is choosing the methods of research. The main problems in that field that a wide variety of methods are presented in the form of printed text (books or methodical instructions) which is hard to process. However, using filtering systems of IT-platform Polyhedron, it is possible to provide management and simplify this task. The ontology used to solve this task called "The selection of methods", and the leaf node of it is method itself with the metadata. For example, the youth researcher "is required to select to determine the content of Al (III) in water. As a result of a user request, the system will propose the photometric analysis

Table 5
The list of cases of application the proposed filtering system

	Filters	Results
Case 1	*The parameter which needs definition:* concentration of heavy metals in the liquid Measuring range: 0.1 μg / dm3-1g / dm3	Universal polarograph EKOTEST-VA
Case 1	*The parameter which needs definition:* CO2 concentration Measurement accuracy: 20% Measuring range: 350-5000%	Carbon dioxide sensor DT040
Case 3	*The parameter which needs definition:* O2 concentration Measuring range: 0-12,5 mg / dm3 Oxygen sensor DT222A	

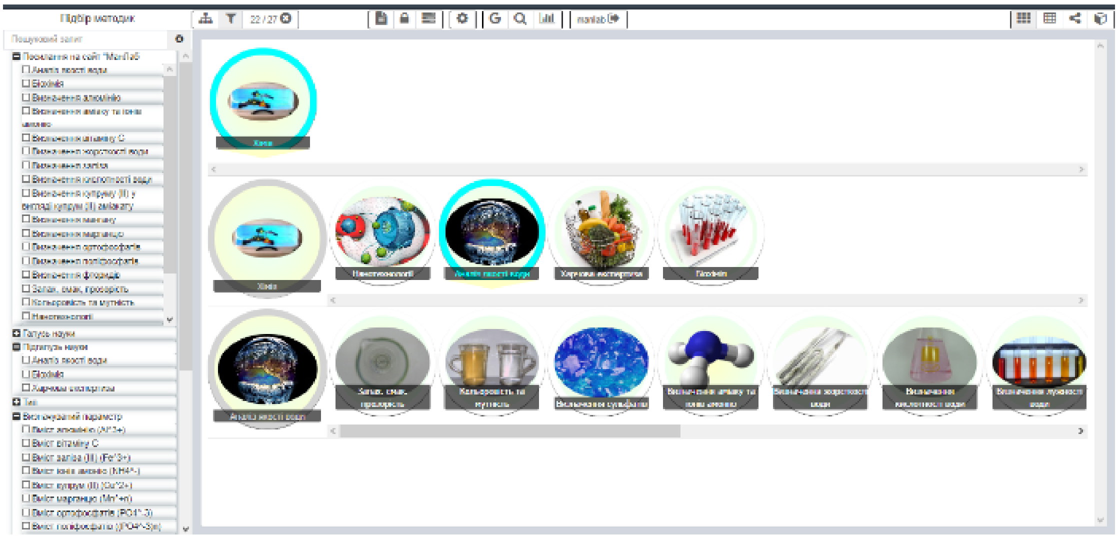


Figure 10: General view of filtering input system for "The selection of methods" ontology.

methodology, and display all necessary information, including chemical utensils, reagents, needed equipment. Finally, the result will contain a link to the web-methodology at Junior Academy of Science web-environments (manlab.science or stemua.science [42, 43]) where it will be detailly described and visualized by video demonstrations. The list of examples of using the proposed filtering system is presented in table 6.

3.5. Stage of "Analise results and draw a conclusion" with using ontological tools

An example of the application of the proposed ontological system has given at "Analise results and Conclude" node. At the stage of result analysis, both offline tools like MS Office, PTS Mathcad Origin Pro, and cloud-based like G Suite and Office 365. The Polyhedron IT-platform can allow to process and present the results of researches. Semantic and numerical characteristics from Excel or Google Sheets have used to construct graphs and diagrams. Also, the necessary data can be taken from the existing ontological graph. This is followed by the standard method of creating

Table 6
The list of examples of using the proposed filtering system

	Filters	Results
Case 1	*Purpose: Water quality analysis* The parameter which needs definition: Al (III)	Investigation of water samples for aluminum content by photometric method
Case 1	*Type of analysis: qualitative* The parameter which needs definition: The presence of proteins	Deposition of proteins by mineral acids
Case 3	*Type of analysis: Titrimetric determination* The parameter which needs definition: vitamin C	Determination of vitamin C content in food by iodometric method

for ontological graphs and further use the module to build graphs and charts. For demonstration results of statistical researches on mortality from various diseases in Ukraine from 2016 to 2020 (include from COVID-19) were taken. The graph with these results of statistical surveys in the Polyhedron system is presented in figure 11.

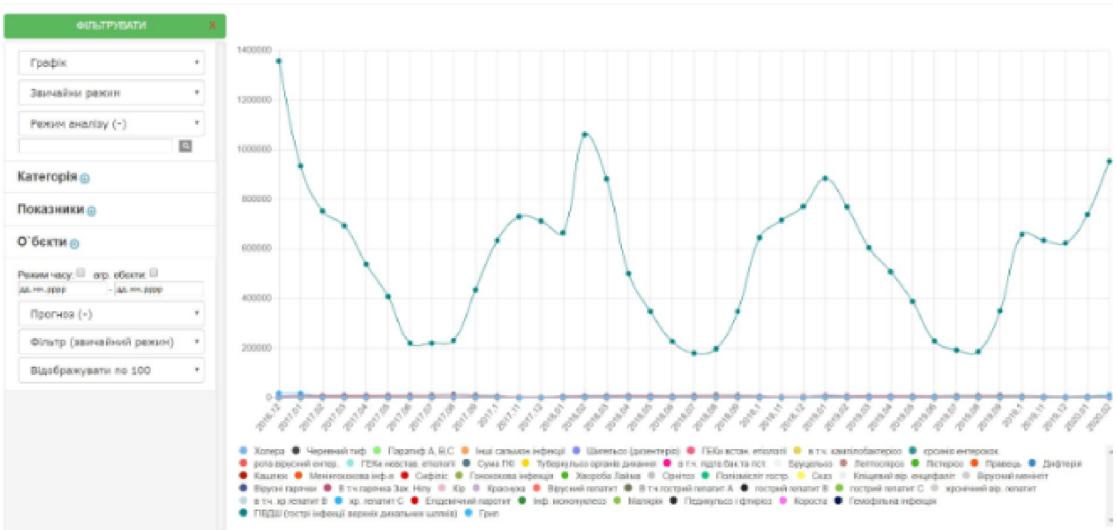
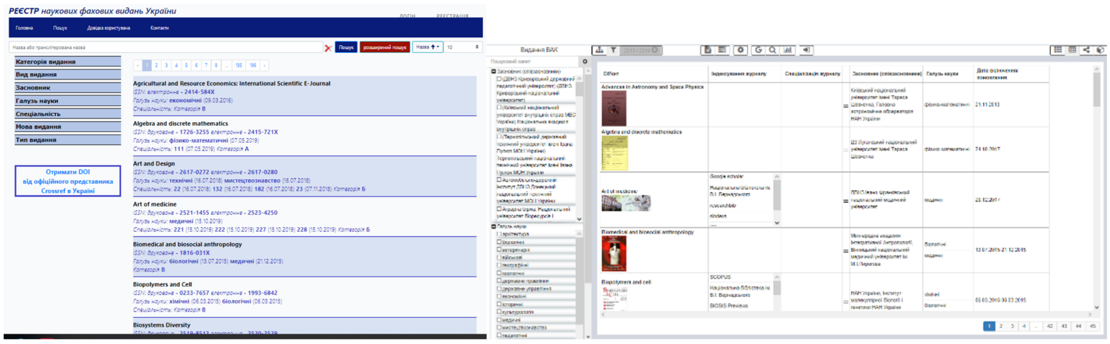


Figure 11: The graph with results of statistical surveys of on mortality from various diseases in Ukraine from 2016 to 2020 by cognitive IT platform Polyhedron.

3.6. Stage of "Report results" with using ontological tools

The "Sources recommended by the Ministry of Education and Science of Ukraine", "Scopus sources" "The promising developments of National Academy of Sciences of Ukraine" ontological systems have represented in "Report Results" node. Those instruments have compared with their non-ontological web-analogues.

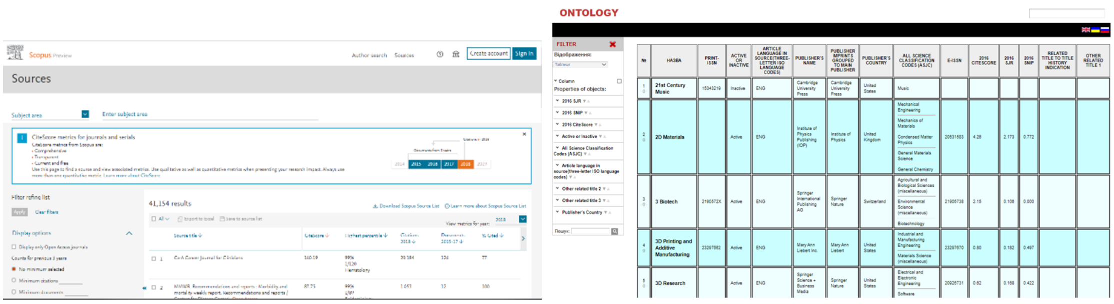
After providing the research and analysing of the results, it may seem relevant to publish the data. Now in Ukraine, it is possible to can be divided into between the journals recommended by the Ministry of Education and Science of Ukraine, and the journals indexed by scientometric bases. However, choosing of the journals, is always the challenge, especially for novice researchers and to simplify the tasks both ontological and non-ontological tools is existing nowadays. The ontological tool developed using IT-platform Polyhedron consist from the leaf nodes (separate journals) with semantic data. To simplify the tasks, the filters like "Field of Science", "Free of Charge Journals", "Publication Languages" have developed. There are web-oriented and ontological systems for the selection of sources recommended by the Ministry of Education and Science of Ukraine. A general view of references recommended by the Ministry of Education and Science of Ukraine in bought forms are shown in figure 12.



a) b)

Figure 12: General view of sources recommended by view of sources recommended by Ministry of Education and Science of Ukraine in (a) non-ontology-based (b) ontological-based form.

"Sources recommended by the Ministry of Education and Science of Ukraine" and "Scopus sources" ontologies have created. Both of ontologies are complex and contains branching by branches, of science, type, indexes, and other parameters of journals for publication. The final child nodes are each journal for publication. Such necessary filters as language of the journal, cost of publication (including frees) is absent in web-based application, which may limit it using. For example, today researchers are increasingly paying attention to the citation style of the journal. General view of Scopus sources in standard web-oriented and ontological form are shown in figure 13. All these systems have compared to each other. The result of the comparison is shown in table 7.



a) b)

Figure 13: General view of Scopus sources in (a) non-ontology-based (b) ontological-based form.

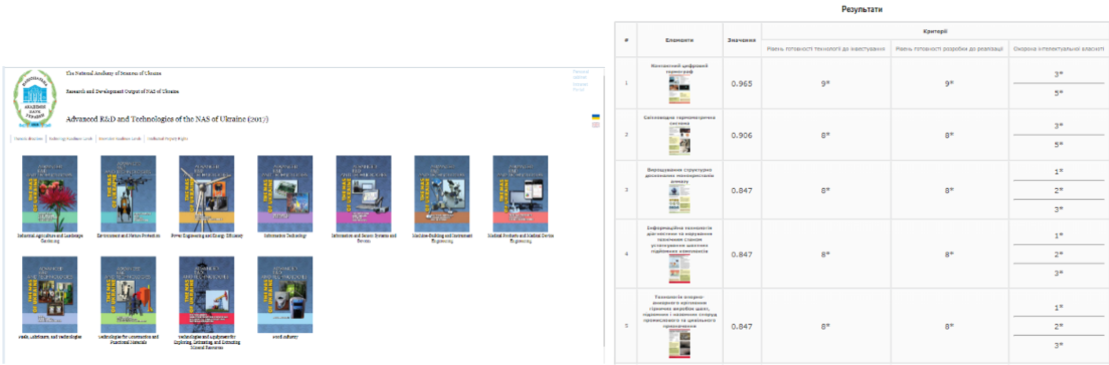
Table 7
The result of the comparison of edition structuration systems

Criterion name	“Sources recommended by the Ministry of Education and Science of Ukraine”	“Scopus sources”	“Sources recommended by the Ministry of Education and Science of Ukraine” in cognitive IT platform Polyhedron	“Scopus sources” by cognitive IT platform Polyhedron
Customization potential	No	No	Yes	Yes
Multifunctionality of information processing	No	No	Yes	Yes
Data structuration	No	No	Yes	Yes
Availability of adaptive interface	No	Yes	Yes	Yes
Data validation	Yes	Yes	Yes	Yes
Multi-user support	No	No	Yes	Yes
Data isolation	Yes	Yes	Yes	Yes

As a result of the comparison, it has found that “Sources recommended by the Ministry of Education and Science of Ukraine” in cognitive IT platform Polyhedron and “Scopus sources” by cognitive IT platform Polyhedron are more appropriate to use because it fully meets all the criteria. “Sources recommended by the Ministry of Education and Science of Ukraine” is undesirable for use because it doesn’t meet the following criterion “Customization potential”, “Multifunctionality of information processing”, “Data structuration”, “Availability of adaptive interface”, “Multi-user support”. As a result of the comparison, it has established that the “Scopus sources” is undesirable for use because it doesn’t meet the following criterion “Customization potential”, “Multifunctionality of information processing”, “Data structuration”, “Multi-user support”. So, ontology-based tools “Sources recommended by the Ministry of Education and Science of Ukraine” and “Scopus sources” is more appropriate to use.

For presentation of research results was created “The promising developments in The National Academy of Sciences of Ukraine” in web-oriented non-ontology form containing all the promising scientific projects of Ukraine. Ontology-based tool” The promising developments of National Academy of Sciences of Ukraine” ranking ontology has created with functions of ranking and provides better information management. The ontology is simple with scientific developments, as leaf nodes. General view all the promising projects of National Academy of Sciences of Ukraine and result of the ranking ontology tool presented in figure 14.

This tool will be useful for potential investors who are looking for investments. For example, investor requesting to find the most finalized developments “The promising developments in The National Academy Sciences of Ukraine” by the cognitive IT platform Polyhedron, the system will display the projects “contact digital thermography”, “fibre-optic thermometric system”, “growing of structurally perfect diamond single crystals”, “Technology of support, and anchor fastening of earthworks appointment” are the most finalized developments. The non-ontology tool “The promising developments in The National Academy of Sciences of Ukraine” has been compared with ontological-based form “The promising developments in The National Academy



a) б)

Figure 14: General view of “The promising developments in The National Academy of Sciences of Ukraine” (a) and result of the ranking ontology tool (b).

Sciences of Ukraine” by cognitive IT platform Polyhedron. The result of the comparison is shown in table 8.

Table 8
The result of the comparison of “The promising developments of The National Academy of Sciences of Ukraine” systems

Criterion name	Non-ontology “The promising developments in The National Academy of Sciences of Ukraine”	“The promising developments in The National Academy Sciences of Ukraine” by cognitive IT platform Polyhedron
Customization potential	No	No
Multifunctionality of information processing	No	Yes
Data structuration	No	Yes
Availability of adaptive interface	No	Yes
Data validation	Yes	Yes
Multi-user support	No	Yes
Data isolation	Yes	Yes

4. Discussion

As a result of the comparison, it has been found that Ontological tools for the support of the scientific method created by cognitive IT-platform Polyhedron are more appropriate to use because they fully meet all of the comparison criteria. And all of the non-ontological tools for the support of the scientific method only meet the criteria: “Availability of adaptive interface”, “Data validation”, “Data isolation”. The overall result of the comparison is shown in table 9.

We can use the “search system” ontology in the background research stage, “Hypothesis test

Table 9
The overall result of the comparison of ontological and non-ontological tools

Criterion name	Ontological tools	Non-ontological tools
Customization potential	Yes	No
Multifunctionality of information processing	Yes	No
Data structuration	Yes	No
Availability of adaptive interface	Yes	Yes
Data validation	Yes	Yes
Multi-user support	Yes	No
Data isolation	Yes	Yes

system" can be used in the construct of hypothesis stage. Depending on the presence or absence of the experiment, we can use two different ontological solutions "The selection of research equipment" and "The selection of methods". In the report results stage it is possible to use three different ontologies "Scopus edition", "The edition recommended by Ministry of education and science of Ukraine" and "The promising developments of NASU". All proposed ontological tools are extensions and support the method as illustrated in the workflow diagram (see figure 15).

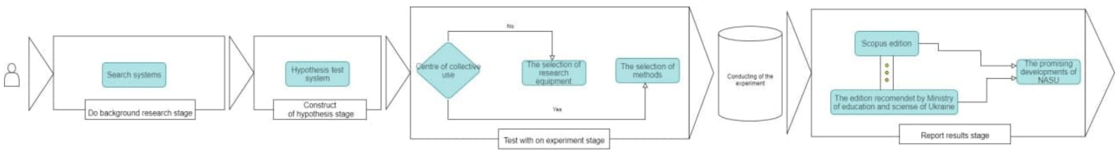


Figure 15: Workflow diagram of proposed ontological tools

5. Conclusions

A centralized ontological tool based on the IT platform Polyhedron consisting of "Search systems ranking", "Search systems", "Hypothesis test system", "Centre for collective use", "The selection of methods", "The selection of research equipment", "Sources recommended by the Ministry of Education and Science of Ukraine", "Scopus sources", "The promising developments of The National Academy of Sciences of Ukraine" has been created. These ontological tools can be used during almost all stages of the scientific method used in educational research. As a result of the comparison, it was found that all systems created by the cognitive IT-platform Polyhedron are more appropriate to use because they fully meet all the comparison criteria.

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A semantic structuring of educational research using ontologies

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Abstract
This article is devoted to the presentation of the semantic interoperability of research and scientific results through an ontological taxonomy. To achieve this, the principles of systematization and structuration of the scientific/research results in scientometrics databases have been analysed. We use the existing cognitive IT platform Polyhedron and extend it with an ontology-based information model as main contribution. As a proof-of-concept we have modelled two ontological graphs, "Development of a rational way for utilization of methane tank waste at LLC Vasylkivska poultry farm" and "Development a method for utilization of methane tank effluent". Also, for a demonstration of the perspective of ontological systems for a systematization of research and scientific results, the "Hypothesis test system" ontological graph has created.

Keywords
cloud technologies, ontology, educational research, taxonomy, systematization

1. Introduction

Now, more than ever, science affects all aspects of human life. Latest scientific developments are often and quickly implemented in industry. However, the scientific results usually are presented in human-readable form and not in a machine-readable, so it is hard to process the knowledge using automated informational technologies.

The basic structure of a typical research paper is the sequence of Introduction, Methods, Results, and Discussion (sometimes noted as IMRAD) [1]. Each section addresses a different objective. The Introduction section motivates the research problem that was discovered or the known facts about the problem; the Method section states what authors did to discover and address the problem in a new solution, what they achieved as results in experiments is written in the Discussion section, and what they had observed is discussed in the Results section.

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The most common form of science reporting is a written paper. Depending on the purpose there are a few different types of papers: Analytical Research Paper, Argumentative (Persuasive) Research Paper, Definition Paper, Compare and Contrast Paper, Cause and Effect Paper, Interpretative Experimental Research Paper, Survey Research. All the most common research papers types are shown in table 1 [2].

Table 1
The most common research papers types

Types of the Research papers	Oriented amount of words required	Specific characteristics
Analytical Research Paper	3000+	Someone poses a question and then collect relevant data from other researchers to analyse their different viewpoints.
Argumentative (Persuasive) Research Paper	3000+	The argumentative paper presents two sides of a controversial question in one paper.
Definition Paper	5000+	The definition paper describes facts or objective arguments without using any personal emotion or opinion of the author.
Compare and Contrast Paper	5000+	Compare and contrast papers are used to analyse the difference between two viewpoints, authors, subjects or stories.
Cause and Effect Paper	3000+	Cause and Effect Paper trace probable or expected results from a specific action and answer the main questions "Why?" and "What?".
Interpretative Paper	3000+*	An interpretative paper requires to use knowledge that have gained from a particular case study.
Experimental Research Paper	3000+*	This type of research paper describes a particular experiment in detail.
Survey Research Paper	5000+*	This research paper demands the conduction of a survey that includes asking questions to respondents.

* Depends on the purpose of the article and the requirements of the journal, institute, teacher

Most of the papers (but not all of them) nowadays are systemized by using scientometric databases. However, educational research reports, which use scientific methods, have not been systemized at all. Besides, scientist, unlike pupils, already know their field of research in detail and can determine by themselves their research hypothesis and they can do further analyse it by themselves. Students instead can't do this. Automated informational tools can help students in this scientific discovery and analysis tasks.

The scientific method is often used in an educational process during STEM approach by providing educational researches. This approach is only recently applied in countries such as Ukraine [3]. There are various school competitions for scientific works, such as the competition on scientific articles of the Junior academy of sciences of Ukraine and international competitions (for example, Intel ISEF). Also, the scientific method can be used during the process of creation of thesis papers (for masters' degree, bachelor's degree, etc.), pupil's research reports (for events noted before), or in simpler, but more common form of essays. In addition, students can report their results in form of scientific papers, if the level of quality of their work will be satisfactory for the scientific requirements. An overview of the types of educational research reports works are presented in table 2. The focus of this paper is on the systematization and processing of educational research reports. The problem to be addresses is the lack of a Structuration mechanism which complicates the automated processing of the reports.

Table 2
Types of the educational research reports

Types of the educational research report	Oriented required amount of the pages	Specific characteristics	The event for which the report was prepared
Esse	In general, up to 10-15 pages	Is simple and very flexible on the content	Classes, completions of school level
Research reports	In general, up to 30-100 pages	Relatively static structure; similar to IMRAD	Competitions of Junior academy of sciences of Ukraine and Intel ISEF
Scientific paper	Declared by the source	Declared by the source	Publication in the journal
Thesis papers	In general, 40-100 pages	Relatively static structure similar to IMRAD	Defence of the qualification works

2. Literature review

To increase the convenience and efficiency of scientific data processing, structuration, and systematization of research and scientific results, the active dissemination and use of different scientometrics databases continues [4]. Specialized databases for structural science information are an integral part of the information-support system for any scientist. Scientometrics is the "quantitative study of science, communication in science, and science policy" [5] commonly referred to as the "science of science". Scientometrics is essential to help academic disciplines understand various aspects of their research efforts, including (but not limited to) the productivity of their scholars [5, 6], the emergence of specializations [7], collaborative networks [8], patterns of scientific communications [9], and quality of research products [10]. Metric studies had developed as a subsidiary branch of Library and Information Science (LIS) over time [11]. In most cases, scientometrics models by using bibliometrics, which is a measure of the impact of publications.

To increase the quality and performance of scientometrics the ten principles of the "Leiden Manifesto of Scientometrics" have been stated [11]:

- Quantitative evaluation should support qualitative expert assessment.
- Measure performance against the research missions of the institution, group, or researcher.
- Protect excellence in locally relevant research.
- Keep data collection and analytical processes open, transparent and simple.

- Allow those evaluated to verify data and analysis.
- Account for variation by field in publication and citation practices.
- Assessment of individual research on a qualitative judgment of their portfolio.
- Avoid misplaced concreteness and false precision.
- Recognize the systemic effects of assessment and indicators.
- Scrutinize indicators regularly and update them.

Today, all existing scientometrics databases can be divided into two major groups: international and national [11, 12, 13, 14, 15, 16, 17]. The most well-known international databases are: Springer, Scopus, Web of Science, CiteseerX, Microsoft Academic, aminer, refseek, BASE (Bielefeld Academic Search Engine), WorldWideSciense, JURN, Google Scholar, Google patent and others. National databases incorporate a variety of bibliographic databases, and a variety of library and university repositories. International scientometric databases are characterized by a larger scale and mandatory support for various languages, including English. Also, a characteristic feature of such databases is the availability and work with various special indices that have international recognition for example h-index [18].

As scienctific publications continue to grow exponentially, also the amount of academic databases and scientometrics databases increases, which supports gaining insights into the structure and processes of science [16].In this case, many scientific publications devoted to the principle of working scientometrics databases, and their number is growing. Thanks to them, concepts such as "metadata" of scientific articles began to be actively used in scientometrics [11, 12, 13, 14, 15, 16, 17]. Metadata is essential data about data providing information such as titles, authors, abstracts, keywords, cited references, sources, and bibliography, and other data. Metadata do not substitute the corresponding article, but it explicitly describes valuable information about the article.

By using of scientometrics systems, the contributions of researchers in the field of informatics and scientometrics were previously quantified [13]. The principal metadata indicators are: the indicators and citation indices of journals, the number of authors, the number of the publication and the degree of cooperation based on affiliation data. The disadvantage of this research is that it is devoted only to scientific articles. The authors noted that their study could not touch student's and pupil's research report because there is no single database where they are all located [13].

The application of the principles of the "Leiden Manifesto of Scientometrics" is stated and substantiated, which provides for transparent monitoring and support of research and encourages constructive dialogue between the scientific community and the public. In this work, the bibliometric base, which corresponds to principles of the "Leiden Manifesto of Scientometrics" has been created. The proposed bibliometric centre did not address the systematization of students and pupils' research reports, but the authors noted the necessity of involvement of students' and pupils' research reports in their bibliometric centre [12].

The approach of co-word analysis has been introduced and its application in scientometrics is substantiated in [14]. The trends and patterns of scientometrics in journals has been revealed by measuring the association strength of selected keywords which represent the produced concept and idea in the field of scientometrics. Also, the authors have developed a web system for extraction of keywords from the title and abstract of the article manually. However, the web system proposed by them cannot work with research reports of students and pupils.

Another concept of analysis is iMetrics or “information metrics”. Its application in scientometrics is substantiated in [19]. iMetrics is devoted to the scientometrics of scientific journals in the field of informatics. The authors note the possibility of applying their approach for systematization of the scientific works of students and pupils. The research related to scientometrics databases is shown in table3.

Table 3
The research related to scientometrics databases

Subject of study	The general result of the study	Authors
Citation indices of journals, number of authors of the publication their affiliation	The contributions of researchers in the field of informatics and scientometrics	K. R. Mulla
Principles of the “Leiden Manifesto of Scientometrics”	Stated and substantiated of , “Leiden Manifesto of Scientometrics”	L. Kostenko, A. Zhabin, A. Kuznetsov, T. Lukashevich, E. Kukharchuk, T. Simonenko
Co-word analysis	The trends and patterns of scientometrics in the journals were revealed	S. Ravikumar, A. Agrahari, S. N. Singh
iMetrics (“information metrics”)	iMetrics scientometric system had provided	S. Milojevic, L. Leydesdorff

Previously, ontological graphs were used to systematize scientific articles [20, 21, 22, 23]. Systematization and structuration in such graphs is based on different approaches such as using of scientific article recommendation system [20], Scientific Articles Tagging system [21], machine learning [22], automatic summarization [23]. Also, ontologies can be to provide interoperability through semantic technologies [24]. However, none of the proposed ontological approaches for systematization and structuration is addressing the structuration of research reports of students and pupils.

None of the scientometrics database systems previously proposed [11, 12, 13, 14, 15, 16, 17] can offer a universal solution for systematization, and structured presentation of research and scientific results to pupils and students. Also, the disadvantages of all these systems are the complete lack of many parameters, that are useful for processing information about scientific works. These parameters are: the scientific novelty of the article, the practical value of the study, the hypothesis of the study, subject and object of the research. Also, existing solutions do not allow to compare research reports between each other.

This work aims to propose and justify the use of an ontological system, which permits the systematization of scientific articles with all advantages of existing scientometrics systems and without disadvantages of these systems. Which at the same time will not be deprived of the functionality of current scientometrics systems and will meet the Leiden Manifesto for Scientometrics.

We propose to use the existing cognitive IT-platform Polyhedron as technical basis for solving this problem. The core of the Polyhedron system consists of advanced and improved functions of the TODOS IT-platform described in previous works. Polyhedron is a multi-agent system which allows for transdisciplinary and acts as an interactive component in any educational and scientific research [25]. Besides, the cognitive IT-platform Polyhedron contains a function for comparison with standards which is called auditing [25, 26, 27]. Polyhedron provides: semantic web support, information systematization and ranking [28] transdisciplinary support, internal search [29] has all advantages of ontological interface tools [30], and the construction of all chains of the process of transdisciplinary integrated interaction is ensured [31]. Due to active states are hyper-ratio plural partial ordering [32, 33], the cognitive IT-platform Polyhedron is an innovative IT technology for ontological management of knowledge and information resource. The user of the Polyhedron IT system has an opportunity to use an internal search function that is more protected and reliable compared to the external one, because it provides information created by experts.

Also, the proposed solution for the structuration of educational and research projects can be used together with other modern developments in the educational field, like a virtual educational experiment [34, 35, 36, 37], different tools to provide development of ICT [38, 39, 40, 41], the use of mobile Internet devices [42, 43, 44, 45], using the technology of augmented reality education [46, 47, 48, 49], online courses [50, 51, 52, 53], distance learning in vocational education and training institutions [54, 55, 56, 57], educational and scientific environments [58, 29, 59, 60].

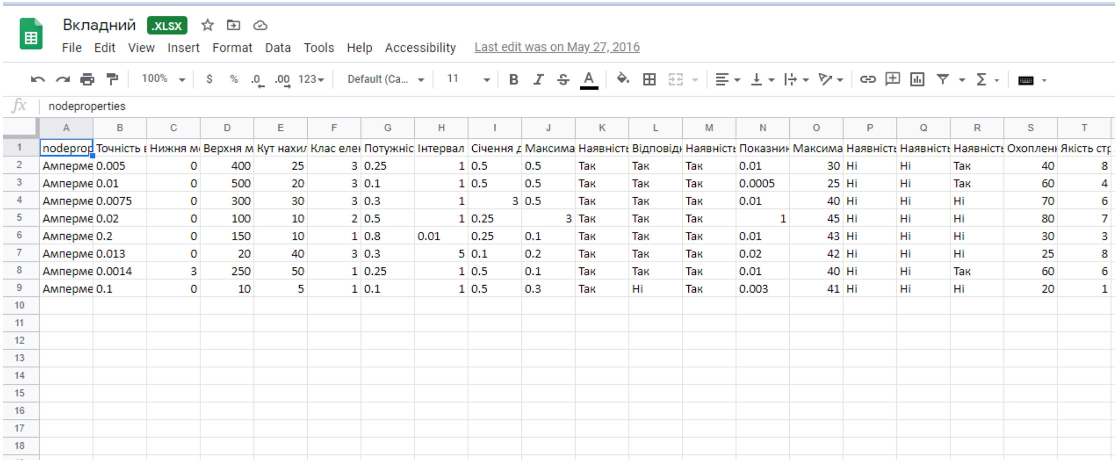
3. Materials and methods

3.1. Ontology creation mechanism

To create ontologies in Polyhedron, Google Sheets were used to collect and structure the information (see example in figure 1). The sheets with research report data (structure file and numeric/semantic data file) have been downloaded and saved in .xls format. The files have been loaded to "editor.stemua.science", which is part of Polyhedron. After that, the generation of the graph nodes (in .xls) with its characteristics using the data structures in the file have been carried out. The obtained graphs have been saved in .xml format and located in the database. The graphs have been filled by semantic and numeric information for ranking and filtering. Ontological edges (relations) have been formed using predicate equations, as described previously in [31].

3.2. Ranking tools

Taking into account that e.g. proposed reports "A" and "B" are technical, the results of the reported works can be used to provide analysis of the rationality of the implementation proposed in the concrete project. For instance, to provide it, research reports "A" and "B" were also compared with each other using ranking tool applying the following criteria: "Short-term economic perspective", "Long-term economic prospects". For creating a ranking the ontologies have used the module "Alternative" which is described in our previous works [28]. To provide this ranking, the nodes of a graph have been filled with semantic data grouped in semantic classes. The ranking uses grade scale from one to ten point to underline the importance coefficient.



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nodeproperties

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	nodeprop	Точність в	Нижня м	Верхня м	Кут нахил	Клас елек	Потужніс	Інтервал	Січення д	Максима	Наявність	Відповідн	Наявність	Показник	Максима	Наявність	Наявність	Наявність	Охоплені	Якість стр
2	Амперме	0.005	0	400	25	3	0.25	1	0.5	0.5	Так	Так	Так	0.01	30	Ні	Ні	Так	40	8
3	Амперме	0.01	0	500	20	3	0.1	1	0.5	0.5	Так	Так	Так	0.0005	25	Ні	Ні	Так	60	4
4	Амперме	0.0075	0	300	30	3	0.3	1	3	0.5	Так	Так	Так	0.01	40	Ні	Ні	Ні	70	6
5	Амперме	0.02	0	100	10	2	0.5	1	0.25	3	Так	Так	Так	1	45	Ні	Ні	Ні	80	7
6	Амперме	0.2	0	150	10	1	0.8	0.01	0.25	0.1	Так	Так	Так	0.01	43	Ні	Ні	Ні	30	3
7	Амперме	0.013	0	20	40	3	0.3	5	0.1	0.2	Так	Так	Так	0.02	42	Ні	Ні	Ні	25	8
8	Амперме	0.0014	3	250	50	1	0.25	1	0.5	0.1	Так	Так	Так	0.01	40	Ні	Ні	Так	60	6
9	Амперме	0.1	0	10	5	1	0.1	1	0.5	0.3	Так	Ні	Так	0.003	41	Ні	Ні	Ні	20	1

Figure 1: Google sheet with data.

The projects with a payback period of more than 25 years have been evaluated with 1 point, with 20–25 years of payback period with 2 points, from 15–20 years of payback period with 3 points, from 10–15 years of payback period with 4 points, 6–10 yeas of payback period with 5 points and with 1–5 years were evaluated as 6-10 points, respectively, by the "Economic attractiveness" criterion. A detailed evaluation for projects with 1–5 years is provided, due to it's utmost interest for the investor's "payback time" , which determines the expediency of investment.

3.3. Auditing tools

To provide an audit of hypothesis of work "A" and "B", the "standard" graph (with which the comparison is done) and the "comparison" graph (which is compared with the "standard") have been created. The "standard" ontology graph contains the data on hypotheses, subjects, objects of research, keywords, and other parameters, of the research reports done before. For the "standard" graph, each parameter was presented in a separate node. The content of this ontological graph "standard" is updates and supplemented constantly.

The nodes of the "comparison" graph have been represented as names of the works which need to be audited with the "standard" graph. The parameters of the work used to be audited with the "standard" graph have been located in the metadata of each separate node. The metadata type names were identical to the names of the nodes of the "standard" graph in order to enable interaction between graphs.

4. Results and discussion

The general concept of the proposed ontology-based graph model for Polyhedron research reports has a specific, logically connected structure and can be represented as an ontology. After structuration, it is possible to represent the reports' content in simpler to understand presentation form. Besides, most results can be domain specific for each industry, and if the current standards are correctly identified, these values will be easy to compare. Also, most research in one field often use the same equipment, materials, chemicals, standard methods of analysis, literature, etc., which allow comparing these works with each other and correctly structuration them.

However, the main advantage of the proposed approach (besides structuration of the research) is the processing of results in terms of separated result parameters of the reports. This supports data analysis, further processing using ranking, and semantic data interoperability. The separation of numeric data and its location metadata class is possible due to the addresses of the same field, that is describing the process using same (or similar) parameters of the process description and result parameters description. For example, for most reports on anaerobic digestion, the process parameters are on temperature, type of substrate, reactor volume, moisture content, initial pH, parameters; the characteristics of efficiency of the process are biogas yield, methane content, average pH during the process, destruction process etc. [61].

As all research reports will be presented in a simplified form, this approach will be especially relevant for pupils and novice researchers with further potential use in the educational process or to simplify the literature review process for the new educational research.

4.1. Description of scientific works used to provide structuration

As an example, the object of the study of research report "A" is the disposal of anaerobic effluent. The subject of the research of the report is the Cultivation of Chlorella Vulgaris microalgae on effluent obtained after methane fermentation. The study aims to develop a method of growing Chlorella Vulgaris in effluent after methane fermentation. The practical significance of this scientific work is the results of this work, which will contribute to the spread of biogas technologies. Also, the proposed approach makes it possible to increase the economic benefits from the utilization of chicken manure by converting the anaerobic digestion effluent into microalgae, that have a wide range of applications. The scientific novelty of that research report is a method of utilization of anaerobic digestion effluent by using microalgae, also had obtained cultures of Chlorella Vulgaris that had adapted to the anaerobic digestion effluent. The working hypothesis was that the effluent obtained after anaerobic digestion can be used as a nutrient medium for microalgae Chlorella Vulgaris.

The object of the study of the research report "B" is the disposal of anaerobic digestion effluent. The subject of the research is the processing of anaerobic digestion effluent into humates by the autocatalytic catalysis method. The study aims to establish regularities of processing of the solid fraction, which had obtained during the process of methane fermentation of chicken manure by autocatalytic catalysis method. The practical significance of this scientific work is that the study indicates the possibility of acquiring salts of humic and fulvic acids by the autocatalytic catalysis method. This approach makes it possible to increase the economic benefits from the disposal of chicken manure by converting the anaerobic digestion effluent into a more valuable product with a wide range of applications. Its scientific novelty is that potassium hu- mate had firstly obtained from anaerobic digestion effluent and for the first time the efficiency of receiving humates from the solid fraction of anaerobic digestion had investigated and the main regularities of the process determined. The working hypothesis was that the solid fraction of methane fermentation of chicken manure can be recycled by the autocatalytic catalysis method.

For both research report “A” and “B”, as a substrate for anaerobic digestion have used the chicken manure from the same poultry farm. In this case, chicken manure and its effluent, which has obtained by anaerobic digestion, were analysed by the same methods and indicators. Such indicators were: “ash and dry content”, “Determination of volatile fatty acids content” (in terms of acetic acid), “Determination of ammonium nitrogen content with Nessler’s reagent”. The equipment which has used to determine these indicators was also the same. Therefore, has considered how these works can be structured and integrated by using of the cognitive IT-platform Polyhedron. All examples of the usage ontological nodes the obtained graphs for further potential information processing are presented in table 4.

4.2. Structuration of the scientific works using ontologies

For the presentation of possibilities and systematization of the research report we have applied a ontological taxonomy for students’ works “A” and “B”. The general view of the obtained graphs is shown in figure 2 [31].

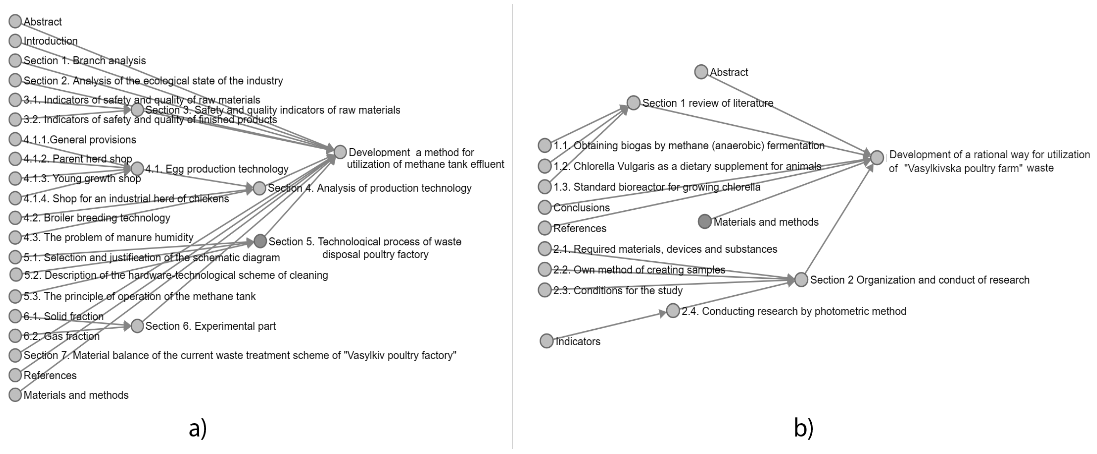


Figure 2: The general view of the (a) research report “A” (b) research report “B” ontological graph.

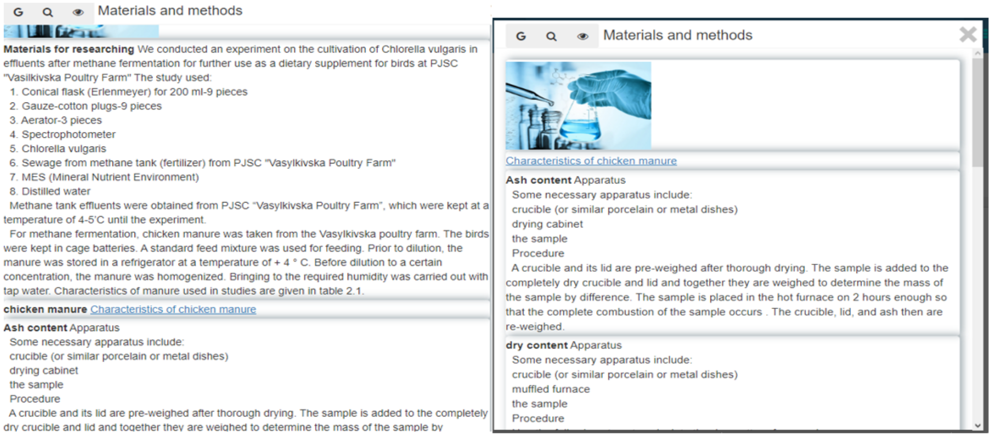
A separate node called “Abstract” has been created, which contains all the necessary metadata of the work such as “Object of the study”, “Subject of study”, “The aim of the study”, “Practical value”, “Scientific novelty”, “Keywords” and “Hypothesis of scientific works” in form of the attributes. All metadata have been used to provide filtering and ranking.

The “Materials and methods” node, which contains all the materials was used to perform the experiments. Every approach has been divided into the separate attribute of the node. This allows concentrating the reader’s attention, and it helps to process the data with each other. In further researchers, this mechanism will be described in detail. The general view of both works’ “Material and Methods” node is shown in figure 3 [31].

For each ontological node that duplicate sections of the research report, and that contain specific indicators after analysing, additional separate leaf nodes with these results have created. In this leaf node, all the issues are held in the form of semantic and numeric data. These results

Table 4
Examples of the usage of the educational research element in ontology

Element of the educational research	Example	The role of the node in the resulting graph	Using of the data
Title	**Node:** "Development a method for utilization of anaerobic digestion effluent"	Parent node	Used only for structuration
Object	**Node:** Abstract **Class:** Object (object is only one per report) **Value:** Anaerobic digestion; **Value:** Microalgae's growth **Value:** Disposal of the waste	Located in Abstract node; each object presented as attribute	Used for the audit; to provide literature review; to link reports for each other with same data; to identify novelty and plagiarism
Subject	**Node:** Abstract **Class:** Subject **Value:** The processing of anaerobic digestion effluent into humates by the autocatalysis method	Located in Abstract node; each object presented as attribute	Same as previous
Hypothesis	**Node:** Abstract **Class:** Hypothesis **Value:** Effluent obtained after anaerobic digestion can be used as a nutrient medium for microalgae Chlorella Vulgaris	Located in Abstract node; each object presented as attribute	Same as previous
Keywords	**Node:** Abstract **Class:** Keywords **Value1:** Biogas; **Value2:** Anaerobic digestion **Value3:** Microalgae	Located in Abstract node; each object presented as attribute	Same as previous
Sections, Abstract, Introduction	**Node:** Introduction; **Class1:** Text; **Value1:** text itself; **Class2:** Biogas production in literature, ml/g of VS; **Value2:** 368; **Class3:** methane content, % ; **Value3:** 59	Each section presented in separated nodes; all text is presented in separate class of metadata, based on type of data	Used for representing of the main text of the educational reports; structuration and navigation
Materials and methods	**Node:** Materials and methods **Class1:** Method1; **Value1:** Desorption1; **Class2:** Method2; **Value2:** Desorption2	Located single node; each method is separated class of metadata	Used to provide links between the reports used same method by indexing and search
Concrete results and parameters of the research	**Node:** Results **Class1:** pH; **Value1:** 7.3; **Class2:** Decomposition, %; **Value2:** 87	Located a in separate node; each parameter is separated class of metadata	Used for the creation of the single ranking tool to systemize results from same field
Economic data	**Node:**Economic data **Class:** Payback period, years; **Value:** 5.3	Located the separate node; payback period presented in metadata	Used to provide comparison of the approaches to assess investment attractiveness
References	**Node:** Li et al. 2018, Chen 2003, Sergienko et al. 2016	Each report (paper) located in separate node	Used to link reports used same reference with each other



a) b)

Figure 3: The general view of a) research report "A" b) research report "B" "Materials and methods" node.

are automatically available for filtering, auditing and ranking. An example of this leaf node is shown in figure 4.

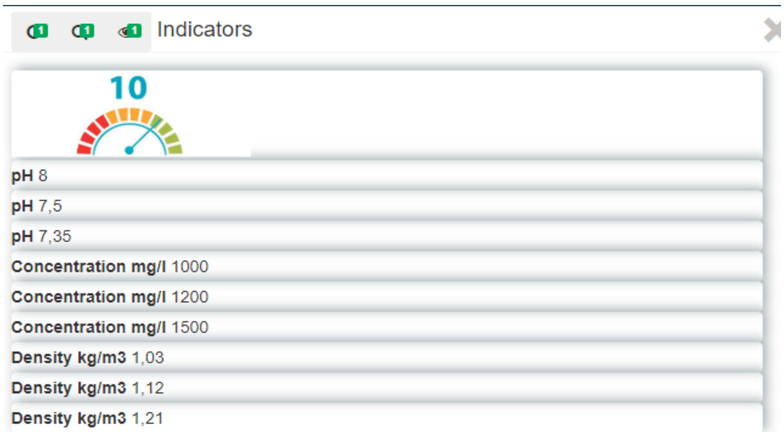


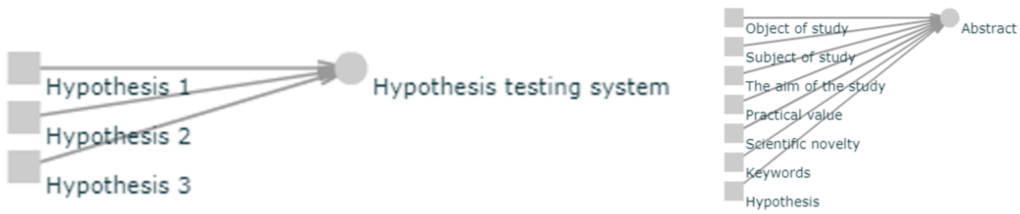
Figure 4: An example of leaf node with indicators after analysing.

5. Information processing of the research report using Polyhedron tools

5.1. Using an audit tool to test a hypothesis

The audit tool [25, 26, 27] can be used to compare the hypotheses, subjects, objects of research, keywords, and other parameters of the research reports. To demonstrate the capabilities of the audit tool, the focus is on auditing only hypotheses. A model version of the “standard” ontology has been created, which contains metadata from the “Abstract” node of the research reports “A” ontological graph. This ontology had a simple structure without branches with the parent node being named “Abstract”. The child nodes duplicate metadata from the “Abstract” node of the research reports “A”.

The “comparison” ontology has been created with the child nodes which contain the following hypothesis: the effluent obtained after anaerobic digestion can be used as a nutrient medium for microalgae Spirulina Platensis (hypothesis 1), the effluent obtained after anaerobic digestion can be used as a nutrient medium for microalgae Chlorella Vulgaris (hypothesis 2), the effluent obtained after anaerobic digestion cannot use it as a nutrient medium for microalgae Chlorella Vulgaris (hypothesis 3). The hypothesis 2 node also contain some metadata. This ontology also had a simple structure without branches with the parent node is the “Hypothesis test system”. The general view of the obtained ontology of the comparison and the ontology of the standard in taxonomic form is shown in figure 5.



a) b)

Figure 5: General view of in the taxonomic form the ontology of the “comparing” (a) and (b) the ontology of the “standard”.

Using the function of the audit the system has checked the hypothesis to be true or false. Those indicators which do not correspond to the standard have been colored by red. Thus, this solution will allow not only to test the hypothesis of these scientific works, but also to check other metadata that have already been set by using information from the “Abstract” node (see figure 6).

5.2. Analysing of the research reports result on the practice value

Research report “A” and research report “B” have been compared with each other by the following criteria “Short-term economic perspective”, “Long-term economic prospects”. According to section 2 of the research report “A”, the payback period of project “A” is five years, which corresponds to 6 points according to the criterion “Economic attractiveness”. This parameter is better for the project described in report “B” with a payback period of four years and three months which corresponds to 5 points on “Economic attractiveness”. The system provides raking of the results. In case, if there will be a large amount of the data, the instrument, will be useful to quickly and effectively evaluate the projects on “Economic attractiveness”. Besides, in further research, the other criteria will be justified and used to provide data management on

Hypothesis testing system
(Аудит)

Враховуються властивості

#	Показники	Одиниця виміру	ДСТУ	Зразки		
				supposition 1	supposition 2	supposition 3
Abstract						
1	Object of study	Object of study	Chlorella vulgaris		Chlorella vulgaris	
2	Subject of study	Subject of study	Cultivation of Chlorella vulgaris microalgae on effluents obtained after methane fermentation.		Cultivation of Chlorella vulgaris microalgae on effluents obtained after methane fermentation.	
3	The aim of the study	The aim of the study	Developing a method of growing Chlorella Vulgaris in effluents after methane fermentation.		Developing a method of growing Chlorella Vulgaris in effluents after methane fermentation.	
4	Practical value	Practical value	The results of this work will contribute to the spread of biogas technologies. This approach makes it possible to increase the economic benefits from the utilization of bird droppings by converting the anaerobic digestion effluents into microalgae that have a wide range of applications.		The results of this work will contribute to the spread of biogas technologies. This approach makes it possible to increase the economic benefits from the utilization of bird droppings by converting the anaerobic digestion effluents into microalgae that have a wide range of applications.	
5	Scientific novelty	Scientific novelty	A method of utilization of methane tank effluent using microalgae is proposed. Cultures of Chlorella Vulgaris were adapted to the methane tank effluent.		A method of utilization of methane tank effluent using microalgae is proposed. Cultures of Chlorella Vulgaris were adapted to the methane tank effluent.	
6	Keywords	Keywords	microalgae		Chlorella Vulgaris	
7	Hypothesis	Hypothesis	The effluent obtained after anaerobic digestion can be used as a nutrient medium for microalgae Chlorella Vulgaris.	The effluent obtained after anaerobic digestion can be used as a nutrient medium for microalgae Spirulina Platensis.	The effluent obtained after anaerobic digestion can be used as a nutrient medium for microalgae Chlorella Vulgaris.	The effluent obtained after anaerobic digestion can not used it as a nutrient medium for microalgae Chlorella Vulgaris.

Figure 6: General view of the audit results in the “Hypothesis test system” ontology.

the educational research, which will make the tool more functional. The general view of the ranking result is presented in figure 7.

6. Discussion

The proposed database follows the “Leiden Manifesto of Scientometrics”. In the obtained ontological database quantitative evaluation can be supported by qualitative expert assessment. Additionally, this ontological database can unite the research missions of the institution, group, or researcher and protect excellence in internally relevant research. The ontological form of research reports can keep data collection and analytical processes open, transparent, and simple. Because all metadata is contained in a separate node that can be expanded and supplemented. Thus the obtained ontological database can also account for variations, e.g. in publication and citation practices and it can provide a base assessment of individual researchers in a qualitative judgment of their portfolio. Because all ontological graphs are validated by experts, in this way it is possible to avoid misplaced concreteness, including false precision and recognize the systemic effects of all assessment and indicators. In addition, in the obtained ontological database indicators can be scrutinized regularly and updated. Furthermore, the proposed ontology-based

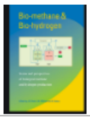
Postion	Name	Short ecomonic perspective, points
1	**Development a method for utilization of methane tank effluent** 	8
2	**Development of a rational way for utilization of meta-tank waste at PJSC Vasylkivska poultry farm** 	6

Figure 7: General view of the ranking result.

research reports can be integrated in a single environment – ontology repositories, as it was proposed before [62].

The process starts from the paper creation, for this stage we can use various text editors, for example, word or google doc. Then expert or author of the paper will formulate metadata, which is necessary for the ontology. For this purpose, the author will use Microsoft Excel or Google Sheets. Then, an editor needs to add information in the graph, in our occasion it is the IT Platform Polyhedron. And last, but not least it is possible to use the "Alternative" system, which includes Audit, Filtering and Ranking instruments. All proposed instruments are illustrated in the workflow diagram in figure 8.

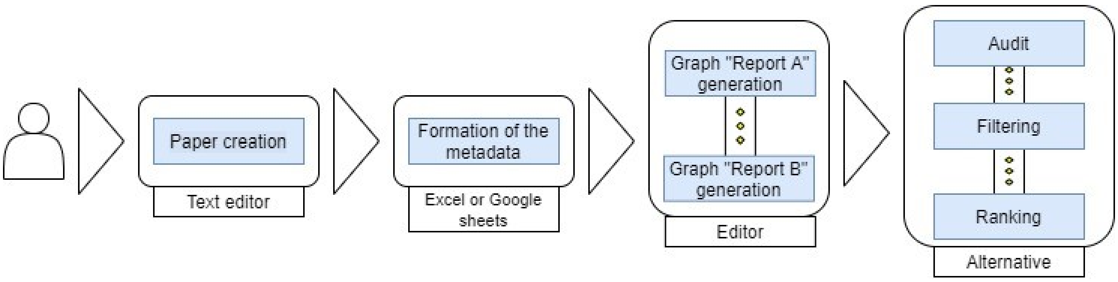


Figure 8: Workflow diagram of the creation of structured ontologies on scientific reports and their processing.

7. Conclusions

An ontological approach for the systematization of scientific works has been proposed, which also ensures their interoperability. A method of research reports structuration using digital taxonomies (ontologies) has been developed. It supports using the native structure of the reports to define hierarchical relations of the nodes. Concrete parameters were added as metadata (semantic, numeric, pictures and links) of the nodes to provide processing using Polyhidron tools. Ranging and filtering were used for semantic and numeric metadata processing. Obtained results provide interoperability between different research reports (including educational). The obtained ontological approach follows the "Leiden Manifesto of Scientometrics".

Further research will be devoted to provide even better interoperability between research works by providing generation of one single taxonomy that provides hierarchization by same methods, literature and results of the reports and its processing using both, methods proposed in the research and newly developed ones.

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Applying digital technologies for work management of young scientists' councils

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Abstract

The publication explores the features of the digital technologies' usage to organize the work of the Young Scientists' Councils and describes the best practices. The digital transformation of society and the quarantine restrictions caused by the COVID-19 pandemic have forced the use of various digital technologies for scientific communication, the organization of work for youth associations, and the training of students and Ph.D. students. An important role in increasing the prestige of scientific activity and encouraging talented young people to participate in scientific projects belongs to the Young Scientists' Councils, which are created at scientific institutions and higher education institutions. It is determined that the peculiarities of the work of Young Scientists' Councils are in providing conditions for further staff development of the institution in which they operate; contribution to the social, psychological and material support of young scientists and Ph.D. students; creating an environment for teamwork and collaborative partnership; development of leadership and organizational qualities; contribution to the development of digital competence. The advantages of using electronic social networks in higher education and research institutions are analyzed, namely: general popularity and free of charge; prompt exchange of messages and multimedia data; user-friendly interface; availability of event planning functions, sending invitations, setting reminders; support of synchronous and asynchronous communication between network participants; possibility of access from various devices; a powerful tool for organizing the learning process; possibility of organization and work of closed and open groups; advertising of various events, etc. Peculiarities of managing the activity of the Young Scientists' Council with the use of digital technologies are determined. The Young Scientists' Council is a social system, and therefore the management of this system refers to social management. The effectiveness of the digital technologies' usage to manage the activities of the Young Scientists' Council depends on the intensity and need for their use to implement organizational, presentation functions and to ensure constant communication. The areas to apply digital technologies for the work managing of Young Scientists' Councils are sorted as the presentation of activity; distribution of various information for young scientists; conducting questionnaires, surveys; organization and holding of scientific mass events; managing of thematic workgroups, holding of work meetings. It is generalized and described the experience of electronic social networks usage for organizing and conducting of scientific mass events.

Keywords
digital technologies, young scientists, Ph.D. students, doctoral students, electronic social networks, information support, management, scientific work

1. The statement of the problem

Currently, countries with developed economies pay special attention to the promotion of science and the active involvement of young people in promising research conducting. An important role in this process belongs to youth associations, and in particular to the Young Scientists' Councils. Youth activities within the Young Scientists' Councils are a way to hear the voice of young scientists in higher education, research institutions, both nationally and internationally. The establishment of Young Scientists' Councils provides not only the conditions for further staff development of the institution in which such a Council operates, but also contributes to the social, psychological, and material support of young scientists and Ph.D. students.

For the scientific youth of Ukraine, the creation and operation of the Young Scientists' Councils have become a platform for uniting efforts and cohesive cooperation based on partnership, not competition. Such interaction forms a desire not just to follow the leader, but to be cooperative and have the opportunity to become a leader oneself. A young scientist is not only an age category. This is an important stage in the formation of a scientist when there are more questions than answers. And at this stage, it is important to support more experienced colleagues, but not from the authoritarianism or dominance standpoint, but from the standpoint of partnership, to guide the young scientist not only to improve what already exists but to find non-standard solutions, create a unique product [1].

We agree with what is stated in [2], that the functioning of the Young Scientists' Council is extremely important in the context of the European Higher Education and Research Area building, which will allow Ukrainian young scientists to be at the epicenter of European information space, to represent and lobby the interests of scientific youth in the European space and to promote contacts with national associations of young scientists and other academic partners of different countries.

The modern period of social development is characterized by the digitalization of all spheres of life: from politics and government to education and science [3, 4, 5, 6]. The general availability and dissemination of digital technologies as an integral part of digital society contributes to the renewal of work functions, simplifies the processes of interaction and experience exchange between people [7]. Also, the development of digital competence is important, especially for researchers and lecturers [8, 9, 10, 11]. Because researchers conduct research that must

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be performed following current scientific trends and be presented to the general public in an accessible form. And lecturers in higher education institutions should ensure the implementation of modern scientific findings in the educational process, being responsible for the training of future professionals of the new technological era. And applying digital technologies, particularly electronic social networks, is convenient and free of charge to develop the specialists' digital competence in various fields [12, 13].

According to scientists, electronic social networks are experiencing not only the peak of popularity but also the stage of rapid development. The main factors of the attractiveness of social networks for users are free registration, popularity, the ability to choose the language of the site, free services, the ability to create your own content, posting photos, videos, chat functions, the ability to create closed and open groups, etc. Electronic social networks are more and more often used by various organizations and enterprises to present activities and interact with consumers.

As digital technologies allow integrating different forms of information presentation, as well as combining methods of communication and interaction, we consider them an important tool for organizing the activities of Young Scientists' Councils and promoting science among the general public.

Information on the activities of youth associations in the scientific and educational spheres, in particular on the work of the Young Scientists' Councils, is presented mainly on the official websites of various institutions, and there are only a few cases of scientific publications related to this issue. Various aspects of the use of digital technologies in higher education and research institutions are described in [12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25]. After analyzing scientific publications and Internet sources on the electronic social networks' usage for various fields of knowledge, these publications were systematized in the following areas [26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47]: the implementation of electronic social networks in the work of educational institutions; to manage social systems; for information and analytical support of scientific research; for journalism; for sociology; for psychology, however, the usage of electronic social networks for information support of youth associations, in particular the Young Scientists' Councils, is considered insufficiently. We believe that it is important to analyze the features of the usage of digital technologies, particularly electronic social networks, to organize the work of the Young Scientists' Councils.

The goal of the article is to explore the features of digital technologies' usage to organize the work of the Young Scientists' Councils, and to describe the best practices.

2. Research results

2.1. Features of the Young Scientists' Councils work

An important aspect for the training of future doctors of philosophy and the becoming of young scientists is the activities of various youth associations, namely: Scientific societies of students, Ph.D. students, doctoral students, and young scientists; Young Scientists' Councils; Public youth organizations, associations.

Let's analyze the features of the *Young Scientists' Councils* functioning, which are formed in higher education institutions, research institutions, and regional state administrations. The main purpose of the Young Scientists’ Council is to promote the rights of young scientists, to ensure their active participation in research, and to protect their interests.

Let’s take a look at the activities of the **Young Scientists’ Council at the Ministry of Education and Science of Ukraine** and its impact on the formation of youth policy in the field of education and science of Ukraine. The Young Scientists’ Council at the Ministry of Education and Science of Ukraine is an advisory body established to promote the constitutional rights of young scientists to participate in the formation and implementation of state policy in the field of science, science-technology, and innovation activities. Since 2014, the Council is the legal successor of the Young Scientists’ Council at the State Agency for Science, Innovation, and Informatization of Ukraine [2]. In figure 1 it is provided information about the Young Scientists Council at the Ministry of Education and Science of Ukraine at the official website of the Ministry.

Figure 1: Website information about the Young Scientists’ Council at the Ministry of Education and Science of Ukraine.

The main tasks of the Young Scientists’ Council at the Ministry of Education and Science of Ukraine are:

- promoting the cooperation between the Ministry of Education and Science of Ukraine and self-governing scientific youth organizations of research and higher education institutions of Ukraine;
- advisory support to young scientists in research activities, cooperation with foreign customers of scientific products, etc.;
- formation of proposals to create legal and socio-economic conditions for attracting talented youth to work in the scientific field, stimulating the professional activity of young scientists in local research and higher education institutions, raising their professional level, and realization of their creative and professional activity;
- assistance in attracting young scientists to participate in competitions of scientific works, formation of young scientists' teams for implementation of perspective scientific projects [2].

On the Ministry of Education and Science of Ukraine website [2] it is described the main activities of the Young Scientists Council at the Ministry of Education and Science of Ukraine:

1. Advisory area – participation in the development of bills and regulations, appeals to the authorities with proposals; participation in parliamentary and committee hearings. During the functioning of the Council, it was prepared a number of proposals (draft amendments, reports, justifications, etc.) to the Laws of Ukraine and other regulations in the field of science and education.
2. Information and communication area – is aimed at communication between individuals and legal entities on the exchange of information (e-mailing, coverage of activities, and current opportunities for young scientists in social networks, etc.). In order to implement this, the following was created: an electronic newsletter with more than 4,000 subscribers – young scientists of Ukraine; Facebook page [48] with more than 6,000 followers, Instagram, Twitter; information groups in social messengers Viber, Telegram; YouTube channel; publications in the newspapers "Osvita Ukrainy", the journal "Vyshcha Shkola", the Eurodoc bulletin "Newsletter", the magazine "Nasha Perspektyva" and others.
3. The international area is aimed at representing the community of young scientists of Ukraine in the global environment (membership and cooperation with the European Council of Doctoral Candidates and Junior Researchers of Eurodoc and Milset Europe). Among the achievements and activities of the members of the Council of Young Scientists at the Ministry of Education and Science of Ukraine in Eurodoc there are the following: membership in Eurodoc working bodies (Board, Advisory Board, Administration); participation in Eurodoc working groups on employment and research careers, education policy research, interdisciplinary research, open access, and mobility; Plenary Meetings delegates and observers; translation into Ukrainian and promotion of the European Charter for Researchers and the Employment of Researchers' Code; participation in workshops at the Eurodoc Plenary Meeting on research integrity and training for new Eurodoc delegates; annual reports on the Conference and the Plenary Meeting, as well as participation in the Annual Questionnaire; editing the Eurodoc Newsletter bulletin; development and administration of a new Eurodoc website; participation in the development of European and Eurodoc documents; participation in the preparation of Open Science Ambassadors;

participation in the European Commission Expert Group – Commission Expert Group in Graduate Tracking, Bologna Follow Up Group; participation in the development of the direction concerning academic diplomacy – presenting Ukraine for representatives of European national organizations of young scientists, dissemination of information about Ukraine; international experience usage to formulate proposals for regulations and their argumentation for key stakeholders in Ukraine; informing the community on topical issues of science and higher education in Europe; development of documentation and the Code of Experts in the Call for Proposals of young scientists of the Ministry of Education and Science, based on the Code of Conduct for Experts of the European Research Council (ERC) and the European Charter for Researchers [2]. The activities of the Young Scientists' Council at the Ministry of Education and Science of Ukraine in are mentioned MILSET. MILSET is an international movement for leisure in science and technology, which is a non-governmental, non-profit, and politically independent youth organization that aims to develop a scientific culture among young people through scientific-technical programs, including exhibitions, congresses, and other events. Also, the Young Scientists' Council at the Ministry of Education and Science of Ukraine signed a declaration on cooperation with the Young Scientists' Council at the Ministry of Science and Higher Education of the Republic of Poland.

4. Organizational area – activities for the organization (co-organization) of events on different levels, namely: round tables, seminars, and webinars, conferences, International Youth Science Festival, international conferences, forums, projects, youth competitions, etc.

Also, the Young Scientists' Council at the Ministry of Education and Science of Ukraine participates in the work of competition commissions and workgroups in the field of science and education, namely [2]:

- it is organized and held a competition for the selection of experts among young scientists of higher education and research institutions of Ukraine to participate in the review of research projects submitted to competitions for funding from the state budget;
- the competition commission of the Competition of scientific projects for young scientists;
- the competition commission for awarding the Prize of the Verkhovna Rada of Ukraine to young scientists and nominal scholarships of the Verkhovna Rada of Ukraine for young scientists – doctors of sciences;
- the workgroup on the preparation of proposals for the development and improvement of the legal framework for the implementation of scientific and scientific-technical activities of the Ministry of Education and Science of Ukraine;
- the competition commission for the award of academic scholarships for students and cadets named after the Heroes of the Heavenly Hundred;
- the Head of the Young Scientists' Council at the Ministry of Education and Science is included in the Board of the Ministry of Education and Science of Ukraine.

We support the opinion stated in [49] that young scientists are a powerful intellectual force that builds the scientific future of the country, actively influencing the formation of the strategy of socio-economic and political development of the state. The Ministry of Education and Science of Ukraine actively supports young scientists in their efforts to unite for the active development of the youth scientific movement. The active work of the Young Scientists' Council at the Ministry of Education and Science of Ukraine confirms the effectiveness of constructive cooperation of young scientists with public authorities and public associations and the high potential for interaction of representatives of various youth scientific associations. Based on the European vision and approaches to scientific career and scientific policy, the Young Scientists' Council at the Ministry of Education and Science will build and strengthen its expert advisory activities for all categories of national stakeholders and work for effective transformations in science and higher education in Ukraine.

Let's analyze in more detail the activities of the *Young Scientists' Council at the National Academy of Educational Sciences of Ukraine* (figure 2). The Young Scientists' Council at the National Academy of Educational Sciences of Ukraine (NAES of Ukraine) is a collegial elected advisory body of the NAES of Ukraine, which unites young scientists of subordinate scientific institutions of the NAES of Ukraine. The Young Scientists' Council of NAES of Ukraine was established in 2016. The activities of the Council are carried out on a voluntary basis and are based on the following principles: scientific ethics; freedom of scientific creativity; equality of all its members; publicity and openness in work; voluntariness and collegiality; democracy; periodic election and reporting. The Council carries out its activities in order to represent, protect, and promote the rights and interests of young scientists of subordinate institutions of the NAES of Ukraine, ensuring their active participation in scientific research. The Facebook page of the Council [50] constantly covers data on various events for young scientists, publishes various news and photo-reports of events in which members of the Council participate. Also, a Youtube channel was created to present activities and post recordings of various events organized by the Council.

The main tasks of the Young Scientists' Council at the NAES of Ukraine are [51]:

- to unite young scientists of subordinate institutions of the National Academy of Educational Sciences of Ukraine in conducting scientific activities, to prepare proposals for the development of the system of their grant, scholarship, and other forms of support;
- to promote the involvement of young scientists in competitions for scientific works, the formation of young scientists' teams to implement promising research projects;
- to promote scientific activities, advanced training, career growth, realization of creative potential, providing informational and organizational support to young scientists of subordinate institutions of the NAES of Ukraine;
- to support young scientists of subordinate institutions of the NAES of Ukraine in conducting scientific, scientific-organizational and scientific-educational activities;
- to promote the development and improvement of the scientific sphere of Ukraine and its integration into the world and European research space.

The Young Scientists' Council at the NAES of Ukraine provides such activities [51]:

- assistance in establishing professional contacts between the subordinate institutions of the National Academy of Educational Sciences of Ukraine, scientific, and higher education

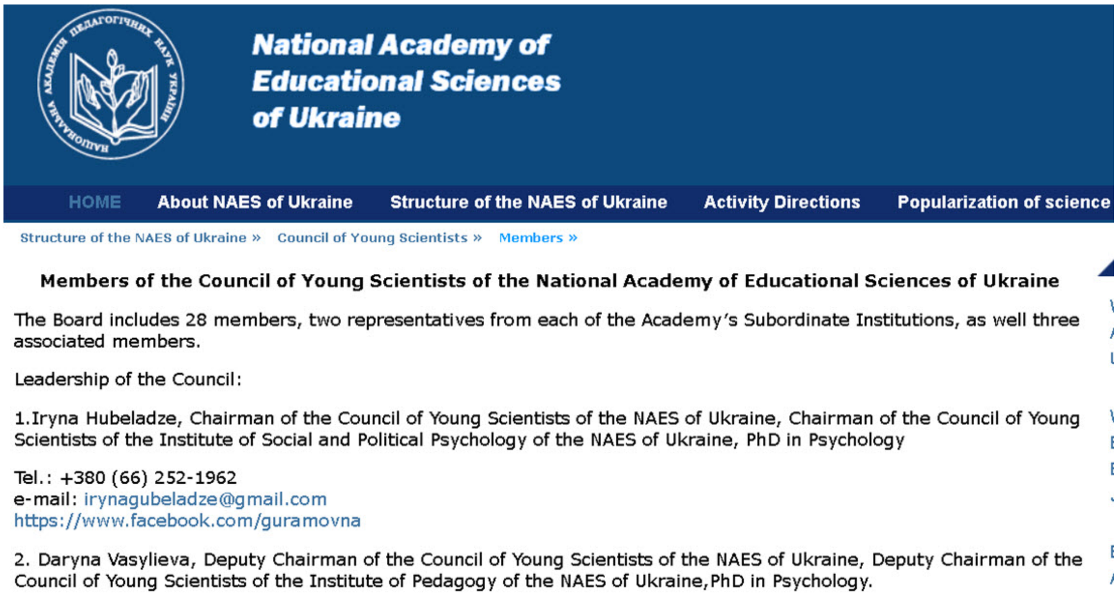

Figure 2: Website information about the Young Scientists' Council at the National Academy of Educational Sciences of Ukraine.

institutions of Ukraine, public scientific organizations and foreign scientific organizations to deepen scientific cooperation and joint scientific, scientific-organizational, and scientific-educational activities;

- ensuring information exchange among young scientists: dissemination of scientific and other information related to the activities of young scientists; providing information on awards, scholarships, grants, conferences, schools and other activities to support young scientists;
- participation in the nomination of applicants from subordinate institutions of the NAES of Ukraine for scholarships and awards for young scientists;
- organization and holding of scientific and scientific-practical conferences, seminars, schools, and other scientific, scientific-organizational, and scientific-educational events;
- popularization of science in Ukrainian society, in particular among schoolchildren and students, by organizing and conducting excursions, lectures, "scientific picnics" and other modern forms of educational work;
- preparation of proposals on improving the social guarantees of young scientists of the NAES of Ukraine, in particular improving the living conditions of young scientists through priority preferential youth lending for construction (reconstruction) and purchase of housing, including the provision of service housing, creating opportunities for their rehabilitation, proper scholarship support for Ph.D. and doctoral students;
- delegation of representatives of the Council to the composition of workgroups (expert commissions) created by the Presidium of the NAES of Ukraine to address issues related to the main tasks of the Council;
- creation and support of information resources of the Council in order to disseminate

information about its activities, provide information support to young scientists, etc.;
- organization and holding of cultural, educational, and sports events, social projects.

Powers of the Young Scientists' Council at the NAES of Ukraine are: to represent the rights and interests of young scientists of subordinate institutions of the NAES of Ukraine; to delegate members of the Council to participate in the general meetings of the NAES of Ukraine; to develop annual work plans of the Council and to ensure their implementation; to elect the Head, the Deputy Head, and the Secretary of the Council; to inform young scientists of subordinate institutions of the NAES of Ukraine about their activities; to make proposals to the Presidium of the NAES of Ukraine, public authorities, public organizations regarding the solution of problems of young scientists; to perform other functions that don't contradict the Regulations. The main events that are constantly held by the Young Scientists' Council at the NAES of Ukraine:

1. English-speaking seminar "OPEN UP!". In order to develop the *foreign language competence* of young scholars, the Council launched a monthly seminar, where everyone, regardless of the level of language proficiency, has the opportunity to gain experience of discussion in English. The coordinator is the Young Scientists' Council at the Institute of Social and Political Psychology of the NAES of Ukraine.
2. Round table "Scientific youth in the context of Ukraine's integration into the international educational and scientific space". The coordinator is the Young Scientists' Council at the State Scientific and Pedagogical Library of Ukraine named after V. O. Sukhomlinskyy. The round table is held to *exchange experiences* between young scientists of the National Academy of Educational Sciences of Ukraine and higher education and other scientific institutions of Ukraine.
3. Training-marathon "OPEN AIR". In order to put the results of scientific research into practice, the Council launched an annual training-marathon. The trainers are the members of the Council. The training topics are chosen annually by open voting.
4. All-Ukrainian scientific-practical conference of students, Ph.D. students and young scientists "Academic culture of the researcher in the educational space", which is held in cooperation with Sumy State Pedagogical University named after A. S. Makarenko in order to *defend the principles of academic integrity*. The coordinator is the Young Scientists' Council of the Ivan Zyaziun Institute for Pedagogical Education and Adult Education.
5. All-Ukrainian scientific-practical conference of young scientists "Scientific Youth". It is held to exchange experiences and to cooperate with the Young Scientists' Councils at the National Academy of Sciences, the Ministry of Education and Science, and single higher education institutions. The coordinator is the Young Scientists' Council at the Institute of Information Technologies and Teaching Tools of the NAES of Ukraine. Also, round tables and master-classes are held during the conference.
6. Cooperation with the Young Scientists' Councils of the National Academy of Sciences, the Ministry of Education and Science, and branch academies of sciences.
7. Seminars, master-classes for young scientists in order to develop digital competence and master webometric methods of evaluating scientific results.

The publication on the work of the Young Scientists' Council at the NAES of Ukraine [1] states that given the experience of European colleagues, it is extremely important to study the quality of Ph.D. training in Ukraine, opportunities for young scientists employment, mental health, work-life balance, geographical, intersectoral and interdisciplinary mobility at all stages of career, favorable research environment, (in)stability of employment, financing, and pensions, etc. The Young Scientists' Council at the NAES of Ukraine is actively involved in resolving these issues.

Let's also describe the features of the **Young Scientists' Council at the National Academy of Sciences of Ukraine** [52]. The Young Scientists' Council at the National Academy of Sciences of Ukraine (NAS of Ukraine) is a collegial elected advisory body of the NAS of Ukraine, which unites young scientists of scientific institutions of the NAS of Ukraine. The activity of the Young Scientists' Council at the NAS of Ukraine (figures 3, 4) is carried out on a voluntary basis and is based on the principles of scientific ethics; freedom of scientific creativity; equality of all its members; publicity and openness in work; voluntariness and collegiality; democracy; periodic election and reporting.

Figure 3: Website information about the Young Scientists' Council at the National Academy of Sciences of Ukraine.

The main tasks of the Young Scientists' Council at the NAS of Ukraine are:

- to unite young scientists in conducting scientific activities, to prepare proposals for the development of their grant system, scholarship and other forms of support;
- to promote the implementation of scientific activities, training, career growth, creative potential, providing informational and organizational support to young scientists of scientific institutions of the NAS of Ukraine;

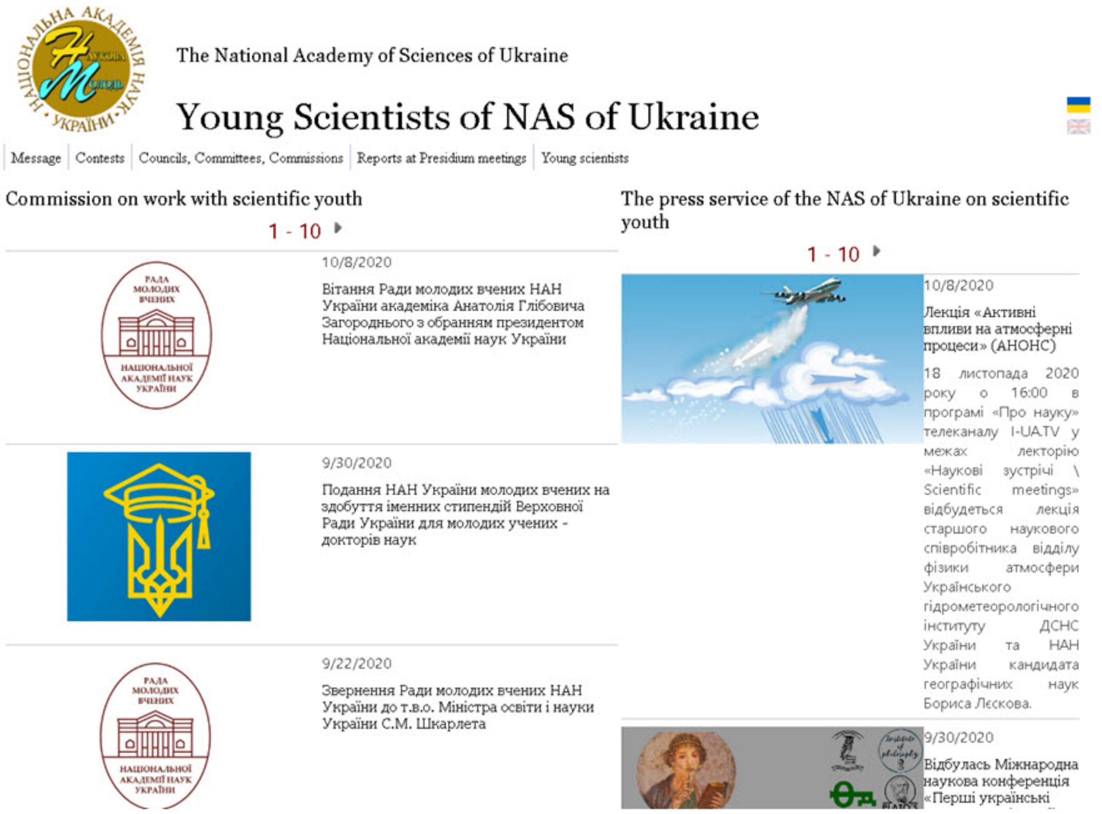

Figure 4: Website information about events and activities of the Young Scientists' Council at the National Academy of Sciences of Ukraine.

- to support young scientists of scientific institutions of the National Academy of Sciences of Ukraine in conducting scientific, scientific-organizational and scientific-educational events;
- to promote the development and improvement of the scientific sphere of Ukraine and its integration into the world and European research space.

Areas of activity of the Young Scientists' Council at the NAS of Ukraine are as following:

1. To represent the interests of young scientists of the National Academy of Sciences of Ukraine, state and public organizations, and provide assistance in solving the young scientists' problems.
2. To promote the establishment of professional contacts between scientific institutions of the NAS of Ukraine, institutions of higher education of Ukraine, and foreign scientific organizations to deepen scientific cooperation and joint conduct of scientific, scientific-organizational, and scientific-educational activities.
3. To provide information exchange among young scientists: dissemination of scientific and other information related to the activities of young scientists; providing information on

awards, scholarships, grants, conferences, schools, and other activities to support young scientists.

4. To organize and conduct scientific and scientific-practical conferences, seminars, schools, and other scientific, scientific-organizational, and scientific-educational events.
5. To popularize science in Ukrainian society, in particular among schoolchildren and students, by organizing and conducting excursions, giving lectures, "scientific picnics" and other modern forms of educational work.
6. To prepare proposals on improving the social guarantees of young scientists of the NAS of Ukraine, in particular the proper compensation for their work, improving the living conditions of young scientists, including providing them with official housing, creating opportunities for their recovery, proper scholarships for Ph.D. and doctoral students.
7. To delegate representatives of the Council to the working groups (expert commissions) established by the Presidium of the NAS of Ukraine to address issues related to the main tasks of the Council, and to the Commission on work with scientific youth of the NAS of Ukraine.
8. To create and maintain information resources of the Council in order to get acquainted with their own activities, provide information support to young scientists, etc.
9. To organize and conduct cultural, educational, and sporting events.

It is also important for this study to consider the experience of international associations of young scientists. For example, in Europe, a powerful organization that brings together young researchers from different countries is the **European Council of Doctoral Candidates and Junior Researchers – Eurodoc**, which is founded in 2002 as an international, non-profit organization. The [53] states that Eurodoc unites national organizations of graduate and junior researchers from 26 countries and is essentially a confederation of more than 35 national associations of graduate and junior researchers from the EU and the Council of Europe, which aims to unite the youth academia space in Europe and to represent its interests. The aim of Eurodoc's work is to develop an ERA in which all researchers have the same status and equal rights and opportunities (funding, pensions, social protection), to defend the interests of junior researchers. Eurodoc officially supports the European Charter for Researchers (recommendations of the European Commission's "good practices" for researchers and their employers) and the Personnel Policy Code for Scientists (employment and career advancement of researchers). Figure 5 presents the main page of the Eurodoc website (as of 2020).

The main tasks of Eurodoc activities are [54]:

- Represent doctoral candidates and junior researchers at the European level in matters of their education, research, and professional development.
- Advance the quality of doctoral programs and the standards of research activity in Europe.
- Promote the circulation of information on issues regarding ECRs and organize events.
- Participate in debates, and assist in the elaboration of policies about Higher Education and Research in Europe.
- Establish and promote cooperation between national associations representing doctoral candidates and junior researchers within Europe.

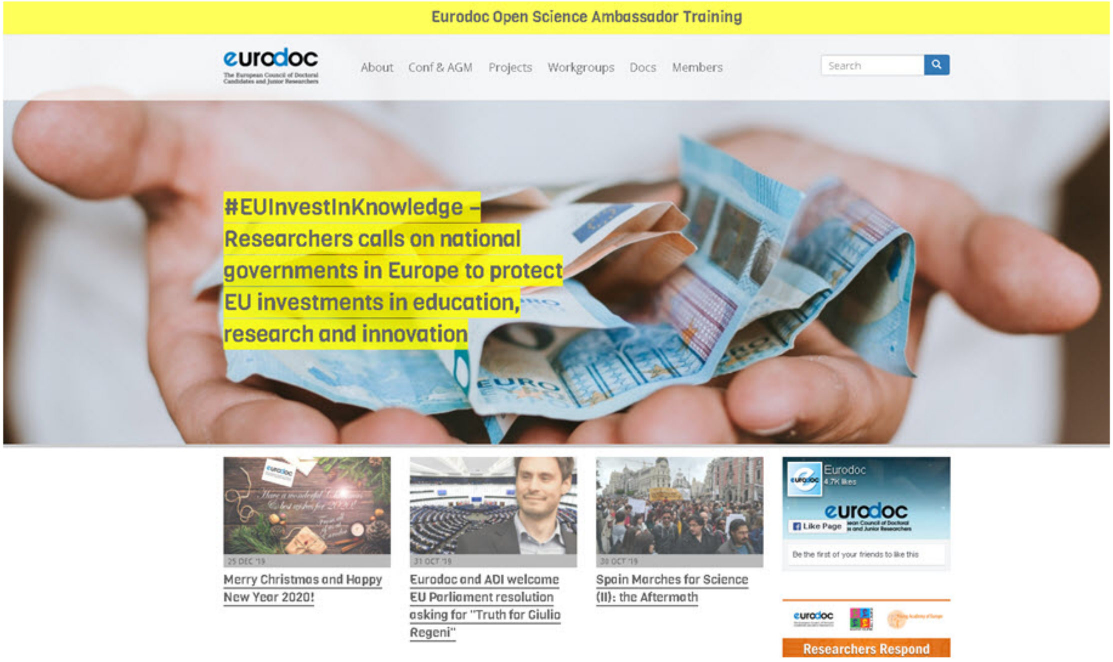

Figure 5: Eurodoc website main page (as of 2020).

The Eurodoc website presents a variety of projects carried out by members of the organization and which you can join as a contractor or propose your own project.

2.2. Applying electronic social networks at higher education and research institutions

A significant increase in the diversity of electronic social networks and the number of their users is one of the forms of self-expression, self-presentation, and development of network communication, which is the basis of the digital society. Also, the electronic social networks' usage is an important tool for the development of the digital competence of users.

Electronic social networks have a different interface and purpose, their audience, mechanisms and certain rules. Scientists distinguish the following types of networks: professional, universal, thematic (academic or research) [7].

Users of electronic social networks have the following opportunities: the view of posted information regardless of location; its storage both in the closed mode (accessible only to the author), and open mode (accessible to all users); systematization of data and organization of search by keywords; collecting data into thematic groups; discussion of available materials; analysis and evaluation of the quality of information posted on the service, etc. This feature of online social services determines their advantages over global network sites, which are essentially just data warehouses. Network social services include: social search engines, social networks, blogs, Wiki, social media repositories, geographic information services [15].

The results of the study on electronic social networks usage in Turkish state universities are described in [26]. It is determined that among 658 teachers from eight different universities, the biggest motivating factor for such usage is that social networks provide fast and effective communication with colleagues and students [26]. A similar study on the electronic social networks' usage in universities was conducted among teachers and students of Malaysian and Australian universities. The studies' results showed that students found a number of advantages in using electronic social networks to interact with each other and with their teachers. The vast majority of students and teachers are positive about the electronic social networks' usage to enhance interaction with each other to get better learning outcomes and address organizational issues related to learning [29].

Various scientific publications were analyzed to study the peculiarities of Twitter, Instagram, and WhatsApp usage in universities. The study [34] analyzed publications on Twitter usage for educational purposes. It is concluded that Twitter was most often used for communication and evaluation. Teachers send students important information on Twitter about courses, homework, and test deadlines [34]. The experience of Twitter and WhatsApp usage to teach medical students is described in [30]. It is noted that professional societies have used various social media platforms, such as Twitter and WhatsApp, to improve lifelong learning through online discussions in closed groups. WhatsApp usage allows you to quickly share and discuss learning material through group chat, based on the case-study method. The purpose of group learning chat is to discuss specific learning situations on a case-by-case basis and to stimulate interesting discussions. WhatsApp was chosen as an interactive platform because it allows you to send instant messages, an unlimited number of participants, encrypt texts at the end, and the ability to evaluate participation and engagement in the discussion [30]. Instagram can also be used for professional development and training. The experience of using Instagram to train future physicians in the discipline of radiology is described in the publication [33].

Exploring the peculiarities of Facebook network usage in universities, various scientific publications were analyzed. The results of a study on the electronic social networks' usage among future bachelors at the University of Western Australia are described in the article [27]. The study results showed that students were satisfied with their learning experience using Facebook because they were able to write their questions and get advice and answers from other students and teachers, they felt encouraged to learn through such cooperation [27]. The impact of the official Facebook group on learning outcomes is described in the study [35]. The results of the study showed that students who used the group on Facebook at the beginning of the training course reported a sense of greater social connection, better relationships with teachers, and less stress associated with training courses compared to students who did not have Facebook groups. Also, the presence of an official group on Facebook indirectly increased the satisfaction of the course through social connections. The impact of Facebook on distracting students from the learning process is described in the publication [28]. Modern requirements for socialization and processing of disparate information on Facebook can also have a detrimental effect on students' academic performance. After the study, teachers and students were informed about the importance of regulating their own behavior regarding the frequency of using Facebook for entertainment.

Features of the electronic social networks' usage to manage the educational social system are described in the paper [38]. The factors influencing the functioning of the educational social system are considered, the corporate social network's usage as an object of management is substantiated. The peculiarities of the corporate social networks' usage are analyzed, their potential for usage in the management of the educational social system is determined.

The publication [55] states that electronic social networks can be helpful to support the educational process of higher education institutions in the following areas: supporting the study of various disciplines; management of the educational process of a higher education institution; electronic social networks' usage to perform research work at the university; formation of the image of a higher education institution in the Internet environment.

As a result of the analysis of scientific publications [26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38] and personal experience [7, 44, 45, 46, 55, 56] there are identified the benefits of electronic social networks' usage in educational and research institutions, namely: accessibility and free of charge; interest and motivation of users to apply them into everyday practices; user-friendly intuitive interface; creating of the content of one's own; possibility of operative messages' and multimedia data's exchange; the possibility of organizing thematic groups (for example, for the joint implementation of an educational or research project); availability of event planning functions; sending invitations, setting reminders; creating a portfolio of own works (completed creative tasks, educational projects, multimedia presentations, etc.); preparation and conducting of surveys on prominent topics; creation of short videos and their instant distribution or live broadcast from various events for joint viewing; mutual evaluation and discussion of the completed work ("likes" and comments); access from various devices (personal computer, tablet, smartphone, etc.); support of synchronous and asynchronous communication between network participants, etc.

2.3. Management of the Young Scientists' Council with the use of digital technologies

In the current conditions of digitalization of various sectors of society, the scientific field should take a leading position and actively implement digital technologies, especially with young scientists and graduate students. Also, the need for more active use of digital technologies was caused by the spread of the COVID-19 pandemic in the world and quarantine restrictions and measures [57, 58, 59, 60].

Let's consider the management of the Young Scientists' Council as a process of managing the social system. The essence of social management is organizational interaction. Organizational interaction is a conscious and controlled process, which is determined by the level of correspondence of needs, interests and goals of organized subjects of joint activity, namely members of the particular social entity. Management of organizational interaction process is inseparable from the management of social education (system) which is in constant development, and provides reliable information about the holistic functioning of this social education, as well as features and opportunities for innovative projects aimed at continuous improvement [61].

In the work of [38] the social system management is defined as a conscious purposeful activity, namely, the process designed to bring a social system or its component in line with needs, laws of functioning and development. Currently, the role of social networks in the management of social systems has significantly increased. The main opportunities for managing the social system with the help of social networks are following: discussion, polls, holding events, forming groups for joint work, administering group content, file sharing, instant messaging, online ad distribution, etc.

We will briefly describe the experience of the authors of this publication on working with young people in the scientific field, work on postgraduate training, ensuring the work of the Councils of Young Scientists and the use of digital technologies for the outlined issues.

1. *Anna Iatsyshyn* (Doctor of Pedagogical Sciences) initiated, created and was the Chairwoman of the Young Scientists' Council at the Institute of Information Technologies and Learning Tools, NAES of Ukraine (2016–2019). She created and administered the Council's Facebook page and ran the Council's blog. Also, she was a member of the Young Scientists' Council of the National Academy of Educational Sciences of Ukraine (2016-2019). A. Iatsyshyn initiated and regularly held a quarterly seminar for junior researchers "ICT in Education and Research" (2010–2019). She organizes an Annual Conference for young scientists with using digital technologies.
2. *Iryna Hubeladze* (Ph.D. in Social Psychology) is the Chairwoman of the Young Scientists' Council of the Institute for Social and Political Psychology of the National Academy of Educational Sciences of Ukraine. In 2019, she was elected as a Chairwoman of the Young Scientists' Council at the National Academy of Educational Sciences of Ukraine. Since 2018 she is a member of the Young Scientists' Council at the Ministry of Education and Science of Ukraine; Plan S Officer and Bologna Follow Up Group Officer, member of working groups "Mental Health" and "Doctoral Training" in Eurodoc. I. Hubeladze constantly conducts various webinars and classes for junior researchers and not only with using digital technologies.
3. *Valeriia Kovach* (Ph.D. in Ecology), Deputy Head of the Young Scientists' Council, National Academy of Sciences of Ukraine, Head of the Young Scientists' Council at the Department of Nuclear Physics and Power Engineering of NAS of Ukraine. Represents the State Institution "The Institute of Environmental Geochemistry of the National Academy of Sciences of Ukraine" and the Educational and Scientific Institute of Continuing Education of the National Aviation University (administers Facebook pages). Constantly conducts various webinars and classes for students, young scientists with the use of digital technologies.
4. *Valentyna Kovalenko* (Ph.D. in Pedagogy). Since 2019 she is the Chairwoman of the Young Scientists' Council at the Institute of Information Technologies and Learning Tools of the NAES of Ukraine. She constantly sends by e-mail to graduate students and junior researchers various information about events held for young people; organizes and conducts a quarterly seminar for young scientists "ICT in Education and Research". Also, conducts various webinars and classes for students and graduate students using digital technology.
5. *Volodymyr Artemchuk* (Ph.D. in Technology) is a Chairman of the Young Scientists' Council at the Department of Physical and Technical Problems of Power Engineering of NAS of Ukraine, Chairman of the Young Scientists' Council of G.E. Pukhov Institute for Modelling in Energy Engineering of NAS of Ukraine, member of the Young Scientists' Council at the NAS of Ukraine. He organizes an Annual Conference for young scientists using digital technologies; created and administered two Telegram channels for junior researchers: @CYSNASU and @YEnergyS.

6. *Maryna Dvornyk* (Ph.D. in Social Psychology) is a Deputy Chairwoman (2017–2019), a member (currently) of the Young Scientists' Council at the Institute for Social and Political Psychology of the National Academy of Educational Sciences of Ukraine. She is a co-organizer of educational events, workshops for young scientists, active user and promoter of digital technologies in the field of mental health.
7. *Oleksandr Popov* (Doctor of Technical Sciences) is a member of the Young Scientists' Council at the State Institution "The Institute of Environmental Geochemistry of the National Academy of Sciences of Ukraine" and a member of the Young Scientists' Council of G.E. Pukhov Institute for Modelling in Energy Engineering of NAS of Ukraine. For many years co-organizes an Annual Conference for young scientists on digital technologies.
8. *Andrii Iatsyshyn* (Doctor of Technical Sciences) was a Chairman of the Young Scientists' Council of G.E. Pukhov Institute for Modelling in Energy Engineering of NAS of Ukraine of Ukraine (2006–2016). He was also a Chairman of the Young Scientists' Council at the State Institution "The Institute of Environmental Geochemistry of the National Academy of Sciences of Ukraine". For many years he has been organizing and holding an Annual Conference for young scientists using digital technologies.

Analysis of publications and own experience allowed us to identify several areas of application of digital technologies to manage the activities of the Young Scientists' Councils.

Firstly, it is important for the Young Scientists' Council to have a separate page on the official website of its host institution. Above (figures 1, 2, 3, 4) information about the Young Scientists' Councils and their activities on the websites of various institutions has already been presented. These pages should contain at least a minimum of information: a list of Board members, Regulations, action plan, work reports, and be sure to provide links to other pages of the Board on various social media (Facebook, Twitter, YouTube, etc.).

Secondly, it is important to create a page "Council of Young Scientists" in the social network to ensure the activities and communication with young scientists. In figure 6 there is the page of Young Scientists' Council at the Ministry of Education and Science of Ukraine and the page of Young Scientists' Council at the National Academy of Educational Sciences of Ukraine on Facebook were submitted. As of October 2020, the page of the Young Scientists' Council at the National Academy of Educational Sciences of Ukraine was signed by 561 people, and the page of the Young Scientists' Council at the Ministry of Education and Science of Ukraine was signed by 6327 people. For example, Facebook services allowed to post on the official page of Young Scientists' Council video recordings of various events and activities (figure 7), create separate pages with different events, post photos, posts and messages, polls, as well as receive statistical reports on various aspects of the page (the number of "likes", the number of subscribers to the page, the distribution of page users by gender, age, etc.). Also, the authors of this paper have experience in creating closed groups on Facebook to discuss important issues, to work together on certain draft documents, etc.

In figure 8 the pages of the Young Scientists' Council at the Institute of Information Technologies and Teaching Aids of the National Academy of Educational Sciences of Ukraine and of the Young Scientists' Council at the Institute for Social and Political Psychology of the National Academy of Educational Sciences of Ukraine on Facebook are presented. Also, on the page of the Council it is possible to post about the activities of other organizations and interesting

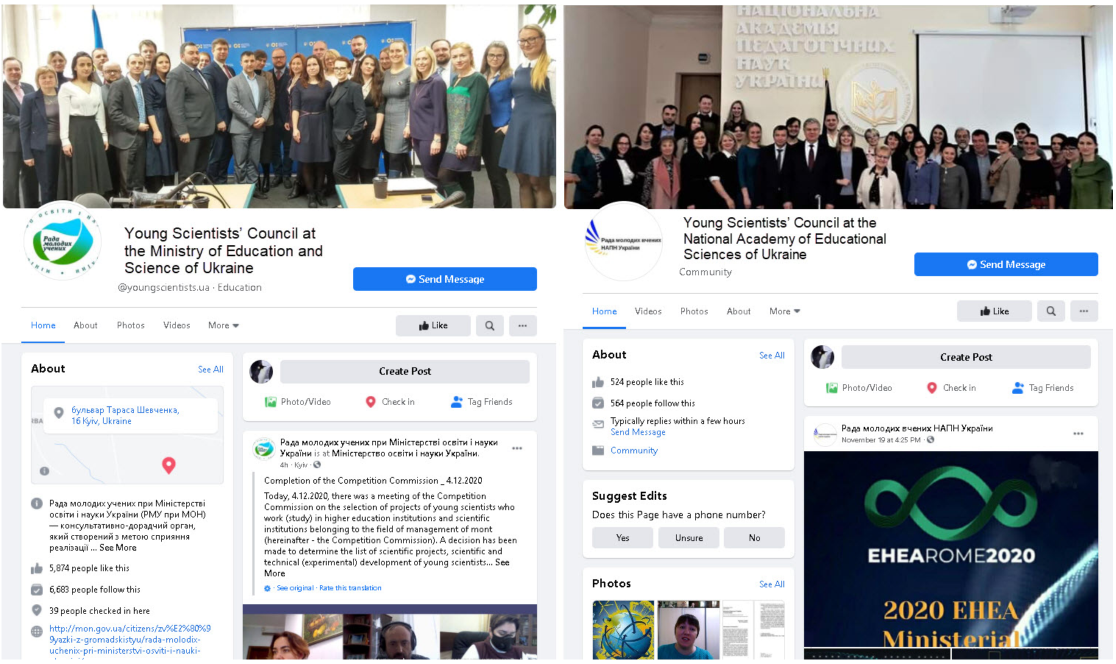

Figure 6: Pages of Young Scientists' Councils on Facebook.

events for junior researchers; disseminate the scientific results of young scientists by posting links to them or announcing where they can be viewed or downloaded. On social networks you need to subscribe to the selected person or thematic page and then the new arrivals will be displayed in the user's news feed.

Thirdly, to expand the channels of communication of young scientists, a wider presentation of their activities, the organization of thematic groups, the Young Scientists' Council should create pages on various social media: Twitter, Instagram, YouTube and others. In figure 9 presents a YouTube channel and a Twitter page of the Young Scientists' Council at the Ministry of Education and Science of Ukraine. Also, with the help of these social media can be a significant informational impact on junior researchers and the general public which will lead to awareness, change public attitudes towards scientists and the results of scientific research, promote scientific achievements and science among young people.

In figure 10 the Telegram channel for young scientists [62], supported by the Young Scientists' Council of the National Academy of Sciences of Ukraine is presented. As the channel was recently created, there are only 224 followers; the number of participants is increasing.

Fourthly, to ensure the activities of the Young Scientists' Council, it is important to constantly send e-mails on various aspects of the work, on activities, on surveys of young scientists and other organizational issues. Therefore, you need to create an e-mail box of the Council and use it for various mailings and when registering different pages in social media, you can specify this e-mail.

In figure 11 the example of sending materials from the Young Scientists' Council at the Ministry of Education and Science of Ukraine is shown. You can also use both email and

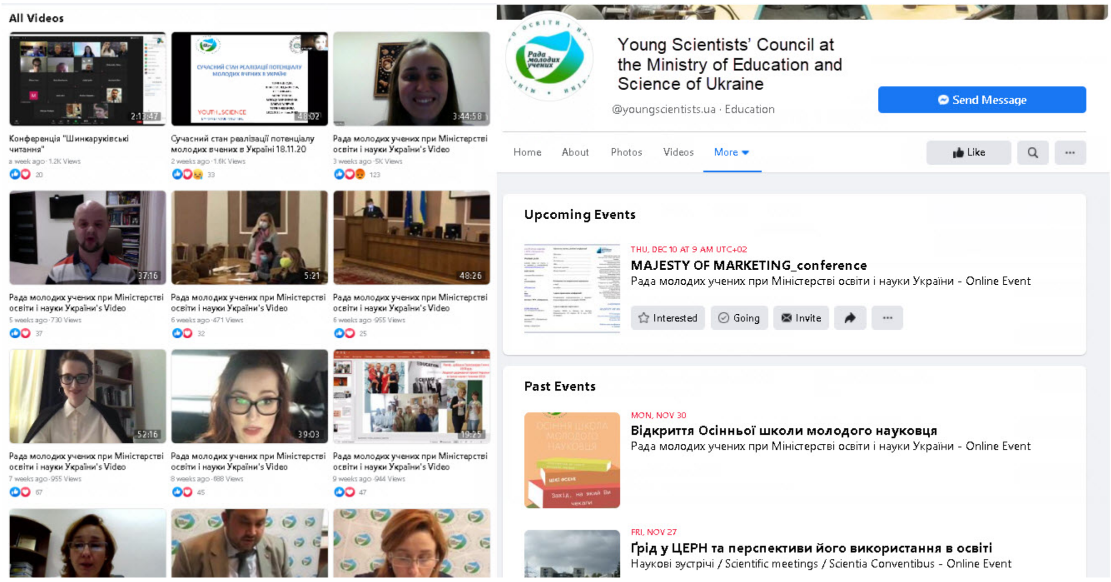

Figure 7: Videos of various events and activities on the page of Young Scientists' Council at the Ministry of Education and Science of Ukraine on Facebook.

special services, such as Google Forms, to organize various surveys, questionnaires, or event registrations. In figure 11 shows an example of using Google Forms to register for the Scientific Youth 2020 conference. These specialized services help reduce the time for organizing various events and improve the visual presentation of statistics about the event. Statistics on Google Forms for Young Scientist Conference Participants are provided in figure 12.

Therefore, we believe that the mandatory use of a variety of digital technologies is essential for the effective management of the Young Scientists' Council.

2.4. The use of electronic social networks for scientific events organization and conducting

In current conditions of digital transformation of society anyone can choose the most convenient means and conditions for communication, self-education, research or dissemination of their own work. Nowadays, electronic social networks, thanks to the convenience of their tools and services, have become the main ones for quick public feedback. We confirm that electronic social networks are a convenient way to interact between researchers from different countries. Now it is easier and faster to share experiences and disseminate research results, observe participants' reactions to discussions or information on specific issues, invite people to participate in various scientific events.

Every day a large number of scientific mass events are held in the world: conferences, seminars, webinars, master classes, trainings, etc. on topics related to various scientific researches, new books and journals are published. Researchers try to disseminate their scientific results to colleagues by posting links to them or announcing where they can be viewed or downloaded. In scientific social networks, as well as in usual: it is necessary to subscribe to the chosen person or

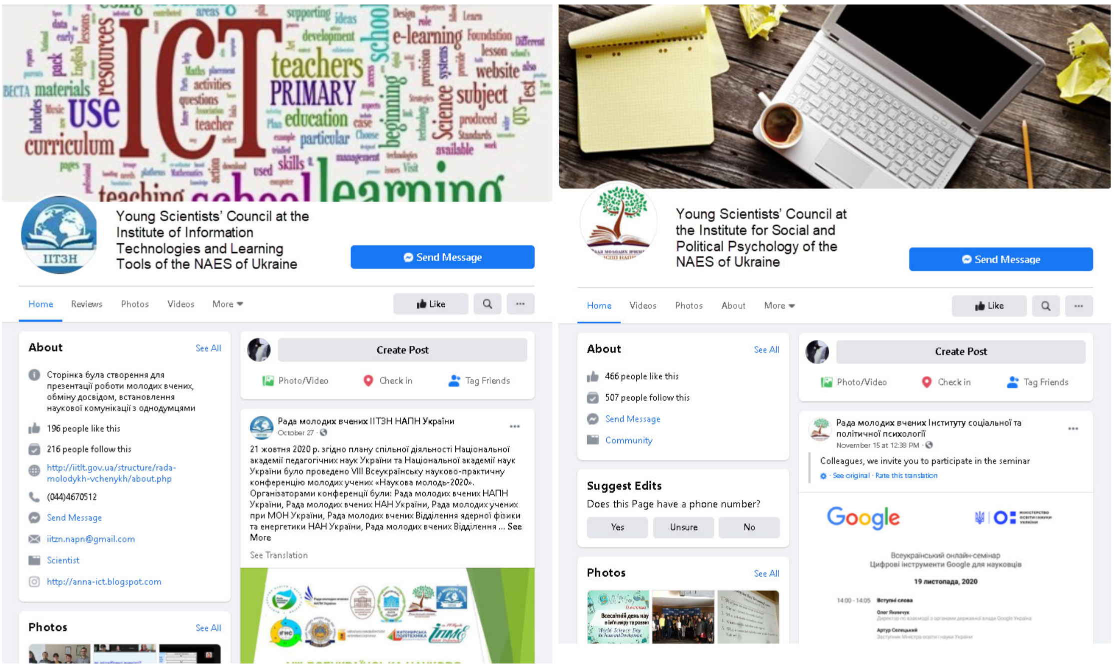

Figure 8: Pages of the Young Scientists' Councils on Facebook.

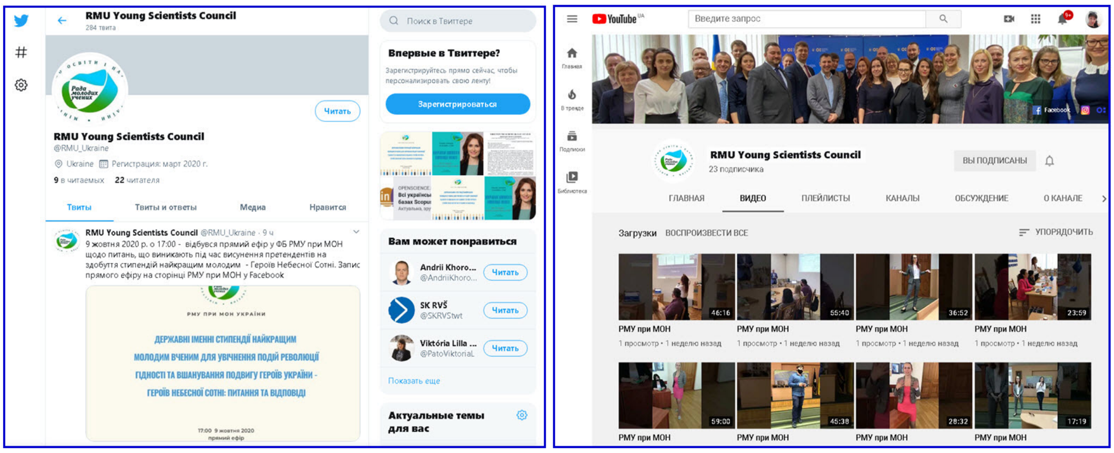

Figure 9: YouTube channel and Twitter page of the Young Scientists' Council at the Ministry of Education and Science of Ukraine.

the thematic page and new receipts will be displayed in your news feed. Also, many researchers want to share their experiences in professional networks, in order to hear feedback about their work. From time to time you should use the statistics tools offered in most electronic social networks. The received analytical reports will show which materials attract the most attention and approval and from which countries users were interested in your publications [63].

The manual [63] states that the use of electronic social networks to support and conduct

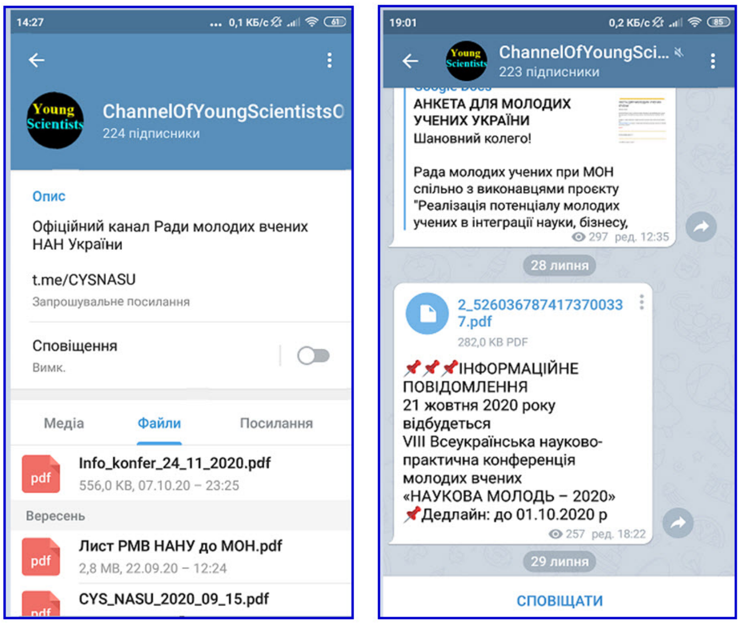

Figure 10: Telegram channel for junior researchers supported by Young Scientists' Council at the National Academy of Sciences of Ukraine.

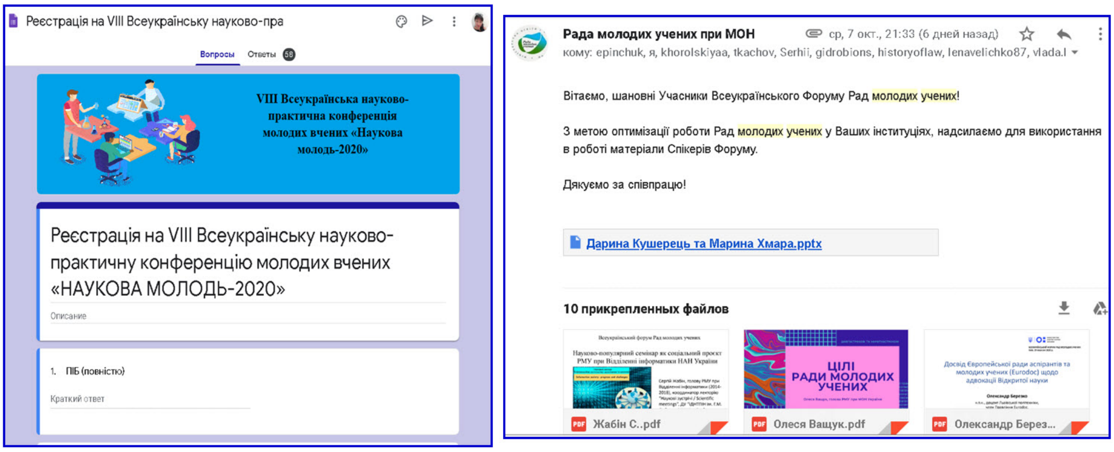

Figure 11: Example of using e-mail and Google Forms for Young Scientists' Councils.

research and to publish and disseminate scientific results is called "information and analytical support for research", which is interpreted as assistance to research activities in obtaining and analytical processing of information and data by ICT on the processes of planning, organization, conducting and implementation of research results. The system of information and analytical support of scientific research primarily involves the use of statistical, information-analytical, sciecometric services of electronic open systems [63].

Informational support of scientific mass events is an important factor in their effective conduct

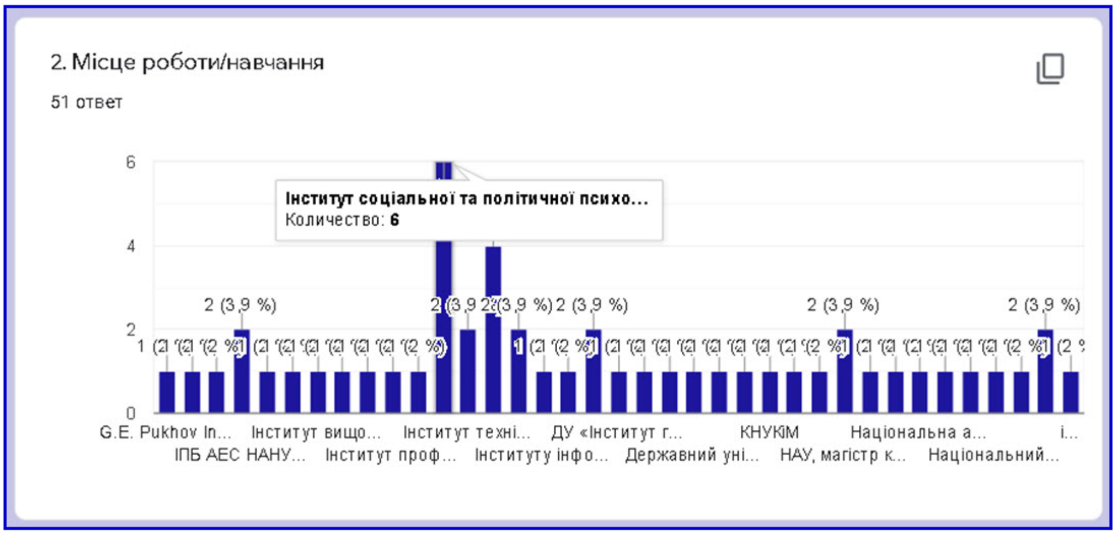

Figure 12: Google Forms Statistics on Participants of Young Scientists' Conference.

and involvement of more participants. Varieties of information support are: messages on radio or television, publication in print media (newspapers, magazines), posters, and ads on websites or blogs. Currently, the information support of scientific mass events with the use of its traditional types is decreasing, and on the contrary, the announcement of scientific mass events through electronic social networks is spreading. After all, submitting ads on the Internet is easy and free. Therefore, the simplest means for information support and for the organization of scientific mass events is the Internet, and in particular electronic social networks.

Let's analyze the main stages of the organization of a scientific mass event and features of the use of electronic social networks at each stage:

1. To define the problems of a scientific action, separate directions (names of sections; to outline a range of issues). The purpose of the scientific event, for example is publication of scientific ideas of the authors; creation of a scientific society; implementation of communication between representatives of various scientific societies [64]. You need to decide on the members of the organizing committee and divide the responsibilities among the organizers. Prepare an information letter (information message), which is the business card of the scientific event. To perform the above tasks, you can create a closed group in the electronic social network and involve participants, discuss each aspect, you can vote among the participants, put up drafts of the information letter and comment on it, and others.
2. To use a special function in social networks "Events". Announcements about scientific events on electronic social networks can be made in different ways: by posting on a personal page (this news will be seen by your friends); by creating a separate "Event" page with a photo and a detailed description of such an event and with the ability to quickly send to friends and invite them to this event, you can also see how many people are interested in this event and who want to attend it, as this page displays data. You

can also advertise a specific “Event” on both the personal page and the page of a specific organization or association, which will significantly increase the number of participants.

For example, we will report on scientific activities that have been posted on the electronic social network Facebook. In figure 13 a Facebook page with a reminder of events that the user is interested in, added to their events and plans to take part in is shown. We will describe them in more detail.

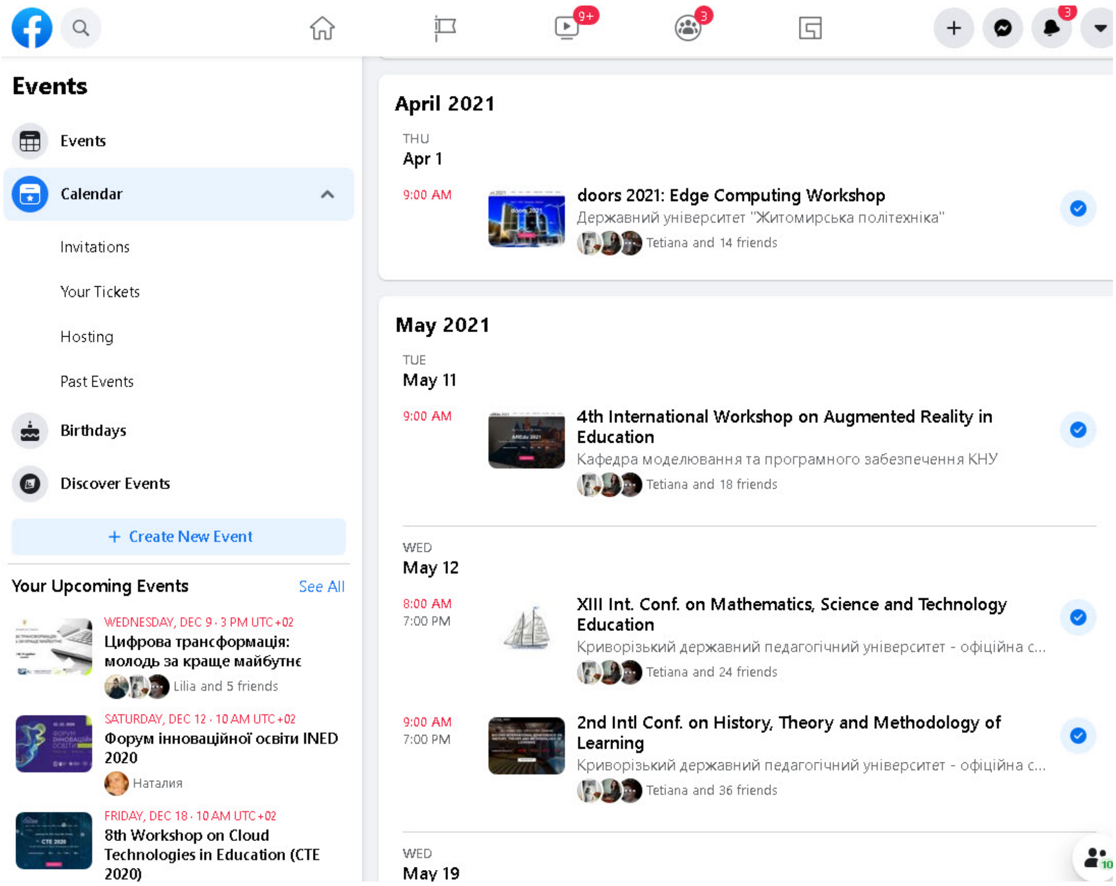

Figure 13: Information about upcoming events on Facebook on the user’s personal page where he/she is going to participate.

Figure 14 shows that 272 people plan to take part in the international conference.

Figure 15 presents statistics from the page of the Young Scientists’ Council on the number of people who reviewed the publications. The largest number of views (411 views) was in the publication on the conference.

Thus, the use of electronic social networks for the organization of scientific events has a number of advantages and features: free advertising of the scientific event; opportunity at any time to join, plan to participate, get interested; possibility of operative organization of discussion some organizational issues; free access to all presented conference materials; opportunity to receive statistical data on those wishing to take part in the scientific event, statistical data on

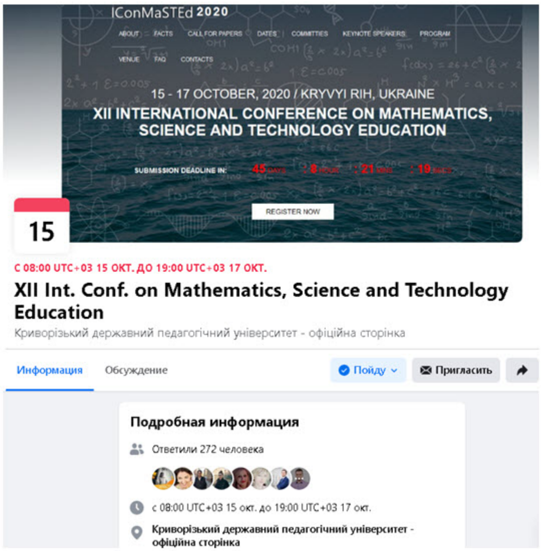

Figure 14: Facebook page of the International Scientific Conference and information on the number of people who plan to take part in this event.

the number of people interested in the event; statistics about users who liked the event, etc. We believe that the use of electronic social networks is promising for the organization and dissemination of messages about scientific events and to support scientific communication.

3. Conclusions

For countries seeking global recognition, it is important to increase the prestige of scientific activity and encourage talented young people to participate in research projects. An important role in this process belongs to the Young Scientists' Councils, which are created at scientific institutions, institutions of higher education and regional state administrations.

Large-scale digitization of all public spheres and quarantine restrictions caused by the COVID-19 pandemic has forced the use of various digital technologies. The scientific and educational spheres should occupy leading positions and be role models in the application of digital technologies, especially in the training of students, graduate students and in working with young scientists.

On the basis of the analyzed scientific literature and own experience of digital technologies implementation for the organization of Young Scientists' Councils activity the following conclusions are made:

1. *The peculiarities of Young Scientists' Councils* activity are following: provide conditions for further staff development of the institution in which they operate; contribute to the social, psychological and material support of young scientists and graduate students; create an environment for teamwork and collaborative partnership; promote the development of leadership and organizational qualities; contribute to the development of digital competence.

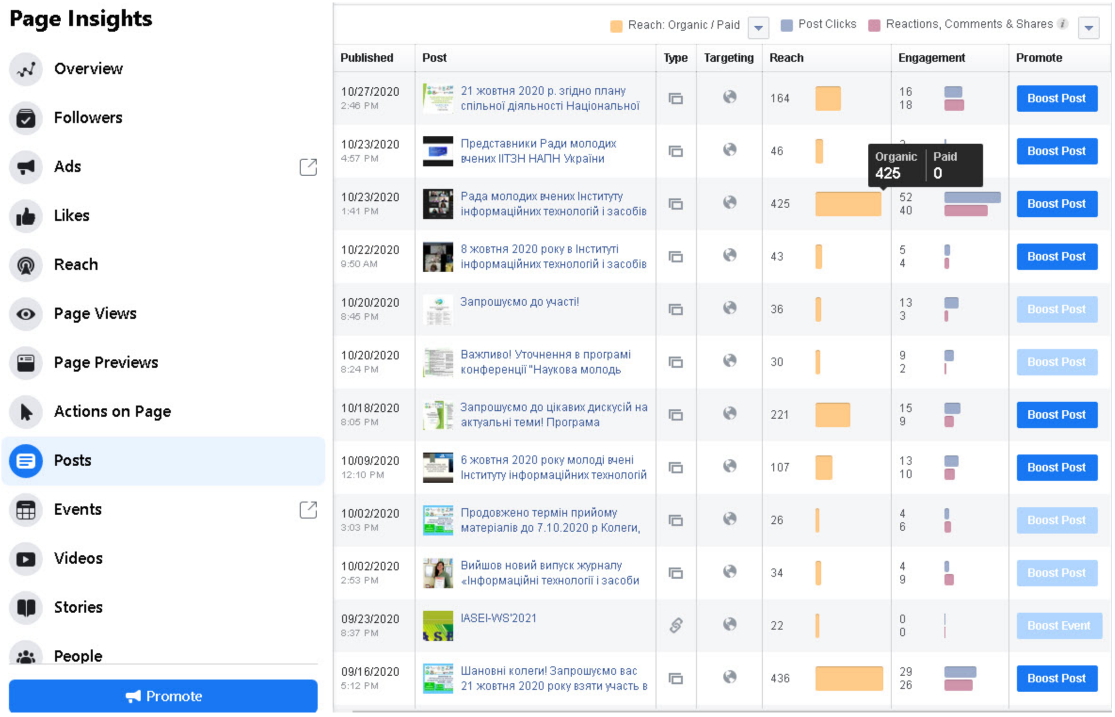

Figure 15: Data from the statistical service of Facebook on publications on the page of Young Scientists' Council at the Institute of Information Technologies and Learning Tools of the NAES of Ukraine in 2020.

2. *The advantages of using electronic social networks* in higher education and research institutions are: general popularity and free; prompt exchange of messages and multimedia data; user-friendly interface; availability of event scheduling functions, sending invitations, setting reminders; support of synchronous and asynchronous communication between network participants; possibility of access from various devices; a powerful tool for organizing the learning process; possibility of organization and work of closed and open groups; advertising of various events, etc.
3. *Features of management of Young Scientists' Councils activity with application of digital technologies are defined.* The Young Scientists' Council with a social system, and therefore the management of this system refers to social management. The key idea of social management is organizational interaction. Management of the process of organizational interaction is inseparable from the management of the social system as one that is in constant development, requires the implementation of various projects aimed at continuous improvement of its activities. The effectiveness of the use of digital technologies to manage the activities of the Young Scientists' Council depends on the intensity and need for their use to implement organizational, presentation functions and ensure constant communication.

   The analyzed scientific publications and the own experience of the authors of this paper on ensuring the functioning of the Young Scientists' Councils, helped to identify the following areas of application of digital technologies for the organization of associations of junior researchers:

- for the presentation of activities (page on the official website of the institution where the Council operates, YouTube channel, pages on social networks: Facebook, Instagram);
- to send various information to young scientists (e-mail, Telegram, Twitter, etc.);
- for conducting questionnaires, surveys (e-mail, Telegram, Google Forms, etc.);
- for the organization and holding of scientific mass events (Facebook, Google Forms, Zoom, Google Meet, Microsoft Teams, etc.);
- to organize the work of thematic working groups, to hold working meetings of the Council (Facebook, Telegram, Zoom, Google Meet, Microsoft Teams, etc.).

4. *The experience of application of electronic social networks for the organization and carrying out of scientific mass actions is generalized.* Thus, one of the main advantages of using electronic social networks for information support of scientific mass events is: receiving quick feedback; convenience of tools and services; opportunity to invite those interested to participate in various scientific events; create a separate page for a scientific event; receive statistics on participants in events; to make a video broadcast of events; store photos and videos of scientific events, etc.

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The use of cloud computing technology in professional training of future programmers

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Abstract

The article provides a brief analysis of the current state of the study of cloud technologies by future software engineers at foreign and Ukrainian universities. The author experience in the application of cloud technologies in the training of future software engineers in Ukraine is presented. The application of cloud business automation systems, online services to monitor the implementation of the software projects, Google services for collaboration, planning and productivity while studying professional disciplines and carrying out diploma projects is described. Based on the survey conducted at Stackoverflow, the state of application of cloud technologies by software engineers around the world has been analyzed. The cloud technologies that are not studied at the analyzed universities of Ukraine and those that are not popular with software developers in the world, but studied at Ukrainian universities by future software engineers are outlined. Conclusions are made on the modernization of training programs for future software engineers. Topics for the study of cloud technologies by future software engineers in the content of professional disciplines are proposed.

Keywords

future programmers, cloud technologies, content of professional disciplines, training of software engineers

1. Introduction

According to International Data Corporation (IDC), leading global provider of market information and consulting services, in the world over the past decade there appeared technology and services in the market of "cloud computing" [1].

According to the Bureau of Labor Statistics [2], the development of cloud computing has promoted an increase of the demand for the information technology specialists. In the United States, in particular, there exists a perspective that this demand will grow by 12% by 2024.

The National Skills Bulletin [3] based on the analysis of the Irish labor market data, systematized from 2013 to 2018, indicates a shortage of skilled workers in the field of information and communication technology (ICT), in particular, in the field of cloud computing.

The growth of the cloud market in Ukraine is evidenced by the following: results of a research, done by leading cloud service operators De Novo and GfK Ukraine [4], a policy brief of the Department of Information Society and Information Strategies Research of the National

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Institute for Strategic Studies [5] and search results in Ukrainian vacancy databases. This fact has been also emphasized by Jan Peter de Jong, CEO of Microsoft Ukraine, in his interview with Interfax-Ukraine [6]. Thus, the growing market of cloud computing leads to the demand for IT professionals, who are able to work with this technology. Therefore, there appears a need to study cloud computing in the process of training of future programmers in the institutions of higher education.

The *aim of the research* is to compare the current state of the future programmers training for cloud computing during their study in the institutions of higher education with the labor market requirements for the training of IT professionals in the field of cloud computing.

2. Results

2.1. Brief analysis of the current state of future programmers' training for the use of cloud computing technology

Due to the development of cloud computing technology, in universities, where future programmers are trained, courses on cloud computing are being introduced.

In particular, at the University of Liverpool at the Faculty of Humanities and Social Sciences, students are introduced to cloud-based systems while doing their Master's Degree and postgraduate study [7]. In addition, for all students, The University of Liverpool provides a range of cloud-based tools and platforms, allowing them to access their network drive (M drive) and campus applications when they are off-campus [8]. According the Nanyang Technological University curriculum, first-year Bachelor students have the opportunity to study such elective course as Cloud Computing and its Applications [9]. Such issues are not fully covered in the process of future programmers' training in Ukraine. Only in the last few years the students of Ukrainian universities have been offered to study cloud computing technology. It is proved by the results of Google Search and analysis of curricula of Ukrainian universities (table 1).

Thus, future programmers study cloud computing technology during their professional training in the institutions of higher education at different educational levels (Bachelor's, Master's, Doctor's). It has to be mentioned that from 2 to 6.5 ECTS credits are allocated for these courses. Content of the courses includes the study of different cloud systems (IaaS, PaaS, SaaS), virtualization and distributed systems, private cloud systems (Microsoft System Center, OpenStack), cluster solutions, grid systems, cloud platforms (Microsoft Azure, Amazon Web Services, Google Cloud Platform, Google Compute Engine, IBM Cloud).

2.2. The use of cloud computing technology in the professional training of future programmers in Ukraine

It has to be said that cloud technology is used in the training of future programmers in Ukraine. In particular, for enhancing communication [10], in STEM education [11, 12, 13], for organizing laboratory and practical classes [14, 15, 16, 17, 18, 19, 20, 21, 22], for studying databases by future IT-specialists [23, 24], etc.

Due to the demand of the labor market in programmers, who are capable of working with cloud computing technology, since 2016 in Bohdan Khmelnitsky Melitopol State Pedagogical

Table 1
The current state of future programmers' training for the use of cloud computing technology in the universities of Ukraine

University	Academic course	Speciality	Degree	Credits ECTS	Technology
Volodymyr Vynnychenko Central Ukrainian State Pedagogical Universit	Cloud computing technology	122 Computer Science and Information Technology	Master's Degree	6.5	Owncloud, Amazon EC2, Google Apps, LMS MOODLE
Interregional Academy of Personnel Management	Cloud computing	121 Software Engineering, 122 Computer Science and Information Technology	Master's Degree	3	Microsoft Azure, AWS, OneDrive, Google Drive, Google Docs, Microsoft Office 365, Heroku, DigitalOcean, ownCloud
National Technical University "Kharkiv Polytechnic Institute"	Cloud Computing: Cloud Technology and its Use	126 Information Systems and Technology	Master's Degree	3	Microsoft System Center, OpenStack, Google Drive, OneDrive, AWS, Windows Azure
Taras Shevchenko National University of Kyiv	Cloud Computing Technology	121 Software Engineering	Master's Degree	5	Microsoft Azure, Google App Engine, IBM Cloud, AWS
Kyiv National University of Construction and Architecture	Innovative Web-Technology and Cloud Computing	015.10 Vocational Education. Computer Technology	Bachelor's Degree	2	VMware, Microsoft Azure, Amazon Web Services, UTOO, De Novo
Bogdan Khmelnitsky Melitopol State Pedagogical University	Cloud Computing Technology	122 Computer Science	Bachelor's Degree	4	VMware, Microsoft Azure, Amazon Web Services, Google Cloud Platform
Open International University of Human Development "Ukraine"	Cloud Computing	122 Computer Science	Master's Degree	6	Amazon EC2, GoogleApps, Windows Azure
Lviv Polytechnic National University	Computer Science and Information Technology	122 Computer Science and Information Technolog	Bachelor's Degree	4.5	Microsoft Azure, Amazon Web Services
Zaporizhzhia Polytechnic National University	Grid Computing and Cloud Computing Technology	123 Computer Engineering	Bachelor's Degree	6	gLite, Globus Toolkit

University the Department of Informatics and Cybernetics has introduced a course "Cloud Technology" for the students undergoing their training in 122 Computer Science. In addition to the introduction of the course "Cloud Technology" into the process of future programmers' training, the lecturers of the Department of Informatics and Cybernetics constantly use a variety of cloud technology while teaching professional courses to the students of the specialty 122 Computer Science and 015.39 "Vocational Education. Digital Technology".

In particular, while doing the course "IT Project Management" future programmers get acquainted and use cloud business automation systems (Gantter, Basecamp, Bitrix24) in laboratory classes and in their self-study. The students can use the service of placing the system Bitrix24 in the cloud.

After setting up the system and introducing students as its users, the teacher can plan the work of students and manage tasks, controlling the timely completion of these tasks. Students can manage the time and control other resources expenditures for the completion of class assignment. This way they practically learn the term "deadline", learn how to manage their time effectively. The trackers, used in the Bitrix24 system, help to monitor the completion of tasks, keeping to deadlines, and allow users to easily control the work of subordinates. The advantage of the system is that the tasks can be represented in the form of a Gantt chart – a classic bar chart, which clearly shows the time frame of the tasks in the sequence in which they must take place during the project.

Looking at the chart, both a teacher and a student immediately see how many tasks there are on the project, how many of them are completed and how many are in progress, which tasks are overdue, and which of them do not have a deadline. The system also allows users to make and display performance reports; it allows a teacher to identify how well each student is working.

It is also necessary to use information systems to monitor the implementation of the software project. Currently, there exist free systems that are just as good as fee-paying systems: Git based on GitHub or Bitbucket. As it is noted in [25, 26], the use of Git and GitHub helps not only to track changes in versions, but also to show students the ways to organize and collaborate on projects using practice-oriented methods. GitHub [27] is positioned as a web service for hosting projects using the Git version control system, as well as a social network for developers. With this service, students can create an unlimited number of repositories, each of which is provided with a wiki, a tracking system, and there is also an opportunity to review code and collaborate on a project.

While doing professional courses, future software engineers, working on a software project, use the following Google cloud services: Google Calendar – for work planning; Google Meet and Google Chat – for voice and text messaging, Google Groups – for ads and group discussion; Google Sites – for creating an electronic portfolio, for content management and hosting; Google Drive – for saving files; Google Docs – for work with documents; Google Keep – for teamwork and productivity; Google Form – for creating your own surveys.

While doing the lecture course "Software Testing" future programmers are invited, using a cognitive approach, to create metal maps based on the course materials. For example, this is how a mental map of testing types was developed (figure 1).

While doing this course in laboratory classes, students are taught to create UML diagrams and tests for software based on UML diagram variants. To do this, they use such web platforms as Lucidchart, Creately, Draw.io, Gliffy, which have the functions of collaboration (access or

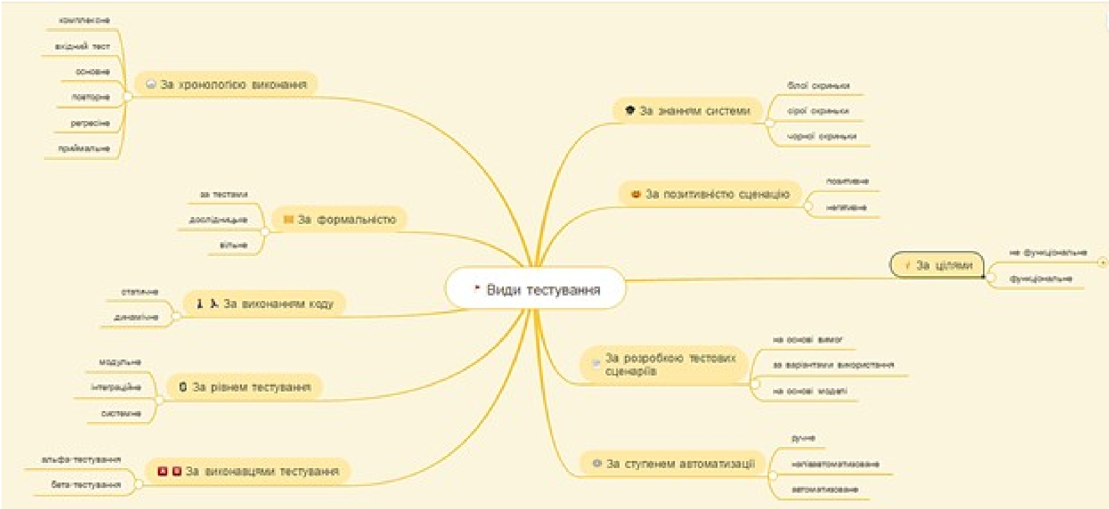

Figure 1: Mental map "Testing Types".

editing).

We consider the use of cloud technology in the future programmers' professional training to be an appropriate one when preparing their graduation work (diploma paper). The students can present the text of the Diploma thesis to the teacher by means of Google Docs. The functions of joint viewing and editing allow the teacher to monitor student's progress in writing the thesis.

It is advisable for a teacher, who is reviewing several thesis projects, done by future programmers, to use Git and GitHub. They provide a teacher with the following opportunities: to put the tasks and assessments online; to look through student listings (program codes), monitoring the time of their placement and authorship; to set a deadline, i.e. to ban the recording of works from a certain moment; to comment not only on the whole project, but also on certain lines of the program; to point out shortcomings in the work performed and give instructions for tasks. Working with GitHub, a student can use his or her own and shared repositories at any time; automatically receive checking reports and teacher's comments.

The methodology of working with Git requires a teacher to: 1) clearly formulate the task, 2) set this task to the developer (student), 3) check the student's understanding of the task, 4) periodically check the result of the task completion during the student's work on it, 5) send back an unsatisfactory result to the developer for revision, 6) mark a satisfactory result, 7) carry out the final check of the software product developed by a student (students), 8) in case of completion close the task as a completed one, otherwise send it for revision.

The functions of a student, using Git, are to receive a task from a teacher, start doing it, present the result in the system, and if the task is returned for revision – to review it and send it back to the system.

The algorithm of work with Git and the general picture of what is going on in the process of students' and teacher's work on the project, can be presented schematically (figure 2).

Work on such algorithm is conducted as follows:

1) a teacher sets tasks for a student (developer),

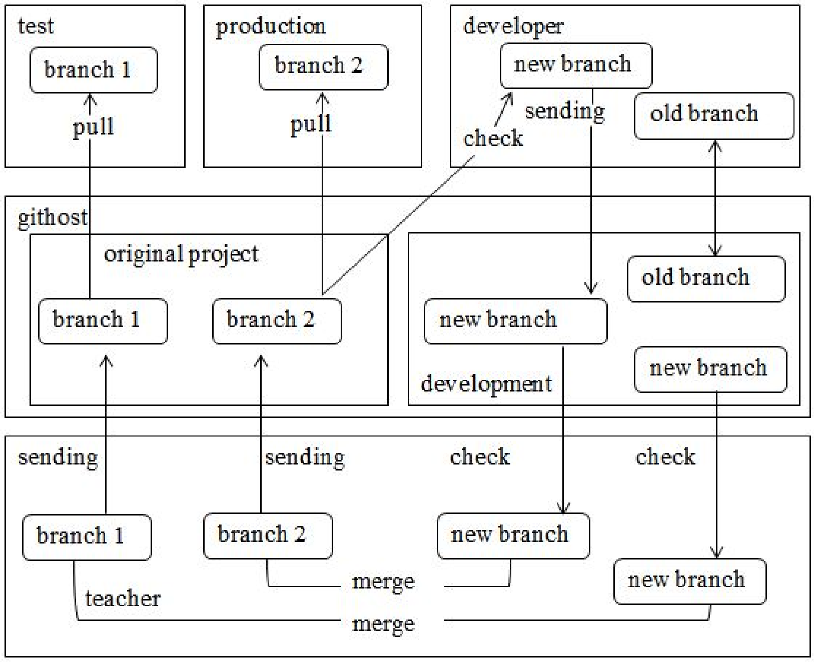

Figure 2: Algorithm of students' and teacher's work with Git while writing the thesis.

2) a student works on the actual branch of the project and makes it a local branch,

3) in this branch a student solves the task,

4) a student sends the branch with the completed task to the working repository,

5) a teacher takes this branch from the working store and checks it,

6) if the task is completed correctly, a teacher merges this branch with the current branch of the project in the main repository or allows the student to do it.

Using cloud services in this way, future software engineers learn to work with the technology which they will use in their future professional activities.

2.3. Labor market analysis in terms of professional training of IT specialists in the field of cloud computing technology

In the process of professional training of future programmers we are aimed at the fact that the training of future programmers should be a modern one and they should get acquainted with the latest software and the latest technology. In this regard, we analyzed Stackoverflow data as for the tools the developers use.

Based on the analysis of the Developer Survey, conducted at Stackoverflow [28], we have identified which cloud technology is used by programmers in the world (table 2).

Table 2
Use of cloud technology by programmers in the world

Type of tools	Name	Percentage of programmers who use it
Infrastructure as code	Terraform	6.2 %
Cloud database	MongoDB	26.4 %
	Firebase	14.4 %
	Amazon DynamoDB	7.1%
	Cassandra	3.3%
	IBM DB2	2.9 %
Platforms	AWS	26.7%
	Microsoft Azure	14.5 %
	Google Cloud Platform	14.1 %
	Heroku	11.1 %
	IBM Cloud or Watson	1.6 %
Programming languages for cloud computing	JavaScript	67.7 %
	Python	44.1 %
	Java	40.2 %
	PHP	26.2 %
	Ruby	7.1 %
Collaboration tools	GitHub	82.8 %
	Slack	53.0 %
	Jira	47.7 %
	Google Suite (Docs. Meet. etc)	41.5 %
	Gitlab	37.0 %
	Confluence	32.4 %
	Trello	29.6 %
	Microsoft Teams	25.6 %
	Microsoft Azure	14.8 %
	Stack Overflow for Teams	5.8 %
	Facebook Workplace	3.0 %

3. Conclusions

Based on the comparison of this survey data with the analysis of the curricula of the above mentioned universities (table 1), we have identified that technology that is not studied in the target universities of Ukraine and technology that is not popular with software developers in the world but taught in Ukrainian universities (table 3).

Therefore, according to the analysis, in our opinion, curricula for future programmers should be revised and modernized in accordance with current trends in the IT industry. Curricula should include topics, aimed at acquaintance with cloud computing technology used in programming. It is recommended to introduce a separate course (for example, “Cloud Technology” or “Cloud Computing”) or separate topics into the process of professional training. Examples of such topics are given in the table 4).

In addition, in the process of future programmers’ training the attention should also be paid

Table 3
Comparison of cloud that technology taught in universities and that which is popular on Stackoverflow.

Cloud technology taught in universities of Ukraine	Cloud technology that is popular among software developers in the world
Common technology	
Amazon Web Service Microsoft Azure Heroku Dropbox, Microsoft OneDrive, Google Docs, Microsoft Office 365 IBM Cloud Google Cloud Platform	
Technology that is not popular at Stackoverflow	Technology that is not taught in the target universities of Ukraine
Owncloud	Terraform
LMS MOODLE	MongoDB
ownCloud	Cassandra
Google Apps	IBM DB2
PXE	Firebase
DigitalOcean	GitHub
OpenStack	Slack
Google App Engine	Jira
VMware	Gitlab
UTOO	Confluence
De Novo	Trello
Red Hat OpenShift	Microsoft Teams
gLite	Stack Overflow for Teams
Globus Toolkit	Facebook Workplace

Table 4
Recommended topics of cloud technology to be included into the courses

Course	Topic
Introduction to the programming course	Collaboration Cloud tools
Computer architecture	Grid systems
Operating systems and system programming	Cloud operating systems
Information networks	Visualizing technology
Database management systems	Cloud database
Organization and processing electronic information	Online office suite
Web-programming	Cloud systems for the execution control
Programming	Cloud systems of task control
Software project management	Cloud systems of automation of business
Software testing	Cloud systems of UML diagrams creation

to the use of modern general-purpose cloud technology while studying professional disciplines, namely: services for work planning, messaging, teamwork, creating web resources, saving files, conducting surveys etc. The introduction of a wide range of cloud technology in future programmers' training will increase the quality of students' preparation for future professional activities.

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Some experience in maintenance of an academic cloud

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Abstract

The article is devoted to the systematization of experience in the deployment, maintenance and servicing of the private academic cloud. The article contains model of the authors' cloud infrastructure. It was developed at Ternopil Volodymyr Hnatiuk National Pedagogical University (Ukraine) on the basis of the Apache CloudStack platform. The authors identify the main tasks for maintaining a private academic cloud. Here they are making changes to the cloud infrastructure; maintenance of virtual machines (VM) to determine the performance and migration of VM instances; work with VMs; backup of all cloud infrastructure. The analysis of productivity and providing students with computing resources is carried out. The main types of VM used in training are given. The number and characteristics of VM that can be served by a private academic cloud are calculated. Approaches and schemes for performing backup are analysed. Some theoretical and practical experience of using cloud services to perform backup has been studied. Several scripts have been developed for archiving the platform database and its repositories. They allow you to upload backups to the Google Drive cloud service. The performance of these scripts for the author's deployment of private cloud infrastructure was evaluated.

Keywords

cloud computing, private academic cloud, Apache CloudStack, G Suite, Google Drive

1. The problem statement

Today, many universities are creating their own cloud-based learning environments (CBLE). Although there is currently no single concept for CBLE, scientists understand it as similar concepts [1, 2, 3, 4], in general, it can be understood as an IT system consisting of cloud services and providing learning mobility, group collaboration of teachers and students to achieve educational goals [5].

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As the analysis of the literature shows, many university CBLE are usually deployed according to the hybrid model [6, 7, 8]. One of the most important components in the structure of this environment is the private academic cloud [9]. It is now deployed according to the most productive IaaS service model. A hybrid cloud is a cost-effective way to solve the problem of insufficient computing resources. The private academic cloud allows the university to meet the peak demand of students and faculty through a combination of local infrastructure and one or more public clouds [10].

Various commercial and free platforms are used in universities to build private academic clouds [11, 12, 13, 14]. A productive method of deploying private academic clouds is to use solutions from leading cloud vendors such as Google Inc., Microsoft, Amazon and others. Google Inc. offers researchers, universities, faculties, faculty and students grants and loans for teaching and research. In particular, leading European educational institutions can access Google Cloud within the Internet2 project [15]. Unfortunately, these opportunities are not currently available for our country (Ukraine). For example, Microsoft Educator Grant is a program designed specifically to provide access to Microsoft Azure to college and university professors teaching advanced courses. As part of this program, faculty teaching Azure in their curricula are awarded subscriptions to support their course [16]. In general, these programs are very useful and productive. However, they are usually provided on a temporary basis and therefore cannot completely replace the cloud-based IT infrastructure of universities and colleges.

Among the free platforms for cloud infrastructure deployment, CloudStack, Openstack, Proxmox, and Eucalyptus are the most suitable. Each of them has its advantages and disadvantages. There are many attempts to compare these platforms. The authors of articles comparing such platforms state [16, 17]:

- OpenStack has large community, offers wide integration with storage, network and compute technologies, but is too complex to deploy and configure;
- Eucalyptus the longest-standing open source project is banking on its very tight technical ties to Amazon Web Services (AWS). The platform is configurable, but not very customizable;
- Proxmox is open source platform. It can provide easy way to deployment cloud infrastructure. But it is not very suitable as a platform for a private cloud in the CLBE;
- CloudStack has well rounted GUI, can provide an advanced cloud infrastructure, but it is very GUI centric built on single Java core.

We have deployed private academic cloud based on the Apache CloudStack platform.

It contains a management server, 4 hosts, 4 primaries and 1 secondary storage. We decided to use hypervisors instead of containers. This is because the former are more versatile. In addition, the use of hypervisors is safer than containers. To save computing resources, we have installed primary storage on the hosts. We used VLANs to distribute traffic across individual networks. These networks can be allocated to groups or individual students.

In general, our private academic cloud provides [17]:

- Development and Execution of student virtual machines;
- Aggregation of computing resources of several hosts;
- VM migration between repositories;

- VM connections to each other through guest networks;
- Launching VMs within other VMs;
- Integration with Active Directory;
- Distribution of student accounts according to their academic groups.

There are many problems and corresponding tasks in the process private academic cloud using.

The purpose of the article is to systematize author's experience in maintenance the Cloud Based Learning Environment.

The following tasks are required to achieve the goal of the research:

1. Analysis of maintenance tasks of academic clouds in foreign and Ukrainian universities.
2. Definition of maintenance tasks of academic cloud which has deployed by authors.
3. Listing and systematization of author's experience in maintenance of academic cloud of Ternopil Volodymyr Hnatiuk National Pedagogical University.

2. The private clouds maintenance tasks

As the experience of cloud infrastructure maintenance shows, this is an ongoing process. It requires constant attention from engineers, network system administrators, teachers, and student involvement. Scientists describe the experience of deploying an academic private cloud, including determining the performance of hypervisors and storage [18]. The biggest challenge for researchers was the transition from a prototype of an academic cloud to a productive one. In this context, they addressed the problem of load balancing, elastic hypervisors, security threats. Storage backup tasks are also important for such clouds.

The authors of the book "Data Backups and Cloud Computing" offer the concept of backup to cloud storage. They say that both the cloud provider and the cloud consumers have to take comprehensive steps to ensure appropriate configurations, hardening of the CBLE, appropriate design and development, appropriate interoperability, and adequate testing [19].

Scientists from the Institute of Physics and Mechanics of the National Academy of Sciences of Ukraine and Lviv Polytechnic National University have developed an effective method of deduplication and distribution of data in cloud storage during the creation of backups. Researchers have developed an intelligent system for such deduplication and tested it [20].

Junfeng Tian, Zilong Wang and Zhen Li also studied cloud data backup [21]. The authors propose a scheme for data separation and backup and encryption. They state that their own scheme resolves the conflict between data security and the survivability of the IT infrastructure with the help of encrypted backup.

The Apache CloudStack cloud infrastructure redundancy model developed by Paul Angus is very useful for our study. It creates a vendor agnostic API and UI in CloudStack for end users. The author's Framework abstracts the specifics of solutions, such that through the use of a plugin, a 3rd party solution can deliver backup and recovery solutions [22].

3. Definition of maintenance tasks of authors' academic cloud

Here are the main tasks for servicing our sample private academic cloud:

1. Work with student accounts;
2. Making changes to the cloud infrastructure;
3. Creating VM templates;
4. VM service (system, student, teacher);
5. Determining the performance of individual hosts and the cloud as a whole;
6. Migration of VM specimens;
7. Stopping and restarting physical hosts;
8. Cloud infrastructure backup.

The first task involves creating student and faculty accounts. We authenticate users of the academic cloud from a centralized database – LDAP-directory (Microsoft Active Directory). This approach makes it possible to use single registration data to access all hybrid IT infrastructure services. We used CloudStack domains to distribute students according to academic groups. Adding users to them is possible in automatic (using links at the first successful authentication) and manual mode. Unfortunately, due to the incompatibility of our users' logins with the Apache CloudStack platform, we had to choose the manual mode. To reduce the technical work involved in finding LDAP directory entries, we have created several queries to filter user account data.

Maintenance of our developed cloud infrastructure involves the implementation of tasks such as:

- changing the parameters of the components of the cloud infrastructure – zones, clusters, hosts, storages;
- creating and routing of virtual networks for individual groups or students;
- creating and modifying templates of compute offering services that determine the performance of VM;
- creating and modifying network offering service templates such as VPN, DHCP, DNS servers, Firewall, Load Balancer and others;
- creating projects for VM sharing by students.

When creating the service offering templates, we compared the characteristics of the hardware hosts (CPU frequency, RAM) with the minimum guest OS requirements and the number of students. To do this, we used the inequality:

$$FRQ = N_{st} * F_{OS} < FRQ_{hosts},$$

where FRQ – the total frequency of VMs processors; N_{st} – amount of students; F_{OS} – the minimum frequency is recommended for the guest OS; FRQ_{hosts} – total frequency of hardware host processors. The last value can be found from the ratio:

$$FRQ_{hosts} = \sum_{i=1}^{n}(N_{ci}F_{ci}),$$

where N_{ci} – the number of cores in the processor of the *i*-th host, F_{ci} – CPU frequency of the *i*-th host.

It is well known that the frequency of a modern processor is not constant. It can increase or decrease depending on the mode of operation of the CPU. That's why we use Processor Base Frequency in the tables and formulas above. Processor Base Frequency describes the rate at which the processor's transistors are open and close. This processor frequency is measured by each hypervisor in the Apache CloudStack platform.

Similarly, to determine the required amount of memory we used the inequality:

$$MEM = N_{st} * MEM_{OS} < MEM_{hosts}$$

As table 1 shows, the private academic cloud has a total frequency of about 50GHz. And the total amount of memory is about 90 Gb. Regarding the frequency, two other opposite factors should be taken into account:

- Table 1 shows the base frequency, and processors can run faster thanks to Turbo-Boost technology;
- Hosts run other software (OS, databases, management servers, hypervisors). It also consumes resources.

Table 1
Main Characteristics of Academic Cloud's Hardware

	N_{ci}	F_{ci}	MEM_{ci}	FRQ_{hosts}
Host0	4	3200	16384	12800
Host1	4	3100	24576	12400
Host2	4	3100	16384	12400
Host3	4	3700	32768	14800
Sum			90112	52400

Comparing the data in table 2 and table 1, we can conclude that our academic cloud provides about 50 VM with Linux without a graphical user interface (GUI), more than 40 VM with Windows Workstation, about 35 VM with Windows Server and OC Linux with GUI.

Table 2
Basic calculations of our academic cloud's performance

OS	F_{OS}	MEM_{OS}	N_{st}	FRQ	MEM
OSLinuxNoGUI	500	500	20	10000	10000
OSLinuxGUI	1500	2000	20	30000	40000
OSWindowsWs	1000	2000	20	20000	40000
OSWindowsSrv	1500	2000	20	30000	40000
OSAdvLinux	2500	4000	20	50000	80000

We use the EVE-NG platform for modelling in the study of computer networks. It launches its own VMs inside the main Apache CloudStack VM [23]. Such nested virtualization requires more resources. Therefore, Table 1 has a row named OSAdvLinux. For this OS, our cloud can run about 20 instances. We have created in our cloud infrastructure some compute offering templates based on the data provided.

Regarding VM migration, we used the approach described in [21]. Its authors propose to evaluate the efficiency of the cloud infrastructure as an integrated indicator of the use of resources of each instance of the VM. The authors indicate that a specific instance needs to be migrated to another host to resolve the issue. They propose the concept of non-uniformity, which is determined by the ratio:

$$N_R^p = \sqrt{\sum_{i=1}^{n} \left(\frac{r_i - \bar{r}}{\bar{r}} \right)^2},$$

where n is the number of resources, r_i is the projected use of the i-th resource, $\bar{r}$ is the average predicted value of the use of all resources of the p-th server. Academic cloud administrators should minimize value N_R^p.

To define an overloaded host, the concept of "hot spot" is used. The host will be "hot" if at least one of its resources exceeds the limit value ("temperature"). To determine the host's "temperature" the amount of use of all its resources.

$$t^* = \sum_{t \in R}^{n} (r_i - r_t)^2 ,$$

If the value of t^* is greater than zero, then virtual machines should be migrated from the appropriate host. Apache CloudStack system implements the appropriate functionality. Root or domain administrator can transfer both disks of virtual machines and run them on another host.

Another way to solve the problem of lack of computing resources is CPU and RAM overcommit. In this case, the Apache CloudStack system administrator sets the multiplier. This number is multiplied by the total CPU frequency or amount of RAM. However, this method should not be abused. This can lead to unpredictable consequences, such as denial of service to virtual machines.

4. Designing and realization an academic clouds' backup model

Experience shows that the task of backup is very important and time consuming. This is primarily due to the large amounts of student VMs data in the private academic cloud. Large companies develop a disaster recovery plan in this case. Large companies are developing a disaster recovery plan in this case. But in educational institutions, IT services work to perform such tasks. Therefore, they need to develop a model, identify potential risks in the IT infrastructure, consider and implement an appropriate backup system.

The development of a backup strategy requires the definition of the main goals and objectives of the backup, tools and regulations. In general, the problem of back-up is relevant for almost all IT infrastructures. When choosing a backup method, the following criteria are important [24].

The development of a backup strategy requires the definition of the main goals and objectives of the backup, tools and regulations. In general, the problem of backup is relevant for almost all IT infrastructures. When choosing a backup method, the following criteria are important:

- backup time to the storage;
- recovery time from backup;
- the number of copies that can be stored;
- risks due to inconsistency of backups, imperfection of the backup method, complete or partial loss of backups;
- overhead costs: the level of load on the servers when performing copying, reducing the speed of service response, etc;
- the cost of renting all services and storage.

Currently, there are 3 main backup schemes such as:

- *Full.* This type of backup creates a complete copy of all data.
- *Incremental.* In this case, only files that have changed since the previous backup are copied. The following incremental backup only adds files that have been modified since the previous backup.
- *Differential.* The backup program copies each file that has changed since the last full backup. Differential copying speeds up the recovery process.

To save material costs, we use almost no server equipment and powerful and high-speed network storage in our academic cloud installation. Instead, we decided to use cloud services. For example, the Google Drive service within the G Suite for education package offers virtually unlimited disk space [25]. The disadvantage of such a repository is the significant time to upload or download backups. This speed will be limited by the bandwidth of the university's Internet channel. The latter requirement can be considered acceptable, as our implementation of the academic cloud is used primarily for training rather than for production.

To use Google Drive in our own scripts, we need to use the API of this service. This interface is accessible through Google Developers Console, a software developer service. First you need to create your own project. Credentials were created to access this project. We have chosen to access OAuth 2.0 accounts. OAuth is an open authorization standard that allows a user or application to give and access data without having to enter a login and password. Access tokens are used for this purpose. Each access token provides access to a specific client to specific resources and for a specified period of time [25]. After adding a new project, we created new data for authentication, selected the type of application (desktop) and activated the appropriate API (Google Drive API).

Our research was performed at the Joint Laboratory of the Institute of Information Technologies and Learning Tools of the National Academy of Educational Sciences of Ukraine, and Ternopil Volodymyr Hnatiuk National Pedagogical University.

Our academic cloud deployment contains the following objects:

- One management server;
- Four hosts for running VMs instances;
- Four primary repositories containing disks of these VMs;
- One secondary repository for saving templates and ISO images.

Because templates and ISO images do not change, but only new ones are added, we chose the incremental method to back up the secondary storage. Its implementation was based on the use of a ready-made utility for synchronizing storage files. Unfortunately, there is currently almost no such high-quality utility like Google back-up and Sync, which is developed for OC Windows. We analysed several tools such as:

- Gdrive (grive2). Google Drive client with the support for the new Drive REST API and partial sync. It can't provide continuously wait for changes in file system or in Google Drive to occur and upload.
- Gnome-online-accounts. It is system utility located within system's settings in Gnome GUI. But it can only be executed in a graphical interface.
- GoSync is a Google Drive client with GUI support for Linux. It is designed under the GNU General Public License. The client is not perfect enough, for example, it has automatic regular synchronization every 10 minutes.
- Google-drive-ocamlfuse is a FUSE (Filesystem in Userspace) filesystem for Google Drive, written in OCaml. FUSE is a free module for the kernel of Unix-like operating systems. It allows developers to create new types of file systems available for users to mount without the root privileges of Google Drive on Linux.

We used the latest utility. Here are its main features [26]:

- full read/write access to ordinary files and folders;
- read-only access to google docs, sheets, and slides;
- multiple account support;
- duplicate file handling;
- access to trash;
- storing Unix permissions and ownership;
- support symbolic links;
- streaming through read-ahead buffers.

Some problem was that the utility requires authorization using a browser in a graphical interface. Therefore, we used an alternative authorization mode. Since we already had our own OAuth2 client ID and client secret, we specified them in the command:

google-drive-ocamlfuse -id 12345678.apps.googleusercontent.com -secret abcde12345

As the command tries to start the browser on the server where there is no GUI we formed the necessary URL as it is written in the documentation on Google Developers Console. After going to this address, we received a verification code. This code gave access to folder synchronization to the Google Drive.

For security reasons, we decided to sync not the secondary storage itself, but a copy of it from the backup drive (Backup_Secondary task, see figure 1). So, we first synchronized local folders with the command:

rsync -azvh /export/secondary /export/sync_secondary/arch_cloud

where */export/secondary* – the secondary storage of Apache CloudStack infrastructure; */export/sync_secondary/arch_cloud* – the local copy of this storage.

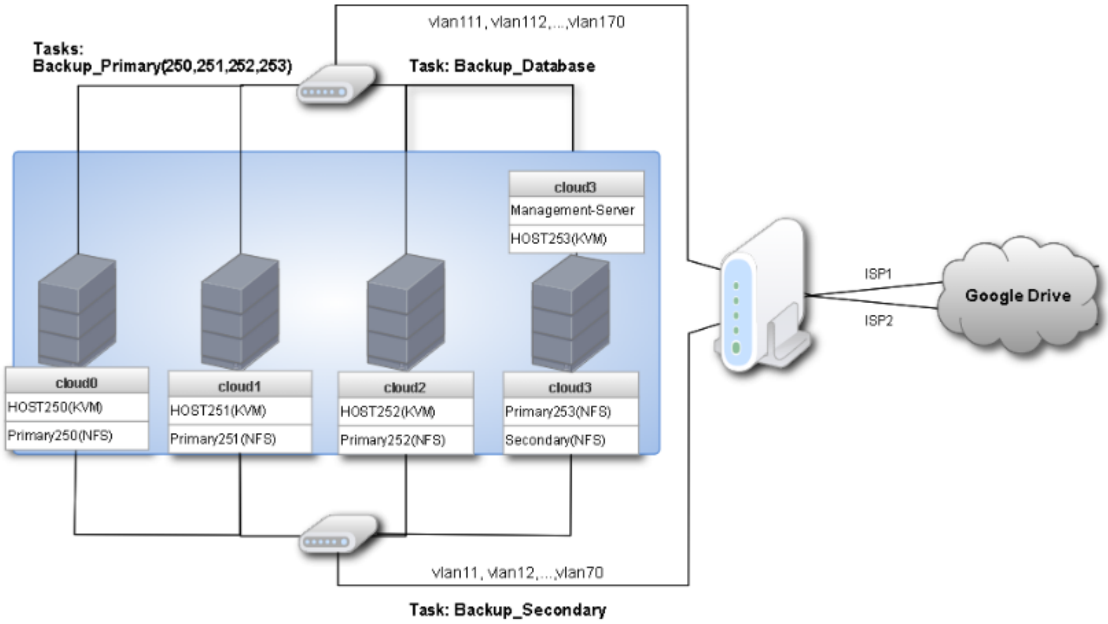

Figure 1: Academic cloud infrastructure backup scheme.

To synchronize the /export/sync_secondary/arch_cloud folder, the following command has been added to the server task scheduler: *google-drive-ocamlfuse /export/sync_secondary*

It runs every time a server with secondary storage is loaded.

A backup of all databases is required to restore the Apache CloudStack cloud infrastructure. These are such databases:

- *Cloud.* It contains all objects of cloud infrastructure.
- *Cloud_usage.* A database that contains generalized data on resource consumption by the end user. It is used to obtain statistics and compile reports.

Since the backup of these databases is quite small, we decided to store all backups in the cloud storage (Backup_Database task, see figure 1). The traditional database for the Apache CloudStack platform is MySQL. The main utility for backing up MySQL databases is mysqldump. Its syntax involves entering a login name and password. Because the shell script in Linux is written as a plain-text file, it will contain the name of the user's password (usually the root) of the database. This is a potential security risk for the entire server. In order not to leave open the data for authorization of the database user, we used the "login path" option. A "login path" is an option group containing options that specify which MySQL server to connect to and which ac-count to authenticate as. To create or modify a login path file, we have used the mysql_config_editor utility. In general, the commands for creating and archiving a database dump are as follows:

/usr/bin/mysqldump –login-path=DailyBackup -u root -A > $BACKUP_DIR/"archive_cloud_all_""$date_daily"".sql"

tar -czf $BACKUP_DIR/"archive_cloud_all_""$date_daily"".sql.tgz" $BACKUP_DIR/"archive_cloud_all_""$date_daily"".sql"

The variable *$date_daily* contains the current date of the archive. This allows you to see the date of archiving directly in the file name.

To upload the files to the server, we used a ready-made script from github [27]. Here is its launch:

upload.sh "arch_cloud/DB" "$entry" $upl_file folder_ID "application/x-gzip"

where

- *arch_cloud/DB* – folder for uploading files;
- *$entry* – full path to the file;
- *$upl_file* – file name to download;
- *folder_ID* – Google Drive folder ID;
- *application/x-gzip* – file MIME-type.

A special refresh_token token is required to provide long-term access of the up-load.sh script to Google Drive. It can be obtained by curl-calling a URL such as:

curl --silent "https://accounts.google.com/o/oauth2/token" --data "code=<access_token>& client_id=<client_ID>&client_secret=<client_secret >&redirect_uri=urn:ietf:wg:oauth:2.0:oob& grant_type=authorization_code"

In general, the scheme of backuping of cloud infrastructure is shown in figure 1.

Performing backup of primary repositories (Backup_Primary task (250,251,252,253)) has some difficulties. An analysis of Internet sources, management server databases, and storages files showed that the Apache CloudStack platform does not typically use full copies of disk templates for each VM. This means that full backups should be made to reduce the risk of inconsistencies in primary repository archives.

Additionally, it would be good to prepare a cloud platform, stopping all VMs. Of course, students need to form an understanding of the need to turn off their own VM. However, in practice this is not always possible. Therefore, it is necessary to stop all VM programmatically, by means of a script. This can be done using the API features of the Apache CloudStack platform. Using API functions allows the developer to access data about cloud infrastructure objects. It is also possible to change the state of these objects. To generate a query that contains API functions, you must specify:

- URL of the management server;
- Service construct “api?”. It contains the path to a certain API-function, and indicates the beginning of the parameters that are transmitted using the GET method.
- Command. It is the name of the API-function.
- ApiKey. The key, that can be generated for each user account.
- Additional query options separated like GET queries using the “&” character.
- Response format (JSON or XML).
- Signature of the request.

Regardless of the protocol (HTTP or HTTPS) used to access the Apache Cloud-Stack API functions, the request must be signed. This allows the platform to confirm that the request was sent from a trusted accounting request that has the authority to execute the appropriate command. To sign a request, the developer must have an API key and an account secret key. They are generated by the platform administrator [28].

Here is our bash-script to stop all working users' VMs.

mysql --login-path=DailyBackup -D cloud -e "SELECT uuid FROM vm_instance WHERE type = \"User\" and state = \"running\";" > uuid.txt
sed -i '1d' uuid.txt
while read LINE; do php -q cloudstackapi.php "$LINE" ; done < uuid.txt

In the first line we receive in a file from a database the list of user VM with a running state. The next command clears the first line because it does not contain a VM. The third line runs the cloudstackapi.php script. It generates a signature and calls the stopVirtualMachine API.

Another way to back up the current state of the VM is to create their snapshots. The Apache CloudStack platform provides 2 types of images [22]:

- VM Snapshot – a hypervisor-driven point-in-time image of a virtual machine's disks. The exact mechanism of this is dependent on the hypervisor.
- Volume snapshot – a point-in-time image of a specific volume. The process usually involves taking a VM snapshot and then copying the required volume to secondary storage and the deleting the VM snapshot.

This approach requires additional space on the secondary storage or data coping on the user's local disk. Such images can be taken by students from the web interface of the Apache CloudStack platform. Performing this action and turning off their own VMs after the end of their use are important components of ICT competence of the student.

However, experience shows that not all students perform these actions. Therefore, these are also worth automating with scripts. Among the API functions of the Cloud-Stack platform are relevant [29].

Another task of backing up our academic cloud is to estimate the time required to upload data to the cloud storage. Currently (October 2020) the sizes of our academic cloud storage is approximately as follows:

- primary250 – 120 Gb;
- primary251 – 80 Gb;
- primary252 – 140 Gb;
- primary253 – 80 Gb;
- secondary – 100 Gb.

Since we make a full copy of the primary storage, we need to download about 400 GB to the cloud storage each time. Let the speed of the Internet channel at night be 80 Mbps (10 Mbytes per second). Then it will take 11 hours to download 400*1024 MB. That's a lot. Therefore, we balanced Internet access through 2 providers. At the time of backup, our router routes hosts cloud0 and cloud1 through the first provider, and cloud2 and cloud3 through the second. In this case, a full backup takes about 5 hours and 30 minutes. This time is also significant, but is acceptable.

Another disadvantage of our scheme is the significant time required to download backups from the Google Drive service. However, this time will be significant if the management or storage servers fail. This means that we must back up the entire OS of the management server to fast local area network storage.

5. Conclusions

The private academic clouds should be used in cloud based learning environment, as they are necessary for education of future ICT specialists. Virtualization is one of the most up-to-date and advanced technologies for modelling many ICT objects. Despite the availability of educational grants from leading cloud vendors, many universities are deploying their own private academic clouds. During the production phase, administrators have a lot of work to do to maintain and support these academic clouds. Among these tasks, one of the most important is to ensure the productivity and elasticity of the cloud. Solving them will allow them to load the maximum number of VMs in the cloud infrastructure.

An important task in the maintenance of the academic private cloud is the backup of its components. To solve it effectively, you need to use different backup schemes such as full, incremental, differential. To save data, it is advisable to use both cloud and local storage. In any case, administrators should determine how long it will take to build and restore the entire cloud infrastructure. It is also advisable to use the API functions of the cloud platform. This will automate some maintenance tasks.

We see the prospects for our further research of our installation of a private academic cloud in the development of more efficient scripts based on a differential circuit. They should reduce the time it takes to create and copy all backups. According-ly, the time to recover data from it will be reduced. Also relevant the study of new versions of cloud platforms regarding the emergence of ready-made modules for backup. Probably, they will allow to solve many current problems.

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Digitalization of the educational process for the training of the pre-service teachers

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Abstract

According to the Development Concept of the Digital Economy and Society in Ukraine, the priority of this area is to develop a substantial national policy on digitalization of education, as this is the key part of the education reform in Ukraine. For this reason, universities should firstly take into account the particularities of teaching the current generation of students and the needs of the digital society as a whole. This paper considers the process of transition from informatization to digitalization in society, implementation of digital support for the educational process in the university, development of the digital educational environment for the training university teachers, and proposes the digital tools for such an environment. The authors propose several ways to improve the development level of digitalization of the educational environment in the university. This is to take into account the needs of the digital society and the modern generation of students, provide a high level of the digital literacy formation of university graduates and support the development of a new digital security system of the modern university. Aiming to design the digital educational environment for increasing the of educators' digital literacy level, the authors propose to develop and implement the following computer, multimedia and computer-based learning tools and equipment, which includes blended and distance learning classes, cloud technologies, tools of virtual and augmented reality, tools for gamification of the educational process, educational robotics, tools for learning 3D technologies, MOOCs.

Keywords

digitalization of the educational process, digital educational environment, training, future teachers, pre-service teachers

1. Introduction

According to the main development priorities adopted by the European Commission for 2019-2024 (6 Commission priorities for 2019–2024), one of the key priorities is "A Europe fit for the digital age", which includes empowering people with a new generation of technologies [1].

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At the same time, innovative and modernized education and trainings are strong parts of the Europe 2020 strategy [2]. This process relates not only to the European countries, but seems very important for Ukraine.

The Ukrainian government has approved (in 2018) the Concept of development of the digital economy and society of Ukraine for 2018-2020 years and the Plan for its implementation [3]. The main purpose of the concept is to implement the Digital Agenda 2020 (Digital Strategy) initiatives to remove barriers on the way the Ukrainian digital transformation in the most promising areas. This is planned to be achieved by stimulating the economy and attracting investments, overcoming digital inequalities, deepening cooperation with the EU in the digital area, and building up the country's innovation infrastructure and digital transformation.

Meanwhile, the recommendations from the EU Parliament and the Council [4] (dated 2006 and updated in 2018 [5]) state that digital competence is one of eight key competences considered as fundamental to each individual in a knowledge-based society. According to the Development Concept of the Digital Economy and Society of Ukraine, the priorities of this area are [3]:

- to develop a substantial national policy on digitalization of education, as this is the key part of the education reform in Ukraine;
- to identify specific initiatives for connecting the classes to the broadband Internet;
- to design and implement modern computer models, institutions, and tools;
- to prepare, adapt and organize access to multimedia technologies and create appropriate digital education platforms for use in the learning process and management of education.

Therefore, digital literacy is an indispensable requirement of the present, which is gradually beginning to be implemented in Ukraine. Another powerful step on this way was setting up of the Ministry of Digital Transformation of Ukraine in September 2019. Under the guidance of the Ministry, since January 21, 2020, the Ukrainian National Digital Literacy Education Platform Action: "Digital Education" has been launched [6]. On the National Digital Literacy Platform, the Ukrainians are free to take three online courses: Basic Digital Literacy, Digital Literacy for Teachers and Parents' course on Online Safety for Kids.

"We are taking another important step, which is a step towards overcoming digital inequality in Ukraine. The necessary digital skills should be accessible to all. To this end, a national digital literacy program will be launched on 21 January 2020. I will mention this as the best, most effective course in the world", – said the head of the government.

Burov et al. [7], Fedorenko et al. [8], Gergei and Mashbits [9], Glazunova and Shyshkina [10], Kalogiannakis et al. [11], Morze and Kucherovska [12], Papadakis et al. [13], Spivakovsky et al. [14], Tryus and Herasymenko [15], Vakaliuk et al. [16], Vidakis et al. [17], Zhaldak et al. [18] and others have addressed the digitalization of education issues.

Thus, Andrushchenko [19], Bykov and Shyshkina [20], Semerikov et al. [21], Spivakovsky et al. [22], Yashanov [23] and Zhaldak and Franchuk [24] have considered the informatization of the teaching-learning process in whole; Mashbits [25], Varina et al. [26] has explored psychological aspects of using digital technology in education; Bondarenko et al. [27], Lavrentieva et al. [28], Morze and Strutynska [29], Glazunova et al. [30], Pererva et al. [31], Vlasenko et al. [32], Zelinska et al. [33] have developed digital environments for higher educational institutions; Bondarenko et al. [34], Kiv et al. [35], Kholoshyn et al. [36], Korotun et al. [37], Lovianova et al. [38], Merzlykin et al. [39], Nechypurenko et al. [40], Popel et al. [41], Vakaliuk et al. [42], Velychko et al. [43], Vlasenko et al. [44], Volikova et al. [45] has studied the use of cloud technology for educational needs; Kalogiannakis et al. [11], Papadakis et al. [46], Vidakis et al. [17] have examined the ways of evaluating the learning process in the current educational environment.

Paper goal: to analyze the process of digitalization of educational environment and to develop the model of Digital educational environment for the pedagogical university.

Below we will consider the process of transition from informatization to digitalization in society, implementation of digital support for the educational process in the university, development of the digital educational environment for the training teacher university, propose of the digital tools for such an environment.

2. Theoretical backgrounds

The rapid development of digital technologies and, as a consequence, the digitalization of many sectors of society, led to the introducing such terms as "digitization", "digitalization", "digital transformation", which, in its turn, has led later to the so-called of digital transformation concept.

Bimber et al. [47], Brennen and Kreiss [48], Bumann and Peter [49], Bykova et al. [50], Dannikov and Sichkarenko [51], Knorr Cetina and Bruegger [52], [53], Castells [54], Kravchenko et al. [55], Kucherova et al. [56], Dijk [57], Pikilnyak et al. [58], Verhulst [59], Vyshnevskyi et al. [60] pay their attention to the issue of defining the concept of "digitalization". Following on the analysis and synthesis of experience and research, we define digitalization as a process of transformation and/or improvement of enterprise activities, business models, business functions, communications, use of online platforms, training and retraining of staff to work in new conditions, etc. based on the widespread use of digital technologies and digitized data.

One of the areas, in which fundamental changes take place due to the digitalization and digital transformation, is education.

In accordance with the Draft Law of Ukraine "On the Digital Agenda of Ukraine" (figure 1), there is a process of transition from informatization to digitalization in society [61].

The Development Concept of the Digital Economy and Society in Ukraine for 2018–2020 Cabinet of Ministers of Ukraine [3] identifies the main goals of digital development of Ukraine and eight principles of digitalization:

1. Digitalization has to provide every citizen with equal access to services, information and knowledge through ICT and digital technologies.
2. Digitalization should be aimed at creating benefits in various areas of daily life.
3. Digitalization is achieved through the economic growth mechanism by improving the efficiency, productivity and competitiveness of digital technologies.
4. Digitalization should promote the development of the information society and media.
5. Digitalization has to focus on international, national and regional cooperation to integrate Ukraine into the EU entering the European and world market.
6. Standardization is the basis of digitalization, one of the main factors for its successful implementation.

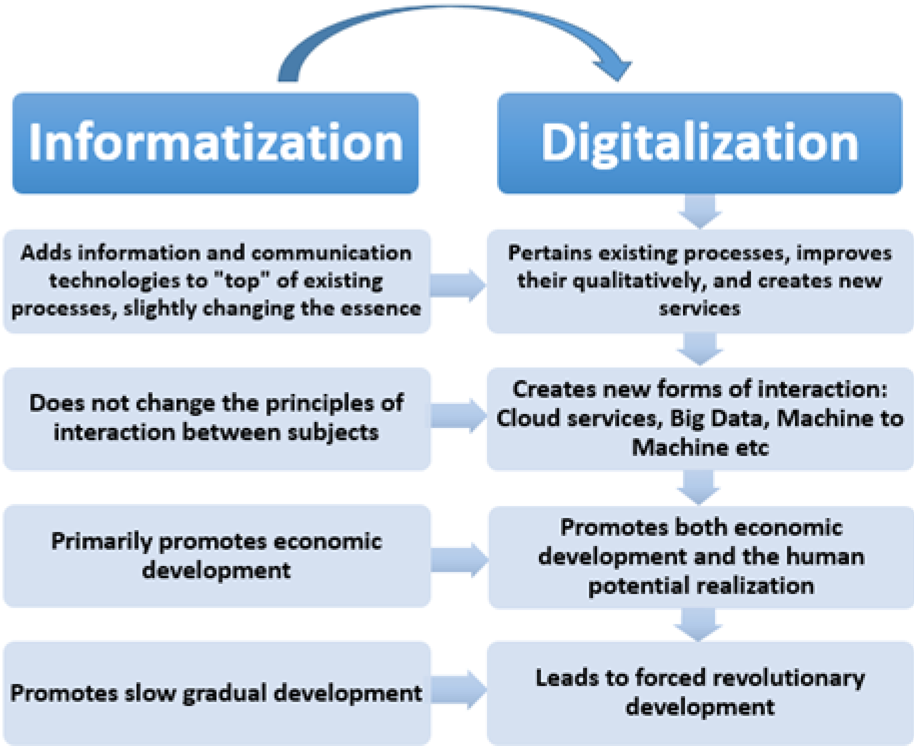

Figure 1: Process of transition from informatization to digitalization in society (based on [61])

7. Digitalization should be accompanied by increased confidence and security.
8. Digitalization is an object of focal and integrated governance.

Digital competencies are described as the knowledge, skills, and experience of using end-to-end and multi-platform digital technologies in professional activities. Besides that, this is for self-education, knowledge, skills and competencies in many other fields (e.g., for learning of languages, mastering new professions, etc.).

Digital competence of the Ukrainian teachers is not considered in the Concept, but there is a process of establishing the digital competence.

However, according to the European Framework for the Digital Competence of Educators [62], Digital Competence can be broadly defined as confident, critical and creative use of ICTs to achieve goals related to work, employability, learning, leisure, inclusion and/or participation in society. Digital Competence provides not only the ability to use digital technologies. It has also become increasingly necessary for the formation of creativity and critical thinking that is so meaningful in the 21st century.

On the way to digital development of the Education Concept [63], it is very important to harmoniously combine new digital technologies with traditional ones. Digital technologies make the learning process mobile, differentiated and individual. At the same time, the technologies do not replace the teacher, but complement him/her. Such lessons are adaptive, manageable, interactive, combining individual work with group one and time-limited learning.

3. Results

In order to improve the students' knowledge quality, to develop the digital competence of all participants in the learning process, create favorable conditions for self-development and self-studying, ensure access to education in 7×24 format (i.e., 7 days a week, 24 hours per day), and also raising of the national and international rating of National Pedagogical Dragomanov University, there is effective implementation of digital support for the educational process in the university. That's why the priority areas for educational institutions are:

- digitalization and innovation;
- globalization (establishing of an intercultural environment);
- mobility of students, pupils, teachers, lecturers;
- distance and online learning;
- informal learning and MOOC technologies.

The conditions of the pandemic put the heads of educational institutions up to reconsidering and changing approaches to the educational process. Accordingly, the digital educational environment of educational institutions were changed and adapted, i.e., a digital analogue of physical institutions. Specialists with different success rates try to model the digital environment of all structural and learning components of educational institutions. Virtual classes, remote personal accounts, online lectures, etc. have appeared. The problem of placement and full functioning of all elements of the educational process in the distance and blended learning modes has become extremely acute. An example of such adaptation is the following model of distance learning, which describes the features of the educational process organization during the quarantine in the National Pedagogical Dragomanov University (figure 2).

This model of distance university work has arisen by force and, for the greater part, it was a swift response to the quarantine conditions, in which the whole world found itself. As part of the digital transformation of the educational process, NPU develops and implements innovative computer, multimedia and computer-aided learning tools and equipment to create a digital educational environment, such as:

- Blended and distance learning classes;
- Cloud technologies;
- Tools of virtual and augmented reality;
- Tools for gamification of the educational process;
- Educational robotics;
- Tools for learning 3D technologies;
- MOOCs.

3.1. Distance learning

According to the concept of digital economy and society development [3] one of the main areas of digitalization of education is "the development of distance learning using cognitive and multimedia technologies". Therefore, the introduction of distance and blended learning at pedagogical universities is an extremely urgent requirement of our times [64]. In addition to

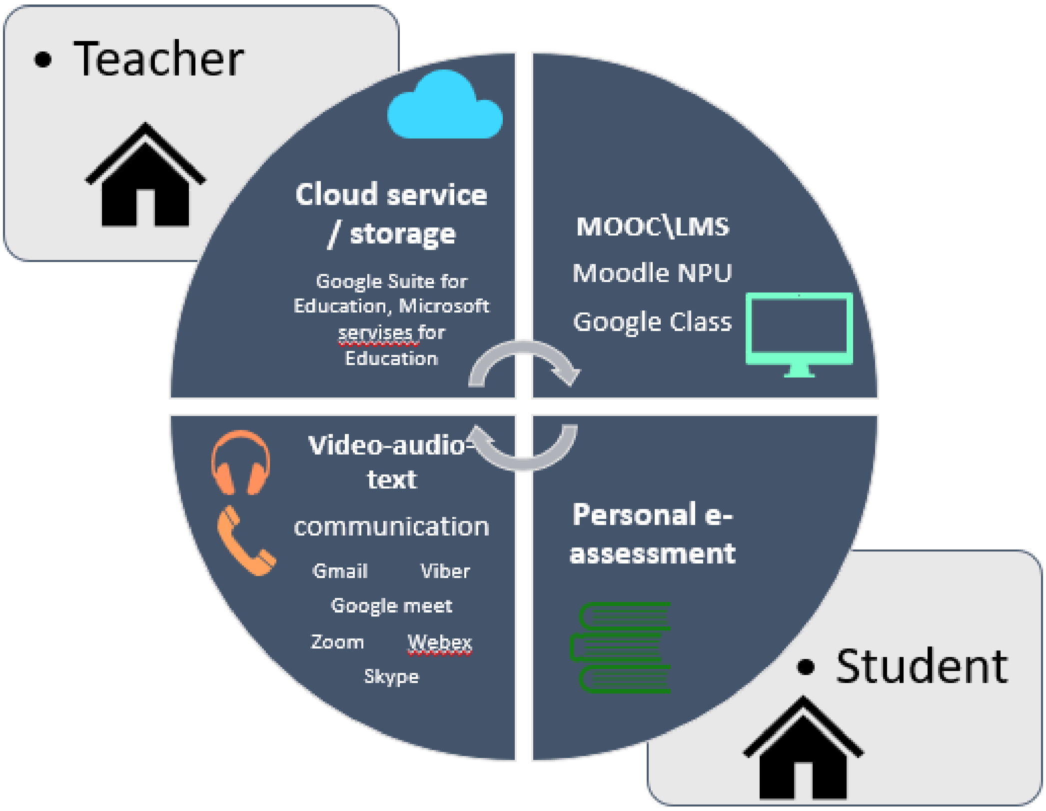

Figure 2: Digital educational environment of the National Pedagogical Dragomanov University (NPU).

traditional opportunities and aiming to improve the quality of providing educational services to students, there is an implementation of a full-featured IT space of the university with the use of remote educational technologies that have proven themselves at the leading universities in the world and have the most powerful potential within the educational process.

It should be noted that the main advantages of distance and blended learning are independence from the place of study, individual pace, time of study, rapid adaptation of the content of learning to the educational needs of students, etc.

Distance learning is an independent activity of the learner that is realized in a specific didactic system, in which both (the one who is teaching and the one who is learning) are independent in space and time and can interact with each other [65, 66, 67, 68, 69].

Since 2010, the system of distance learning based on Moodle [70] was implemented in National Pedagogical Dragomanov University [71] (figure 3).

Moodle is a learning platform designed to bring teachers, administrators and students together in a reliable and integrated system for creating personalized distance learning environment. For now, Moodle platform has over 500 e-courses.

The distance learning environment at the university is used both to support full-time and

Figure 3: Home page of the university's distance learning environment.

part-time students (blended learning), as well as to organize independent distance learning in the local centers of the university for professional training and retraining (Lubny, Lviv).

3.2. Blended learning

According to the Concept of development of digital economy and society [3] the priority area in digitalization of education is development and introduction of innovative computer, multimedia and computer-based learning tools and equipment for creating a digital learning environment (multimedia classes, lab STEM research centers, inclusive classes, blended learning classes).

The steps of introducing distance learning at university are briefly described above. Let us focus on the other areas of digitalization, which are the development and implementation of innovative computer, multimedia and computer-aided learning tools and equipment to create a digital learning environment for pedagogical universities.

Therefore, organizing blended learning in the university has to be considered.

This pedagogical technology is very important for the formation of high-quality education.

Blended learning provides flexibility in relation to traditional learning, and enables teachers to offer training in different variations of presentation on training material. Thus, a harmonious combination of traditional and distance learning is carried out [72]. Blended learning is implemented at the university by using Moodle platform [64] and MOOC elements (Massive Open Online Courses) within in-person training (figure 4).

3.3. Massive Open Online Courses

MOOC is an acronym for Massive Open Online Courses. MOOC students watch video lectures and participate in online discussions with professors and other students. Some MOOCs require students to complete test assignments that allow them to choose the answer from the suggested ones, and some tests require the completion of assignments that are assessed by several people, including the students themselves.

National Pedagogical Dragomanov University suggests using of MOOC to support students' full-time study [73]:

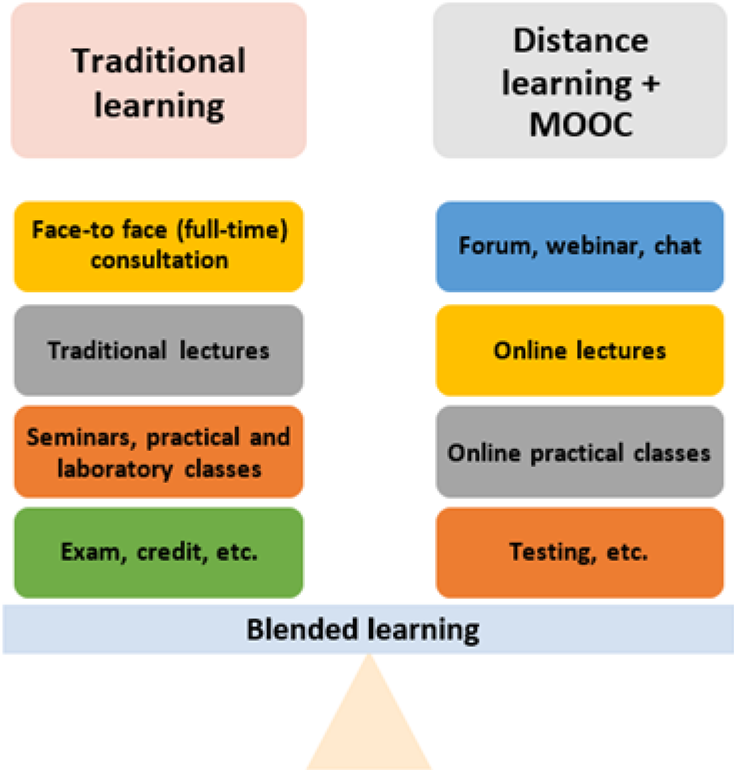

Figure 4: Organization of blended learning in the university.

1. Pre-university education.
2. Adding MOOC training elements to traditional courses.
3. Advanced training and retraining of specialists.

The recommended MOOC's are shown in table 1 and table 2.

Table 1
MOOC recommended for pre-university education

Name of MOOC	Reference to MOOC
Ukrainian language and literature	http://courses.prometheus.org.ua/courses/OsvitaOnline/Ukr101/2015_T1
Mathematics	http://courses.prometheus.org.ua/courses/Prometheus/101/2015_T1
English language	http://courses.prometheus.org.ua/courses/OsvitaOnline/Eng101/2015_T1
Physics	http://courses.prometheus.org.ua/courses/Prometheus/102/2015_T1
Chemistry	http://courses.prometheus.org.ua/courses/Prometheus/103/2015_T1

Now NPU has personal subscriptions to MOOC-platforms Coursera and EdX. They are used as training elements for students within traditional courses and as advanced training and retraining for University teaching staff.

Table 2
MOOC recommended for in-depth study of individual ICT topics and programming of different difficulty levels for masters, pre-service (future) Computer Science teachers (in English)

Name of MOOC	Platform
Understanding IELTS: Techniques for English Language Tests course	FutureLearn
How to create a Windows 8 App	Independent
Codecademy	http://www.codecademy.com
Python For Informatics	Independent
Design and Development of Educational Technology	edX
Cloud Computing Concepts, Part 1	Coursera
Introduction to the Internet of Things and Embedded Systems	Coursera
Java for Android	Coursera
Beginning Game Programming with C#	Coursera
English for Teaching Purposes	Coursera
Fundamentals of Online Education: Planning and Application	Coursera
Teaching Math Through Problem-Solving K-12	Canvas.net
How to create MOOC (in Ukrainian)	Prometheus

3.4. Virtual and augmented reality

Virtual Reality (VR) is the world, which is artificially created with the help of special technical means that has the maximum impact on almost all human senses (sight, hearing, sense of smell and touch). Augmented Reality (AR) is a technology that enhances the user's imagination in the real world and is complemented by additional computer models while keeping the user connected to the real environment [74].

At the Digital Educational Technology Center of the National Pedagogical Dragomanov University, there is a working group aimed at creating educational materials based on virtual and augmented reality. Such development is a separate area of study for the field of distance learning and is used to organize virtual classes of the university's distance learning environment. The center plans to develop the training materials for both individual subjects in the school cycle and for use in the university's remote environment.

There are VR and AR examples for stereometry and astronomy (figure 5 and figure 6).

We have proposed to study VR/AR as the optional course for students from the Faculty of Informatics (NPU) within the last academic year. This course has got positive feedbacks from students (MSc and BSc) and administration of the Faculty and University. Therefore, we are extending this experience to other Faculties during the current academic year.

3.5. Gamification

Gamification is attracting to games where there is usually no place for play. Many experts consider gamification as one of the most important trends in the information technology industry [75, 46, 76, 77, 78, 79].

The elements of gamification are used to organize distance, blended and traditional learning in the university.

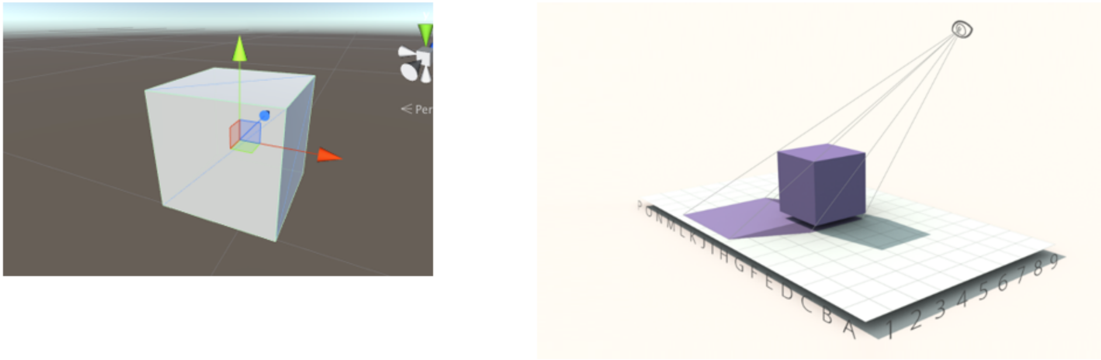

Figure 5: Virtual geometric shapes for stereometry designed by students of the Faculty of Informatics.

Figure 6: Virtual and augmented reality model of the solar system in the Unity environment designed by students of the Faculty of Informatics.

As an example of using gamification in carrying out research quest on the modern programming languages for pre-service Computer Science teachers we are using encrypted QR codes [80].

Gamification is widely used in remote courses to create VR and AR applications (figure 7).

We use the elements of the gamification within every course on the Faculty of Informatics. This requirement is stated in the courses' curriculum.

3.6. Educational robotics and 3D technology

The laboratory of Robotics and 3D Technologies operates at the Faculty of Informatics in National Pedagogical Dragomanov University (starting from 2017).

Robotics and 3D technologies are powerful learning tools that are suitable for all ages (from elementary students to professors). Educational robotics education and 3D technologies are in line with the ideas of advanced learning (learning the technologies that will be needed in the

Figure 7: Designing virtual reality of "7 Wonders of the World" within the university distance learning courses.

future) and allow students of all ages to be involved in the process of innovative and scientific and technical creativity [81, 82, 83, 84, 85, 86, 87, 88].

Examples of students' works developed based on Arduino robotic platforms and 3D technologies are presented below (figure 8 and figure 9).

Figure 8: 3D printed robot arm based on Arduino robotic platform.

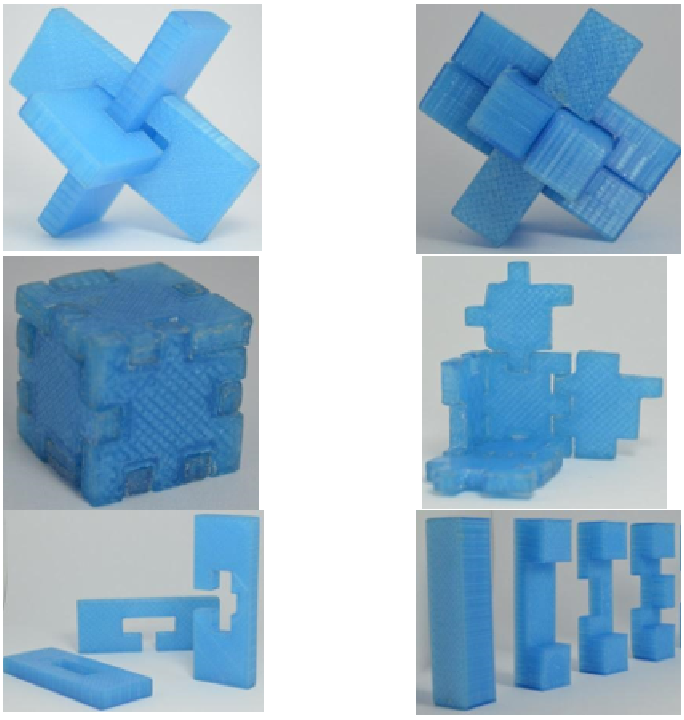

Figure 9: Prototype model of 3D puzzles designed by students of the Faculty of Informatics.

The Faculty of Informatics in National Pedagogical Dragomanov University has designed educational programs “Secondary education (Computer Science) and Robotics” (2018) for the preparation BSc and MSc students (specialty 014.09 “Secondary education (Computer Science)”) [89, 90]. All students, who choose this specialty, will get qualification of the Computer Science and Robotics teachers. Now we provide the training of educational robotics for students of other NPU Faculties to involve them in research projects (also STEAM projects).

3.7. Cloud technologies in education

According to the Development Concept of the Digital Economy and Society in Ukraine [3], one of the main priorities of digitalization of education is the creation of educational resources and digital platforms with supporting of interactive and multimedia content for public access to educational institutions and students, including tools for automating the main processes of educational institutions.

Cloud technologies are used at National Pedagogical Dragomanov University to automate the basic processes in the university work and ensure universal access to educational resources and digital platforms.

Cloud is a model that allows you to scale data sources as needed. The more users use the system, the more sources will be involved. Cloud storage takes advantage of the computer network and applies them to e-learning (from digital university classes to small training modules used for specific purposes).

Since 2016, the university staff and students have been using specialized cloud software and collaboration tools for G Suite for Education. The cloud contains a set of communication and collaboration tools, including Google Classroom, Gmail, Docs, and Drive, etc., allowing students, teachers and administrative staff to work and learn together regardless of time and place. The use of cloud services greatly increases the efficiency of the learning process.

4. Discussion

Thus, the paper addresses the following issues:

- analyzing the digitalization of the educational process in the EU and Ukraine;
- implementing the digital educational environment in National Pedagogical Dragomanov University and, as a result, increasing the digital competence of the future teachers.

According to the research conducted, the authors propose several ways to improve the development level of digitalization of the educational environment in the university. This is to take into account the needs of the digital society and the modern generation of students, provide a high level of digital literacy formation of university graduates and support the development of a new digital security system of the modern university:

- development of distance and blended learning;
- adaptive learning, which incorporates the benefits of distance, blended, MOOC learning and virtual / augmented reality technologies;
- widespread use of cloud technologies to automate the core processes of the university and ensure public access to educational resources and digital platforms;
- update of curricula for future teachers through the inclusion of the STEM approach and educational robotics (for students);
- involvement of the University teaching staff in retraining of the teachers for further development of their digital skills.

Recommendation for Researchers. The research gives us the opportunity not only to develop a model of the digital educational environment for pedagogical universities, but it also can be used as a roadmap for development of the model of digital educational environment for secondary institutions.

There is a controversial issue of creating a full-featured digital educational environment, which addresses the needs of the digital society and the current generation of students and ensures the highlevel of digital literacy of university graduates.

The digitalization of the educational process during the training of the future teachers will benefit within different levels:

- local level:
  - increase of awareness of the digitalization of the training process of the educators;
  - improvement of study skills;

- participation in the collaboration on research activities with the use of different digital tools.

- regional / national level:
  - improvement of the national core curricula according to the article findings;
  - bringing together students, specialists and civil society to promote the digitalization of the educational process.

- overall expected impact is following:
  - increase of opportunities for academic staff;
  - support and promotion of young researchers and teaching staff;
  - enhance of employability, career prospective for students and young researchers;
  - integration of the best practices in the digital competency field into the Ukrainian universities learning process;
  - implementation of improved innovative curricula into educational process of universities;
  - collaboration with other organizations (the Ukrainian universities and public schools);
  - formation of more active citizenship with regard to the Digitalization of the educational process issues.

5. Conclusions

In the paper, the authors declare to introduce digitalization of the educational process by creating a developed digital educational environment.

Aiming to design the digital educational environment for increasing the of educators' digital literacy level, the authors propose to development and to implement of the following computer, multimedia and computer-based learning tools and equipment:

- Blended and distance learning classes;
- Cloud technologies;
- Tools of virtual and augmented reality;
- Tools for gamification of the educational process;
- Educational robotics;
- Tools for learning 3D technologies;
- MOOCs.

Our future work is finding the effective ways to develop the Ukrainian educators' digital literacy level and their digital competences for making them as fluency use of the digital educational tools and digital educational environments.

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Ways to design a digital educational environment for K-12 education

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Abstract

Most educational institutions strive to create favourable conditions for students which meet educational needs of each student. It leads to high demand in the digital educational environment of K-12 education institutions. The article is devoted to the description of the concept, components and ways of designing the digital educational environment of a K-12 education institution through the transformation of educational activities. The importance of developing an educational policy of an educational institution in the field of digital technology is described. Authors present the model and the ways of designing the digital educational environment of the K-12 education institution. The necessity of self-assessment of digital technologies usage in the educational process by all its participants is substantiated; the ways of application of the European tool SELFIE for carrying out such self-analysis are described. Based on the adaptation of all components of the tool SELFIE for Ukrainian education, the results of its usage at one of the secondary schools in Kyiv are presented.

Keywords

digital digital educational environment, educational strategies, digitalization of education, SELFIE tool, self-assessment, K-12 Educational Policy

1. Introduction

Socio-economic changes around the world, the comprehensive processes of globalization and the rapid spread of innovation lead to constant transformations of educational systems at various levels. As a result, the entrenched models, methods, forms of learning and educational content are undergoing radical changes. The key task of general K-12 education in these conditions is to ensure quality training of students, focusing on the requirements of the modern labour market. A modern graduate of a secondary school must be competitive, mobile and ready for continuous learning. Such requirements include a rethinking of the structure and content of the provision of educational services by K-12 education institutions (SEC). Mastering and using the latest forms of educational activities, modernization of educational approaches will promote the development of competent professionals who will have thorough knowledge and will be highly trained; they will be able to think rationally and will have an integrated approach to stated problems.

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However, today the essence of education remains constant, the conditions of teaching and learning are being transformed very slowly and too carefully. Digital tools are gradually being introduced at the state level, but not all educational institutions are ready for this, as most teachers, educational politicians and heads of educational institutions do not have basic digital competencies. At the same time, there are still no approved standards for the use of digital technologies in educational activities in Ukraine. Digital competences for the population and educators have already been adopted in Europe, the United States and some post-Soviet countries, particularly in education: the European Digital Competence Framework 3.0 [1], the UNESCO Teacher ICT Competence Framework [2] and the ISTE Standards for Educators from the International Society for Educational Technology [3].

At the same time, in Ukraine there are still no state requirements to assess the digitalization level of the educational process for educational institutions and the level of digital competence development of all stakeholders in education. As a result, there is a low level of digital literacy among the entire population. The Ministry of Digital Transformation of Ukraine in 2019 conducted research that shows the importance of determining ways to implement the digital transformation of education. Thus, 37.9% of Ukrainians aged 18-70 have low digital skills, another 15.1% do not have them at all. 53% of the population of Ukraine is below the mark "average level" according to the methodology for assessing the level of digital skills, which is developed and proposed by the European Commission for implementation. Another number obtained from the survey relates to the actualization of digital skills training in the country – 47% of Ukrainians aged 18–70 believe that digital skills training is relevant for them. And it should be noted that most of them are young people [4]. Interest in mastering digital skills is probably worse due to low digital readiness. This leads to the irrelevance for the population to learn the latest digital systems and tools. As for interest, the need for research of new directions and tools, deepening of already acquired knowledge and expansion of relevant competencies is actualized.

Based on the experience we can say that creation of a digital educational environment is a necessary and sufficient condition for the development of digital competencies of all stakeholders in the educational process especially at the level of secondary education. Furthermore, its effective usage will ensure the quality of learning outcomes.

The purpose of the article is to determine the principles of educational policy for designing a digital educational environment of K-12 education, a description of tools for identifying the level of digital readiness of all participants in the educational process based on reflection and self-assessment systems using the examples of secondary schools.

2. Literature review

Today, studies of theoretical and methodological aspects of digital transformation of K-12 education and the creation and effective use of educational institutions digital policy are quite relevant. These issues are not fully studied, researched and generalized in the implementation of the New Ukrainian School Concept [5] and the updated Law of Ukraine "On complete general secondary education" [6].

The problems of digitalization of education are in the center of attention of the pedagogical community, as evidenced by numerous conceptual and thorough studies of Ala-Mutka and Punie [7], Barna [8], Burov et al. [9], Bykov et al. [10], Lázaro-Cantabrana et al. [11], Carretero Gomez et al. [12], Clark [13], Fedorenko et al. [14], Ghomi and Redecker [15], Haddad and Demsky [16], Ivaniuk [17], Kozma [18], Morze et al. [19], Pokulyta and Kolotylo [20], Semerikov et al. [21], Smyrnova-Trybulska et al. [22], Strutynska et al. [23], Vuorikari and Scimeca [24], Xu and Warschauer [25].

Digitalization of education is an important component of the transformation of K-12 education, one of the main tasks of information society development in Ukraine. The concept of development of the digital economy and society of Ukraine for 2018–2020 provides that the digitalization of education is a modern stage of its informatization [26].

The main obstacle to the digital transformation of the educational process is the lack of understanding of starting points, the lack of integrated vision and understanding of the necessary and sufficient conditions for the success of such transformation. As the outlook of radical change can be misleading, it is important to understand which strategy to choose and how effectively develop an educational policy in the field of digitization and create a digital educational environment of high quality.

Unfortunately, at the state level Ukraine has not yet formed a strategic document that would regulate the process of formation and use of digital education policy. The Decree of the President of Ukraine "On the National Strategy for the Development of Education in Ukraine until 2021" provided for some provisions that indirectly relate to educational policy, in particular: the section on the informatization of education [27]. Some strategic provisions for the education development are presented in the Digital Agenda of Ukraine–2020 [28]. Educational policy can accelerate the progress of updating approaches to the use of digital educational technologies. A clear action plan at all levels of interaction will contribute to empowering educators in using digital technologies that promote their professional activities.

To create a digital educational strategy one needs to analyze the state of the institution. Intel has developed guidelines to create digital education policies for all stakeholders. It [29] consists of six interrelated components: a shared vision and division of responsibilities in the team; combination of leadership, methodology and evaluation; professional development of teachers; resource provision; educational repository; openness and transparency.

Experts of the Ukrainian Institute of the Future [30] suggest for analysis the following indicators that characterize the state of implementation of digital educational policy in the educational institution:

1. providing access to technology;
2. high-quality network coverage;
3. development of multimedia educational content;
4. increasing digital literacy;
5. data protection.

3. Research methods

To research the peculiarities of the education environment a complex of theoretical (analysis and synthesis of Ukrainian and foreign scientific, pedagogical and methodological sources on the article's topic) and empirical methods and analysis of the received data. Students and teachers took part in the survey within SELFIE.

4. Research result

To develop an educational policy, it is necessary to determine what are the external and internal components of the educational environment, what tools should be used, how participants in the educational process can interact to achieve their goals and how coordination, management and evaluation of results is going to happen. It is important to note that such activities are not limited to work in the field of the educational institution; it continues to exist outside, through digital tools as well.

Based on the study of Kulesz [31] we built a model that reflects the ways of designing a digital educational environment (figure 1).

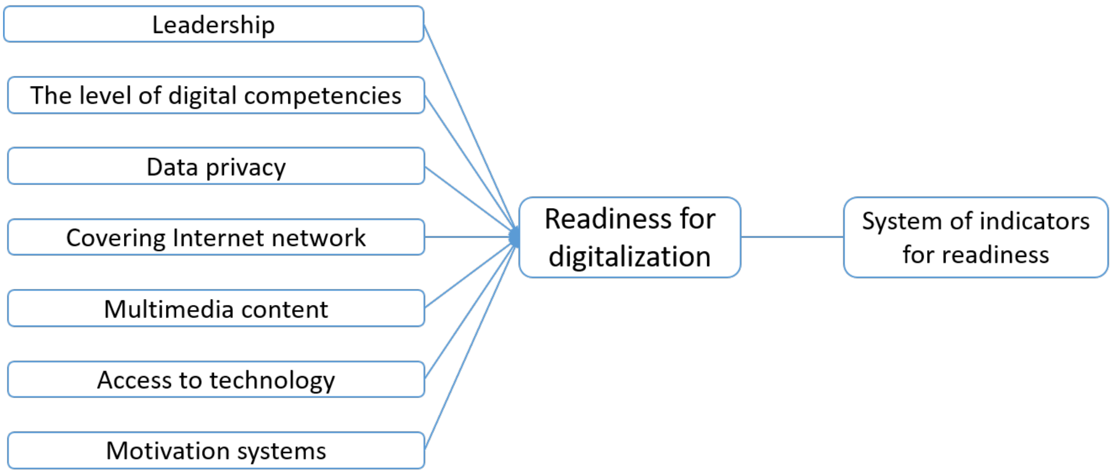

Figure 1: Model of designing a digital educational environment.

Based on the model and in accordance with the Digital Agenda of Ukraine–2020 [28] and the program "Ukraine – learning nation" [32], we can identify the following ways to build a digital educational environment of K-12 education (figure 2):

- `independent` qualitative and quantitative research of digital competencies of participants in the educational process, identification of factors influencing their development, outlining the main obstacles to building a holistic digital educational policy;
- `creation` of a universal set of digital services for all participants in the educational process;
- `assigning` each participant of the educational process a unique digital signature to certify learning outcomes;
- `introduction` of the BYOD model (bring your own device);
- `creation` of high-quality educational multimedia digital content;

- `measuring` and certifying the level of digital skills in accordance with modern needs on the basis of the adopted European Digital Competence Framework (DigComp) [12].

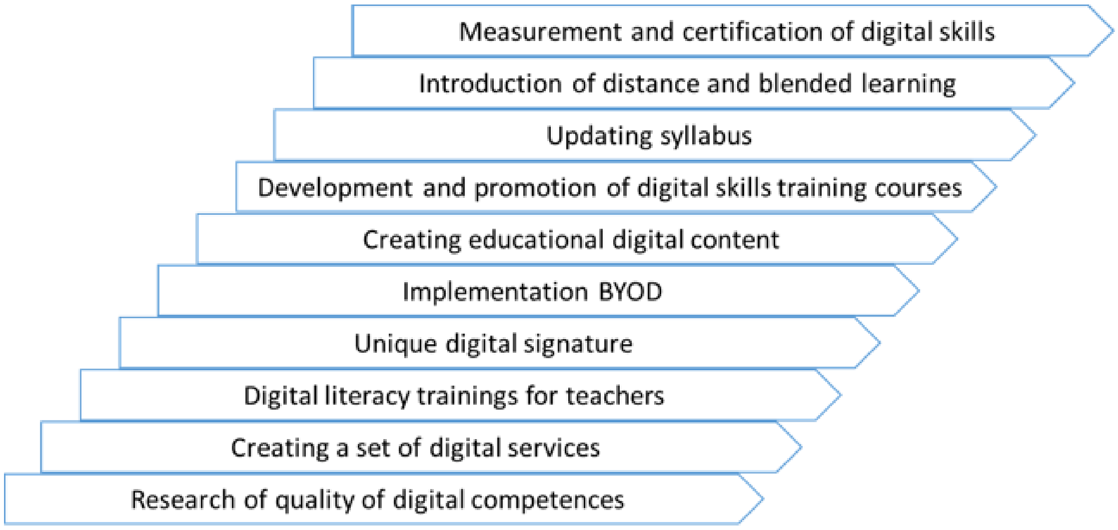

Figure 2: Ways of designing the educational environment of secondary education [28, 32].

To help with selection of digital resources for educational policy design in secondary education Intel has developed certain strategies to find resources for learning in the implementation of educational policy [29]:

- `selection` of appropriate digital resources, taking into account specific goals and objectives;
- `assessment` of reliability and security of digital sources and resources;
- `review` of restrictions on the use of digital resources.

Innovations have significant potential to ensure the quality of educational programs, but participants in the educational process may not be ready to integrate technologies and do not have the appropriate knowledge and skills to use them. The successful application of digital technologies in the curriculum relies heavily on the teachers' and managers' willingness to accept change [29].

There are already various resources and tools in the world to assess the level of digital competences. For example, Microsoft Customer assessment tool [33], COMDID [11], ETS iCritical Thinking, NAEP, Australian National ICT Literacy [16], SELFIE [34].

Analysis of the activity of secondary education institutions proves that the use of SELFIE tool is quite relevant. Moreover, in our opinion its usage is a necessary condition for creation of educational policy by educational institutions in terms of digitalization of educational process.

SELFIE is a free online tool that helps schools in assessment of digital technology usage for innovative and effective learning [34]. This self-assessment process can help to start a conversation at school about potential areas for improvement. SELFIE enables schools to make a brief description of where they stand in the use of digital technology. SELFIE also allows school to track its progress over time.

Through a series of questions to teachers, school leaders and students, SELFIE measures how digital technologies are used for teaching at school. The questions for school leaders focus primarily on school-level strategies and practices related to the use of digital technologies. The questions for teachers mostly focus on their teaching practices, and as for students they have questions regarding their experience and learning practices related to the use of digital technologies. Schools can customize the tool by adding questions that fit their context. With SELFIE, you can anonymously gather the views of students, teachers and school leaders on how technology is used in their school today. The survey process takes about 30 minutes. The questions are adapted to each group [34].

SELFIE is seen as a tool for self-reflection of the educational institution by promoting the use of innovative educational technologies. It is designed to help educational institutions implement digital technologies in the educational process effectively. This tool helps to analyze comprehensively the results of the whole team and draw sound conclusions about it, identify problems and outline further development. One of the main features of SELFIE is that it can be used to prioritize the quality of the internal educational environment. Due to this resource, you can get information from students, teachers and school administration about the way a particular educational institution uses digital technology [34].

SELFIE covers the following stages of self-assessment: reflection, discussion, planning, and improvement. Any educational institution needs self-reflection on a regular basis. Moreover, building a shared vision and involving the entire school community will help create lasting change.

The survey is conducted anonymously, without specifying the name, class, field of activity. The questions used provide answers in the form of short statements, which are evaluated in the range from 1 to 5. The questions of the comprehensive questionnaire are divided into the following groups: leadership, infrastructure, teacher training process and its evaluation, continuous professional development and digital competence of students (figure 3) [34].

After conducting a survey using the SELFIE tool, an individual interactive report on the strengths and weaknesses of the educational institution in the field of digital technology in the educational process is generated. The accuracy of the result largely depends on the number of respondents participating in the survey. Such analysis provides a solid ground for building the educational policy of the educational institution, and as a result its proper and rapid development, and consequently the development of all participants in the educational process. If necessary, the tool can be reused over time to assess the results of implementation.

The report on the summary of the survey results is available only to the respondent institution, so from an ethical point of view, we will not announce the name of the secondary school. Infographics are only available to the school in the personal account, and no one outside can access them. The survey was conducted during February 28, 2020 – March 19, 2020. 75% of managers, 74% of teachers and 84% of students participated (figure 4). Testing for students was conducted mainly during school hours, which is in line with the advice of the European Commission.

The study found that the leadership qualities of all participants in the educational process are above average: managers and teachers rank them by 4.5 points out of 5 possible, and students by

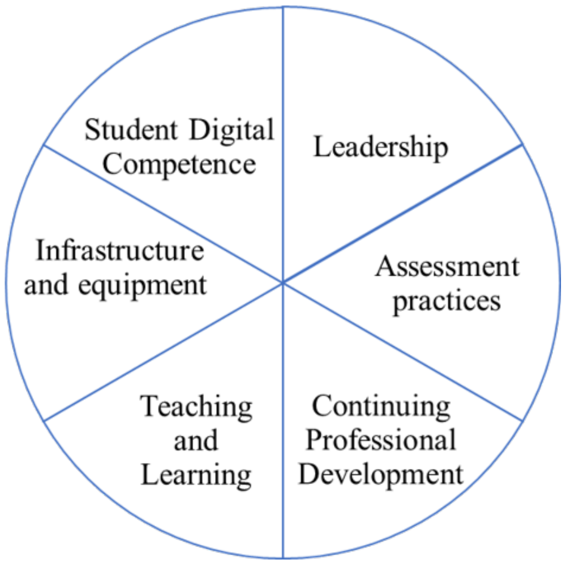

Figure 3: Structure of SELFIE questionnaire tools.

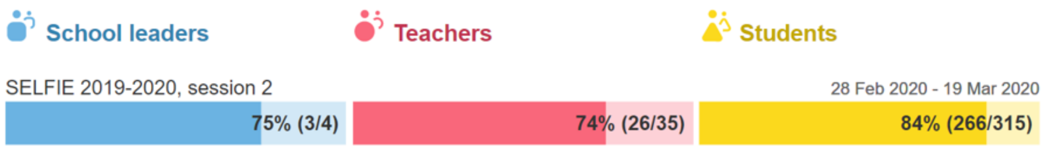

Figure 4: The number of respondents.

3.4 (figure 5). After discussion, it was found that the leading roles in the institution are mainly occupied by members of the student government; while the rest of the children are aimed at earning grades and admission (the school teaches 8-11 grades).

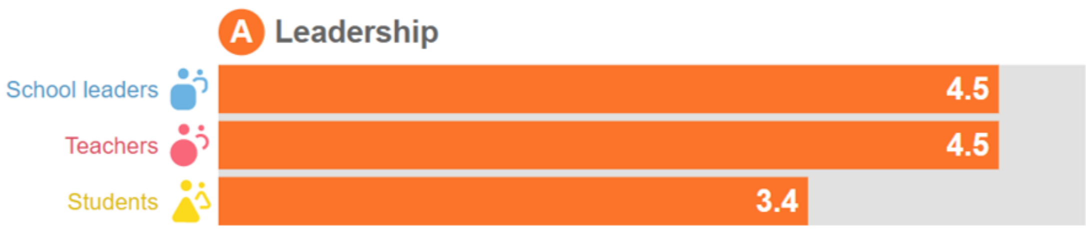

Figure 5: Average leadership indicators, points.

The equipment of the institution receives a high rating (figure 6). Students lack digital devices for individual use. At the same time, the institution has a photo-video studio, a 3D farm and a robotics office.

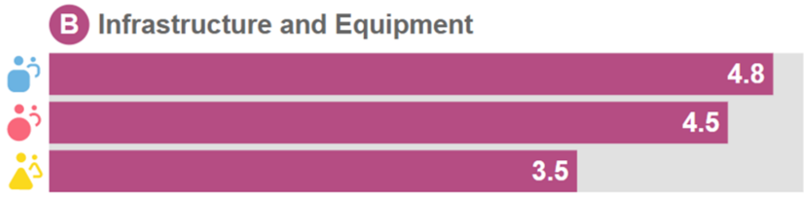

Figure 6: Average indicators of infrastructure and logistics satisfaction, points.

Continuing professional development of educators is ranked at 4.7 points (figure 7). Teachers note that the administration provides the tools and resources needed to enhance their digital competencies.

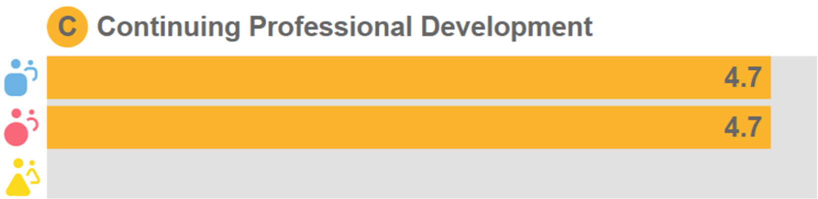

Figure 7: Average performance indicators of continuous professional development of teachers, scores.

Students' level of satisfaction with teaching and learning is on the average, because in their opinion, the educational process lacks innovation and relates poorly to real life (figure 8). In turn, teachers emphasize that they try to keep up with the times and innovation.

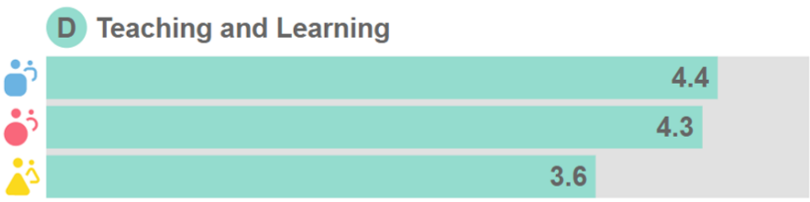

Figure 8: Average indicators of satisfaction with teaching and learning, points.

The school partially uses formative assessment, students note that they are interested in this approach to learning, but not all teachers adhere to the rules provided by its specifics (figure 9).

Managers rate students' digital competencies with the highest score, while students say they have insufficient knowledge of media literacy (figure 10).

Figure 9: Average satisfaction with assessment practices, scores.

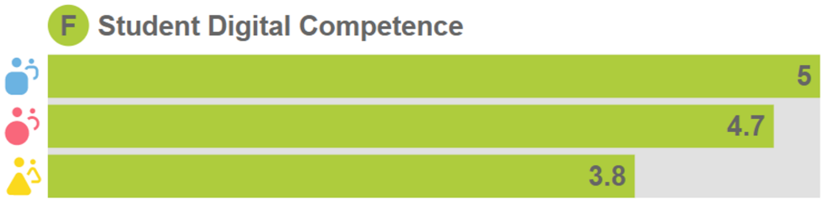

Figure 10: Average indicators of students' digital competencies level, points. Source: SELFIE tool

5. Conclusions

Generalization of foreign and domestic experience, analysis of scientific and methodological sources, methods, ways and tools of digital transformation of secondary education and self-assessment of all participants in the educational process on the introduction of digital technologies in educational policy, identification of ways to build a digital educational environment, the results of the survey allow us to draw the following conclusions.

1. The modern system of education in Ukraine and, the educational process of each individual educational institution, directly, needs a digital transformation that can ensure the quality and efficiency of the educational process. To ensure its effective provision, it is expedient to envisage and design educational policies at all levels of education, which will include aspects of digitalization and development of digital educational environment. A high level of digital competence of all stakeholders of the educational process is necessary and sufficient for its effective use.
   Due to the rapid development of digital technologies and modern techno trends, an integrated approach to the transformation of the education system involves comprehensive interaction of all participants in the educational process, to avoid resistance to digital technologies usage, it is important to outline the benefits of digital transformation in education. Understanding and applying educational digitization is the key to success, so it is important to prioritize it. By focusing on promoting the development of digital citizenship among teachers and students, making it the basis of the educational policy of the educational institution, it is possible to create an effective educational space of high-quality for the new generation. This, in turn, will help the educational institution to remain relevant, offering students a modern level of education that is needed for future success in life and further learning. The design, creation, development and use of a

modern digital educational environment is the right path to the digital maturity of all its participants.

2. To implement the model of digital educational environment we have built, it is necessary to create a team of like-minded people, defining the main goals and objectives, as well as technologies, methodologies and innovations that will be needed to achieve them. You then need to create a step-by-step action plan and notify all stakeholders. Cooperation with private and state-owned enterprises plays an important role in building digital transformation to address changes, adjustments and updates in educational programs and learning models. Technologies are used in enterprises on a daily basis, and joint activities of educators with representatives of the commercial sector will contribute to a better understanding of the needs of the time.
3. It is important to monitor the level of digital skills and digital readiness of all participants in the educational process, which is why it is necessary for each educational institution to set requirements for the level of digital competence of all participants and provide special seminars and training for their training and education. It is also important which tool is chosen by educational institutions to organize proper self-analysis and assess the level of readiness for digitalization of the educational process. The SELFIE tool helps educational institutions to analyze and assess the current state of digital competence, and improve the curricula and processes in the field of digitalization in the future.

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Integration of chatbots into the system of professional training of Masters

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Abstract

The article presents and describes innovative technologies of training in the professional training of Masters. For high-quality training of students of technical specialties, it becomes necessary to rethink the purpose, results of studying and means of teaching professional disciplines in modern educational conditions. The experience of implementing the chatbot tool in teaching the discipline "Mathematical modeling of socio-economic systems" in the educational and professional program 124 System Analysis is described. The characteristics of the generalized structure of the chatbot information system for investment analysis are presented and given: input information, information processing system, output information, which creates a closed cycle (system) of direct and feedback interaction. The information processing system is represented by accounting and analytical data management blocks. The investment analysis chatbot will help masters of the specialty system analysis to manage the investment process efficiently based on making the right decisions, understanding investment analysis in the extensive structure of financial management and optimizing risks in these systems using a working mobile application. Also, the chatbot will allow you to systematically assess the disadvantages and advantages of investment projects or the direction of activity of a system analyst, while increasing interest in performing practical tasks. A set of software for developing a chatbot integrated into training is installed: Kotlin programming, a library for network interaction Retrofit, receiving and transmitting data, linking processes using the HTTP API. Based on the results of the study, it is noted that the impact of integrating a chatbot into the training of Masters ensures the development of their professional activities, which gives them the opportunity to be competent specialists and contributes to the organization of high-quality training.

Keywords

Master's students, system analysis, innovative training, chatbots, programming language

1. Introduction

At the current stage of education development, the issue of introducing innovative teaching methods is the one of the greatest significance.

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The Law of Ukraine On Higher Education stipulates "ensuring an organic combination of educational, scientific and innovative activities in the educational process" as one of the primary tasks of higher educational institutions [1].

Government documents on education declare significant changes concerning improvement of higher education: focusing on the world's best standards of education, new intensive educational technologies, differentiation and integration of the content of education, implementation of modern educational technologies. In the formation of innovative society, the functional features of education are not only providing students with the knowledge and skills already accumulated during the previous years, but also the development of their ability to perceive and use new scientific ideas, tools and methods in practice [2].

Thus, the current state of society requires the use of innovative methods and technologies of training students in higher educational institutions which will enable future professionals to be more competitive in the labor market [3, 4, 5, 6]. In particular, Master's students of System Analysis (Educational Program (EP) of System Analysis) should be able to perform innovative tasks of the appropriate level of professional activities which focus on researching and solving complex problems of designing and developing information systems to meet the requirements of science, business and enterprises in different spheres [7].

2. Results

Innovative training is characterized by a constant desire to reappraise values, to preserve the ones that are of undeniable importance and to reject those that are already outdated. Innovations in education are associated with an active process of creating and spreading new methods and tools for solving didactic tasks of training specialists in a harmonious combination of classical traditional methods and the results of creative search, application of non-standard, advanced technologies, original didactic ideas and forms of educational process [8].

The process of innovations in technology and methods of modern training has become the object of study of numerous scientists. Scientific studies deal with general theoretical, scientific and practical problems of the innovation paradigm in higher education, some progressive forms and technologies of teaching, experience and prospects of their use in practice [9, 10, 8, 11, 12].

Particularly, the authors relate innovations in education to the necessity of improving the traditional pedagogical process (modernization, modification, rationalization) and of transforming the existing traditional educational process i.e. radical transformations and complex changes [13]. The researchers of pedagogical innovation correlate understanding of the new in education with such features as being useful, progressive, positive, modern and advanced [14].

Communication technologies based on messengers and chatbots are becoming a global trend in education [15]. The Internet, which was originally a medium for transmitting information, is now increasingly assuming the functions of a communicator. The global network is becoming a special communication environment, which occupies an important place in all spheres of society. This is especially true of the modern generation with mobile devices being dominating [16]. The studies have shown that phones are used for messaging more often than for other purposes [17].

Therefore, companies aspire to gain the attention of online users and create chatbots in order that they should integrate into messengers. According to Flurry Analytics' study, the demand for messaging applications on social networks and mobile networks is continuing to grow in contrast to other spheres. Thus, in 2016, which is associated with the peak of chatbot popularity, the demand for messaging applications increased by 44% compared to 11% of the average annual growth of all the applications, and the time spent by users in messengers increased by 394% compared to 69% of average growth [18].

Scientists address to approaches to the creation and application of chatbots in different fields of work [19, 20, 21, 22].

Ushakova [16] mentioned that messengers are currently used all over the world for solving various tasks that go beyond simple text messaging, as well as for customer's interaction with companies, searching for necessary products, content consumption and others. At the same time, this area is developing dynamically and requires a more detailed analysis and justification of the approaches, frameworks, platforms and analytical tools used to create chatbots.

Thus, due to the rapid development of computer technologies, artificial intelligence (AI) has entered lives of ordinary Ukrainians, making it simpler and more comfortable. Chatbots built on the basis of neural networks [23, 24, 25, 26] and machine learning [27, 28, 29, 30, 31] technologies can communicate using auditory or textual methods. These computer programs are gradually displacing the usual communication marketing, and can significantly help in education.

The digital format of mastering educational programs is expanding at all levels of education. Though online courses have made learning available to millions of people all over the world, researches show that only 7% of students enrolled in a course actually complete it. Despite the global digitalization [32, 33], users in web classes feel uncomfortable due to the lack of support and feedback. Chatbots help to fill in this gap by acting as teaching assistants [34].

With a large number of existing online services in the eLearning segment, chatbots are a promising tool, as they can support each listener individually, according to their level and pace of learning, making learning available to almost anyone who has Wi-Fi access. Chatbots do not require significant resource costs and can potentially help millions of students all over the world [34].

In view of the above, it should be emphasized that the use of chatbots is one of the innovative methods of training and its implementation in the system of professional training of Master's students, specialty 124 System Analysis, is a critical task. The purpose of the article is integrating of chatbots into the system of professional training of Master's students, specialty 124 System Analysis.

Let us consider the implementation of a chatbot into the system of professional training of Master's students, specialty 124 System Analysis while teaching the discipline of Mathematical Modeling of Socio-Economic Systems at Mariupol State University, Ukraine.

Mathematical Modeling of Socio-Economic Systems is taught on the basis of the Educational-Professional Program 124 System Analysis (hereinafter EPP) of Mariupol State University for Master's students and is part of the compulsory components of EPP as a discipline of the training course [7].

The discipline is taught in the 1st term and contains 7 ECTS credits (210 hours), 24 lectures, 46 practical classes, and student's independent work – 140. The form of the final control is an exam.

The purpose of the discipline is to form a system of knowledge and practical skills in the field of structural organization and functioning of socio-economic systems, elaboration and implementation of economic and mathematical models for their analysis, synthesis and optimization.

Teaching of the discipline is carried out through lectures and practical classes, individual and group consultations, independent work of students performing practical tasks on each topic on individual options, presentation of practical work, and testing.

The Department of Mathematical Methods and System Analysis at Mariupol State University has developed and implemented into the educational process a working mobile application with an integrated information retrieval system that helps an investment specialist to make decisions. This application is used in studying the topic Models and Methods of Financial Systems Management in the discipline Mathematical Modeling of Socio-Economic Systems. The information coming from the chatbot is used by students for building optimization models of investment processes in financial systems and for risk optimization in financial systems.

The main professional program training outcomes achieved through the use of this tool are the ability to use various methods, for example, the method of modern information technologies, for effective communication at professional and social levels; an ability to adapt to new situations and to make appropriate decisions; to gain knowledge and skills of working with sources of information for data and knowledge integration in the field of work of the organization through methods of knowledge acquisition, knowledge representation, knowledge classification and compilation [7].

The structure of the information system of the chatbot consists of the following components (figure 1): input information, information processing system, output information.

Information support in this system enables an investment analysis specialist to determine the expedience of investments and further cooperation with various partners.

Information collection involves the implementation of the following subprocesses: creation of information channels; selection of information objects, determination of its sources; organization of work with information sources, information consumption; ensuring continuous functioning of information sources.

Information processing, in its turn, is provided through accumulation, evaluation and analysis of the information, its classification, comparison and verification, extraction of biased and contradictory information, formation of hypotheses, interpretation of information, creation of information databases, distribution of information, elaboration of information documents [35].

The sources of external information of the working mobile application of investment analysis with an integrated information retrieval system are:

- electronic data with news of economic, industrial, financial and marketing activities of different levels;
- information on quotations of economic, industrial and financial tools transmitted via the Internet.

At the input of this system, the information flows are channeled into appropriate functional blocks, in which they are processed to identify key parameters and indicators. At the next stage of data processing, information and accounting information materials are divided and analyzed by the analytical module of the system. After that, the filtered information with answers to the questions is presented in a user-friendly form.

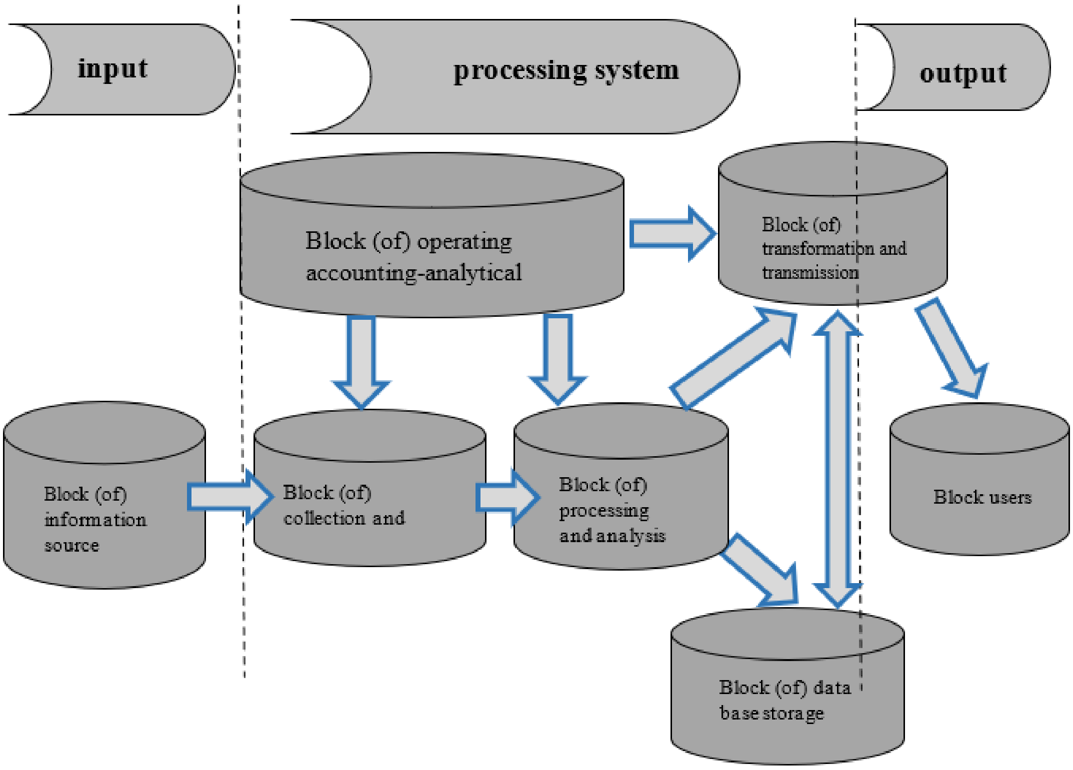

Figure 1: General structure of the chatbot information system for investment analysis.

When searching for tools for creating a chatbot, it was determined that to build a bot you should have knowledge and skills of a particular programming language, such as Python, Ruby, Node.JS, PHP, Kotlin. It was necessary to determine which language should be used for programming the mobile application. It is also important to be able to work with the REST (Representational State Transfer) API (Application Programming Interface), which is provided by messengers and other services.

The analysis of the studies on the demand for specialists in a particular programming language, which are publicly available, shows that the Kotlin programming language is becoming increasingly popular.

Thus, in May 2017, at the Google I/O conference Kotlin was announced to be included in the list of the official languages that are supported for the development of Android applications.

At the current stage of development of programming tools, the Kotlin language has gained popularity in Brazil, India, Germany, the United States and Japan. It should be added that among Android developers the Kotlin programming language is considered to be an alternative to Objective-C and also acts as an analogue of the Swift tool which is used to develop applications on Apple's iOS [36].

The Kotlin language was designed and developed by the Czech company JetBrains, which is known for its popular IDE – IntelliJ IDEA. Google's Android team has announced official support for the Kotlin programming language.

Among the significant advantages of the Kotlin language is its ability to compile in JavaScript or Native to run on the iOS platform; an easy transition from Java to Kotlin (it is sufficient to install the Kotlin plugin and their compatibility); availability of extension functions for the development of pure ARI; the presence of "null" in the system of types; conciseness, which, consequently, reduces the number of errors. However, there are also some drawbacks, among which there is a slower compilation speed of the program, for example, Android Studio runs a bit slower with Kotlin.

A necessary tool for creation a chatbot is a library for network interaction, one of which is Retrofit (REST client for Java and Android). The tool makes it easy to obtain and download JSON (or other structured data) through a REST-based web service. In Retrofit it is possible to configure the converter used to bring the data in series. GSon is typically used for JSON, but it is possible to add your own converters to process XML or other protocols. It should be mentioned that Retrofit uses the OkHttp library for HTTP requests.

The Retrofit library simplifies interaction with the REST API site by performing part of the routine work; it is convenient when performing a request to various web services with the commands GET, POST, PUT, DELETE; it works in asynchronous mode, which, in its turn, eliminates unnecessary code [37].

The following three classes are required to work with Retrofit:

1. Model class used as a JSON model
2. Interfaces that determine possible HTTP operations
3. Retrofit.Builder class is an instance that uses the interface and API Builder to specify the URL endpoint for HTTP operations.

Each interface method is one of the possible API calls, which must have an HTTP annotation (GET, POST, etc.) to determine the request type and relative URL. The return value completes the response in the Call object with the type of the result expected.

Figure 2 shows examples of using a working mobile application with an integrated information retrieval system (Android Studio is used), which helps to take investment decisions and advice from the expert system.

3. Conclusions

Communication technologies based on the use of various messengers and chatbots are becoming a modern trend in education. The introduction of such tool technologies in the educational environment is a practical example of the use of innovative methods and technologies of teaching students in higher educational institutions.

The Department of Mathematical Methods and System Analysis at Mariupol State University has developed and implemented into the educational process a working mobile application with an integrated information retrieval system that helps an investment specialist to make decisions. This application is used in studying the topic Models and Methods of Financial Systems Management within the discipline Mathematical Modeling of Socio-Economic Systems.

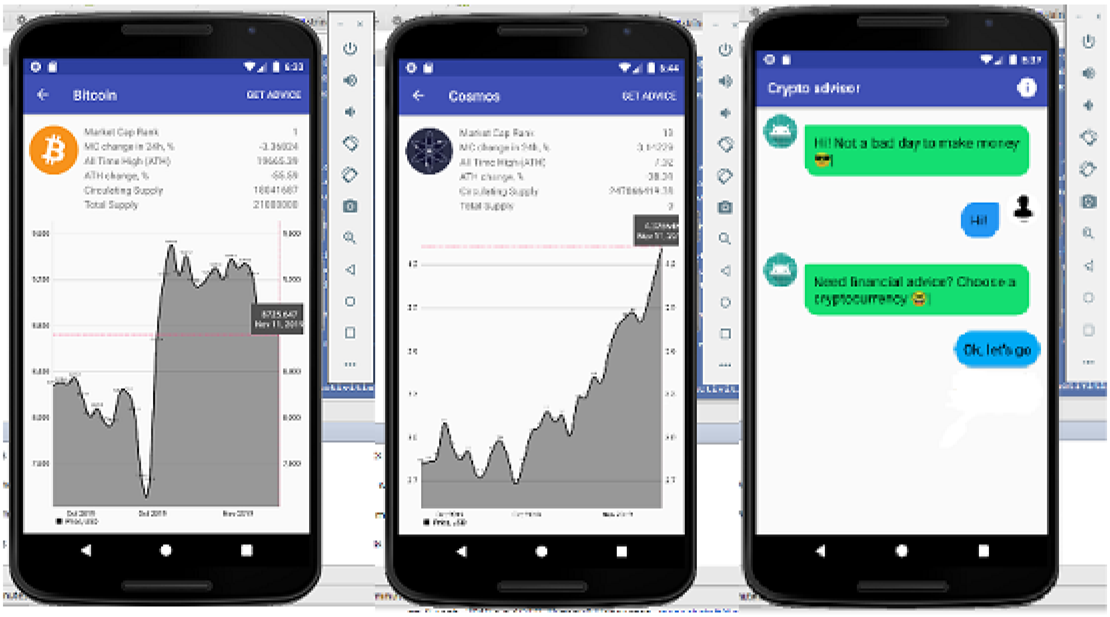

Figure 2: Examples of using a working mobile application for making investment decisions.

Using the application, students receive input information in constructing optimization models of investment processes of financial systems and in risk optimization in these systems, which ensures the acquisition of appropriate professional training results.

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Features of design of digital aids for training students with autistic disorders

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Abstract

In accordance with the aims of the paper, it is covered essential peculiarities of the design of digital aids for ASD-students. They are distinguished coming from the analysis of common learning and social difficulties inherent to the trainees with autistic disorders; needs for their speaking habits development; advantages of special digital support in terms of facilitating ASD-students' training. The distinguished features essential in the process of the digital aids design are demonstrated on the example of the development of an e-simulator for young ASD-students' speech encouragement. The main stages of its design and functionality are characterised. It is emphasised in conclusion that the developed digital simulator due to its functionality helps to overcome a number of problems faced by young ASD-students. The problems are specified.

Keywords

ASD-students' training, digital aids design, digital transformation of education, e-simulator for ASD-students' speech encouragement

1. Introduction

During the last decades digital transformation has referred all aspects of education including inclusive learning. Various surveys testify that one of the global problems of contemporary education in its digital age becomes finding the ways to facilitate the learning process for students with special needs based on technology support. Special focus of experts, however, has been obtained recently by the students with autistic spectrum disorders (ASD), as the number of the cases and variety of the disorder's modifications has been growing for last few years [1, 2, 3, 4, 5]. In particular, it is pointed out that in the USA, for instance, every 54th child now appears to have autistic disorders what is 10% greater than in 2018.

Thus, we deal with the global problem, and it is clear that software and learning aids market tries to respond to the said challenges of ASD-students' social adaptation and academic training at different levels. There are a number of special centers all over the world which offer evidence-

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based educational programs that focus on educating peer groups of ASD-students, and at the same time, teaching prosocial communication strategies to enhance social inclusion and to reduce these students' isolation and bullying. However, it is pointed out [1, 4, 6, 7] that the developed software is mostly of general educational purpose and do not cover specific cognitive needs of ASD-students, one of which is poor speech and communication skills what complicates the students' social adaptation. Thus, it is necessary to develop approaches to special digital aids design based on the psychological peculiarities of these students' training.

One more problem in this aspect is connected directly with Ukrainian localization of such digital aids and their development due to exact needs of national situation in the lines of provision ASD-students' education and social adaptation.

Coming from the said evidence, the purpose of the article is to cover core features of the design of digital aids for ASD-students and demonstrate them on the example of the development of an e-simulator for the students' speech encouragement.

2. Theoretical framework

Theoretical background of the work is made by the analysis of the challenges of ASD students' educational practices and learning of potential benefits which might be given by the digital aids support for the training process of these students.

Analysis of psychological and pedagogical sources [8, 9, 10] allowed us to identify a number of major learning difficulties that are inherent in students with autistic disorders. According to studies, the learning difficulties are caused by the students' problems in three core spheres: social interaction, communication and imagination. The most essential of them include generalized insufficient ability to learn, poor concentration, unawareness of dangerous situations, insufficient or excessive reactivity, increased anxiety, low level of adaptation to new social and educational situations, problems in establishing and maintaining relationships with others etc.

In addition, experts highlight the special disorders of autistic students in the formation and development of their reading and speaking skills in both native and foreign languages [8, 9, 11, 12, 13]. In particular, the students face the problems of insufficient vocabulary and its limited use in their speech; misunderstanding of the general sense of the read content; fragmentary perception of oral speech; lack of motivation to communicate with others, etc. On the other hand, the psychologists emphasize that speaking habits make the most essential basis for the students' socialization. Hence, these habits' developing has to be in focus of all kinds of educational practices for ASD students of all ages.

It is also important to point out some ASD students' strengths which are underlined by the researchers and might be helpful in their teaching: their very well-developed visual memory, considerable attention to details, a large amount of mechanical memory. In this regard, experts recommend involving in the learning process of such students visual aids and visualization tools, but it is emphasized the need for maximum organization and concentration of the student's visual field [11, 12, 13, 14, 15].

In this context, the special attention must be paid to the digital support of ASD students' education. There is a number of research which claim the advantages of technology-supported learning of the students. The results of several studies suggest that autistic students learn faster with the help of a computer than with the help of verbal instructions [10, 11, 16]. Researchers consider the reason for this not only in the fact that the digital devices are able to hold students' attention longer, but also in the fact that it uses the principle of content visualization and encourages students to focus on specific areas of the screen. Besides, computers provide students with multimedia content that enables to combine audio and graphical images, to enrich and facilitate in such a way students' perception of text information developing their reading and speech habits.

In some research papers [6, 16] it is pointed out that digital aids support while learning is very promising for these students as they have significant kinship toward technology and interaction with e-devices, digital means etc. It is explained by the essential advantages which are provided by technology for people with ASD. In fact, a technology functions as an interface between ASD person and other people, providing necessary social and emotional distancing that helps decreasing their anxiety. Another educational technology's benefit is its facility to provide tailored and individually driven digital support for ASD students who usually have their own preferences for sensory outputs (colors, sounds, graphical details etc.) produced by software as well as for the way of learning due to individual peculiarities [6, 13, 16] of their disorder. As a result, due to the technology's advantages, the students obtain personalized, friendly and one-to-one digital aid to master both social and academic skills.

Thus, the said benefits of digital aids for ASD students and their social and learning difficulties determine the variety of the aids as for their main purposes for the students' training as well as the core features of their design.

As we said above, speaking habits, vocabulary boosting, and speech stimulation must be in focus of ASD students' learning on all the levels. In this connection, it is relevant to concentrate on the advantages of e-simulators as a special type of digital support in general and look precisely at the potential of e-simulators focused exactly on ASD students' speech and language boosting.

A simulator in a common sense is a modeling complex (system) created in order to prepare a person to make high-quality and quick decisions. According to studies, with regard to the learning process, a simulator is defined as a device for training which due to psychological and didactic requirements should have constructive, modeling and didactic components as its core parts. It is also mentioned that simulators are promising as for their application to learning practice since they allow students to form the skills of motor-reflex and cognitive actions in difficult situations, to understand the essence of the ongoing processes and their mutual dependence.

A special role in education is played by e-simulators which are defined in the studies [6, 17, 18, 19, 20] as a learning tool that provides a trainee with step-by-step work-out of the learning content, and allows them to obtain sustainable skills of proper actions along with the parallel detection of the trainee's errors. The experience of using e-simulators in the learning process testifies their benefits for trainees. In particular, e-simulators take into account the individual pace of student's work and enable his own managing and controlling the learning process. They also reduce the time of developing necessary skills and do this process more efficient due to the great number and variety of training tasks, which raises the motivation of educational activity.

In the [6, 17] it is pointed out that the general purpose e-simulator must meet the set of requirements. In particular, it is underlined that tools for the simulator design should be simple and flexible. E-simulator should give the student the opportunity to repeatedly perform the same tasks on a particular topic in order to work out certain skills. At the same time the simulator should provide the student with clear instructions and/or a sample solution at his request. In addition, the simulator should analyze the student's actions with a qualitative assessment of the results and giving recommendations as for the achievement of better results. There are also some special recommendations for the e-simulator interface that should be friendly and clear to encourage students to practice routine skills and to create an atmosphere of success and interest.

The analysis of the challenges of ASD students' educational practices, peculiarities of their learning, and importance of the facilitating the students' speech stimulation and language boosting depicted above, testify the urgency of the development of e-simulators with Ukrainian localization for the young students' speech encouragement.

Based on the analyzed needs of speech development of young students with autism and the general requirements for e-simulators, it is possible to formulate the following specific requirements for the said e-simulators for language boosting which are to be used as a basis for their design. Formulating them we bear in mind two core speculations which come from the above analysis of the psychological and pedagogical characteristics of the said students. On the one hand, the software for ASD-students must be helpful for them in terms of their common and individual learning challenges, has to decrease the level of the students' difficulties, and hence, to make smoother the process of their learning and social adaptation. On the other hand, any kind of digital aids for ASD-students including the said e-simulators for speech encouragement must be cooperative in terms of the students' strong points (their well-developed visual memory, attention to details, a large amount of mechanical memory) which are considered by the psychologists to be helpful in their teaching.

Thus, in the process of development of an e-simulator for language boosting for ASD-students the set of recommendations have to be taken into consideration.

Firstly, it must have a concise, intuitively clear interface that must be the same for work in all modes of the simulator. It is recommended to use the same template to support unique basic design of the application which has to be downloaded quite quickly. The application window should not contain too much information in one spot, and must focus the student's attention on certain areas of the screen.

Secondly, the said e-simulator has to provide visual reinforcement of verbal content (as the ASD-students have well-developed visual memory which might compensate their verbal difficulties). It makes topical to include appropriate visual (multimedia) support for text information representation in the application and hence, puts up the problem of rational storing of graphical and text data within the application.

In addition, it is essential to provide opportunities for multiple repetitions of the proper exercises which must be generated by the simulator due to the didactic purposes. At the same time, the application must have facilities for gradual complication of the tasks and a moderate variety of exercises that would provide not only the vocabulary boosting, but also the speech stimulation. In this context, it is important to provide various modes of the application work which include different learning activities with a simulator. Besides simple words-training facilities, a developer should also create options for phrases building and work with digital narratives that provide combination of the verbal content and visual images. According to recent studies, creating of digital narratives by ASD-students, followed by work upon their combined content, provoke the students' needs for expressing ideas and potentially stimulate their speech habits. In order to guarantee such a functionality, the developer has to work in tight collaboration with educators who are experts in ASD students' training.

Finally, the e-simulator on the said purpose should guarantee high level of interaction with friendly feedback in learning situations of success and failure to increase motivation for speech encouragement. Besides, the software should provide significant level of adaptivity due to the student's needs, so the student (together with his tutor) could progress in his own pace, according to his individual preferences, and was able to handle the process of learning.

The formulated specific recommendations for the said e-simulators might be considered as features which are necessary to be regarded in the process of the simulators elaboration and determine their functionality in terms of the ASD students' didactic needs. We would like to cover them in details on the example of the design of an e-simulator for young students' speech boosting in Ukrainian and in English.

3. Development of e-simulator for young students' speech boosting

Coming from the formulated recommendations, the main phases of the application design were outlined which can be characterized as follows.

3.1. Main stages of the application design

At the first stage the didactic functions of the application were specified due to the recommendations, the modes of its work were determined, use cases diagram was built which allowed to specify a potential user's behavior.

In particular, it was determined that the user is expected to initiate such use cases as:

(1) to run the application;
(2) to get familiar with it introducing himself;
(3) to choose the language (Ukrainian or English) to be trained;
(4) to choose the mode of training (boosting vocabulary via learning new words, building phrases, work upon social stories);
(5) to work in any of the modes doing various exercises and repeating them with various content;
(6) to obtain immediate feedback;
(7) to change the content of words training and fill it with user's set of words.

All the use cases are connected with each other, which was also shown at the diagram that is not included into the article for the sake of conciseness.

At the next stage, the conceptual model of the subject area "ASD-students' language encouragement with the help of e-simulator" was created. On the stage of object-oriented design the obtained conceptual model was used to determine application classes, objects, and proper links between them.

Next phase was devoted to the application interface design coming from the requirements to the e-simulator, the use case diagram and obtained conceptual model. In particular, design of all application windows was developed in accordance with all use cases and links between them. It was also followed the necessity to apply the same template to support unique basic design of the application in all its modes. The application windows in all the modes of work contain only proper information which is concentrated in certain spots, and focuses the student's attention on these areas of the screen. Proper concise prompts are put in certain areas of each window. Due to ASD-students' needs for visual reinforcement of verbal content there was solved the problem of vocabulary boosting with the elements of words visualization. All of the elements of the interface were tested as for their usability to make sure that the design solutions are ergonomical ones and enable a user to interact with the simulator efficiently in various learning situations obtaining immediate and relevant feedback.

Then the program realization of the e-simulator was undertaken in Java within Netbeans environment: class diagram was built, and the class and methods description was done along with their program implementations.

Then necessary didactic content for all modes of the e-simulator was created in collaboration with psychologists, ASD experts and primary school teachers. In particular, the variety of word sets with visual support was picked up for their mastering in accordance with Ukrainian and English languages curriculum. Phrases builder of the e-simulator was filled in with proper content. The social stories for work with digital narratives were composed. As a result, all the proper components of the application were filled in with the elaborated learning content.

At the final stage the application was tested, according to the didactic and technical requirements formulated above.

Finally, the application was introduced into practice of ASD-students' classroom and independent learning activities.

Below we are covering the functionality of the developed simulator highlighting the features of their implementation.

3.2. Functionality of the developed e-simulator in terms of ASD-students' speech encouragement

As a result of development, speech e-simulator "Speak-up!" ("Розмовляй-ка!") for young students with autism spectrum disorders has a concise but intuitively clear interface that enables both educators and students to interact with it efficiently from the very beginning.

In addition, the interface of the e-simulator offers to get familiar with a user (ASD-student) introducing his name, which immediately makes training personalized (figure 1).

After getting familiar and choosing the language (Ukrainian of English) of training by the user, the application encourages the trainee to work in three main modes which determine basic didactic functions of the application.

The first core mode focuses the trainee on boosting his vocabulary via learning new words of native (of foreign) language along with their meanings. There are two main activities provided by the e-simulator. First, the student is enabled to look through the vocabulary of the lesson (in accordance with the curriculum theme) along with the words meaning and proper associative

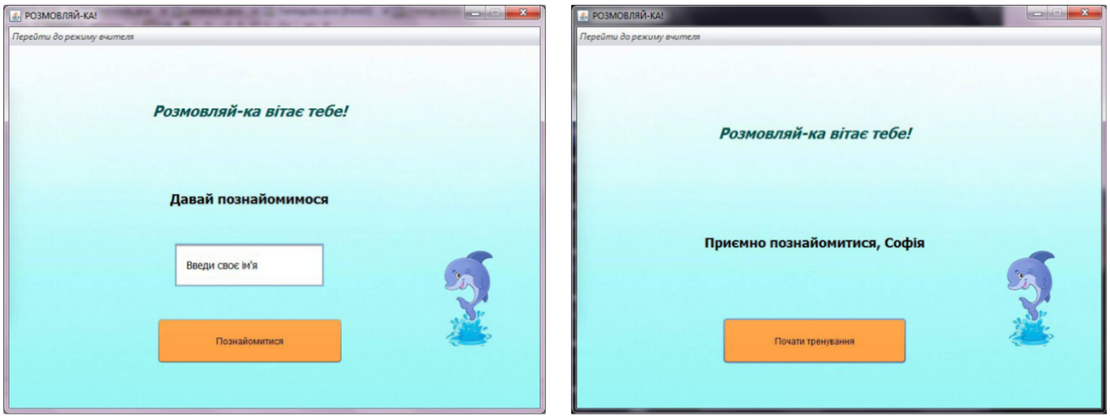

Figure 1: The episode of work with the simulator at the moment of getting familiar with a user.

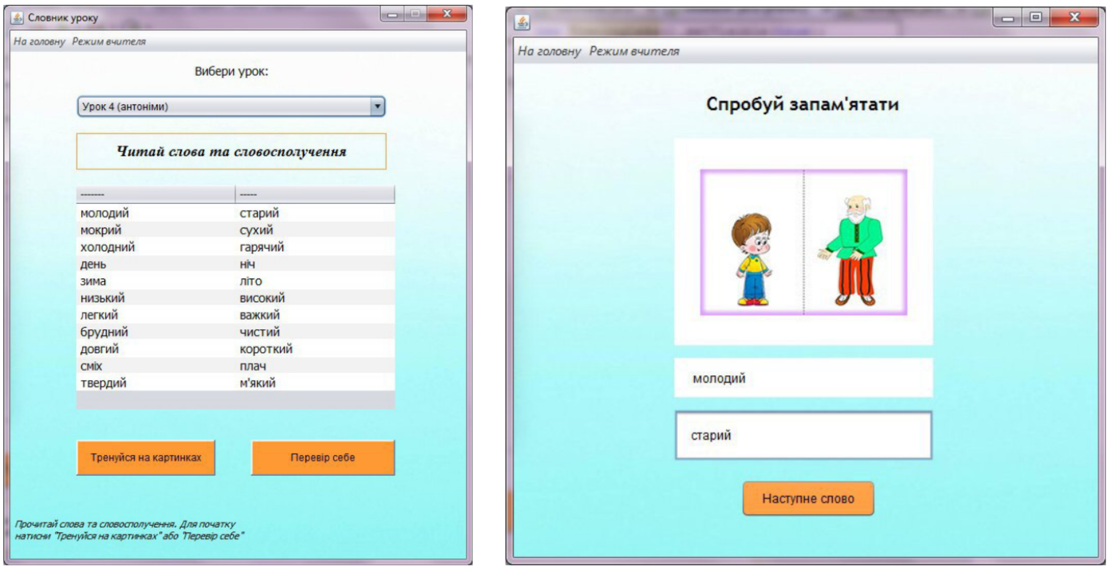

Figure 2: Fragments of work in the simulator in the mode of vocabulary boosting.

images (figure 2). The activity encourages the student to learn the sets of words with visual support in his own pace returning to the same sets as many time as the trainee needs.

The other activity in the vocabulary mode is devoted to the words simulation with estimating of the students' attempts. In particular, in this mode the e-simulator encourages students to recollect the learnt vocabulary with immediate feedback and with friendly processing of the situations of success and failure (figure 3).

Thus, the realized mode of the e-simulator helps ASD-students to get used to the situation of training with estimation, allows to decrease their anxiety, which is essential for the students, and motivates them for vocabulary boosting.

An important function realized in the simulator is the opportunity for the trainee (with the

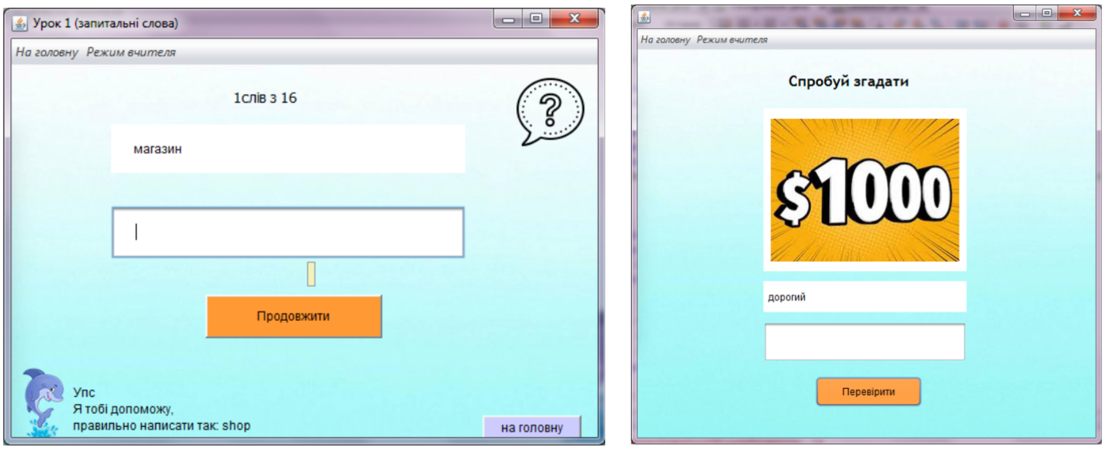

Figure 3: Working out the words in the mode of vocabulary boosting with estimation.

help of his tutor) to edit existing vocabularies, to fill them with their own sets of words, and save their own vocabulary in files (along with proper associative images) within the simulator to use them for work out (figure 4). This ensures the adaptability of the simulator to the needs and requests of the trainee. As he can work out the words which seem for exactly him to be useful and important, it is possible to predict the growth of the student's motivation to remember and use them. In this way, the student can make their learning the most comfortable and individual, as well as avoid the fear of testing their knowledge. The situation of learning, training and control becomes familiar, safe and psychologically comfortable for him.

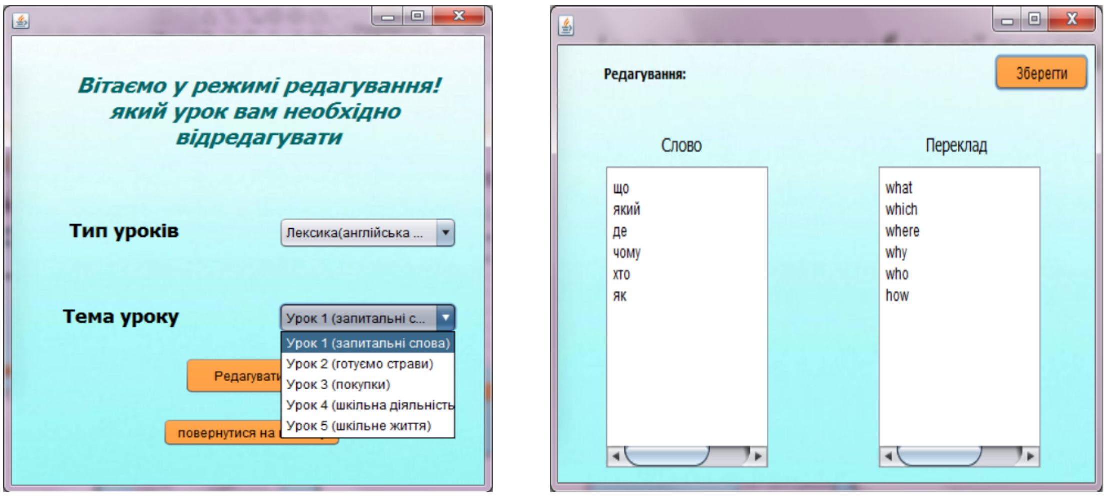

Figure 4: The process of editing existing lessons vocabularies.

The second mode which is realized in the simulator is aimed at progressing the ASD –students' skills of composing sentences of various types. On this purpose, the simulator implements a phrase builder which offers the student two main types of speech learning activities. The first type of activity encourages the student to build sentences according to the scheme and compare their own sentence with the sample. The second type offers to choose from the suggested members of the sentence correct ones, as well as to build their own phrases and check their correctness (figure 5).

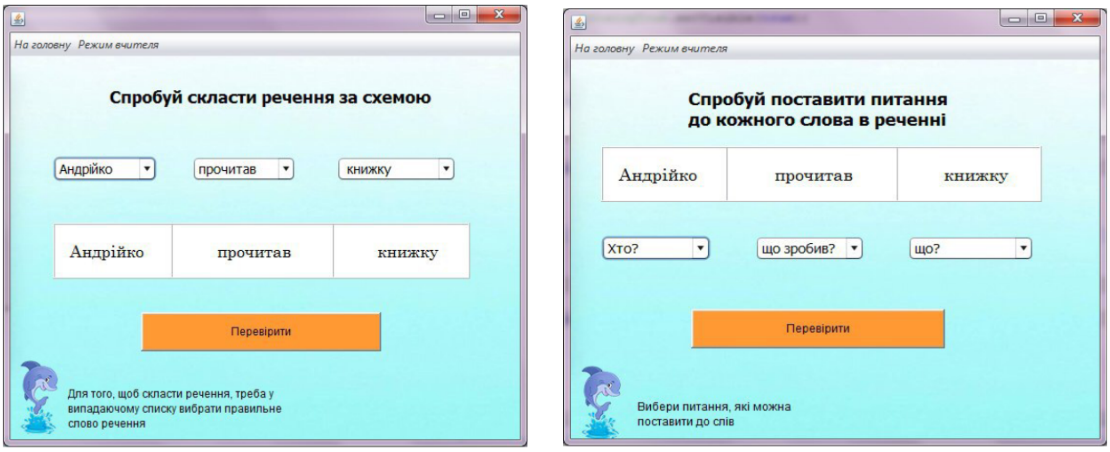

Figure 5: The episodes of work in the mode of phrases builder.

It is important to emphasize that the program realization of this mode addresses to the main peculiarities of ASD-students' learning, such as focusing on details, necessity to concentrate their attention on the proper areas of the screen and certain activities, determination on the repeated habitual tasks with their gradual extension etc.

In the third mode of training the simulator provides an opportunity for students to work with so-called social stories that have social and educative content, and contribute to the effective adaptation of ASD-students to society. The student is offered two main stages of processing the stories: (1) reading the story followed by its analysis via answering suggested questions (figure 6); (2) reading the same text with pictures instead of some words that the student must recollect and enter (or choose from the suggested ones).

At all of the simulator's modes it is realized the facility of monitoring the correct answers with immediate feedback in the form of scored points displaying the results of training. The aid also efficiently handles situations of success and failure, which provides a favorable emotional background, creates a friendly atmosphere of training, and helps to increase motivation to practice language and speech skills.

Thus, the depicted above functionality of the developed digital simulator for ASD-students' language encouragement meets the core features of such aids design which were grounded and formulated in the section 2 of the paper.

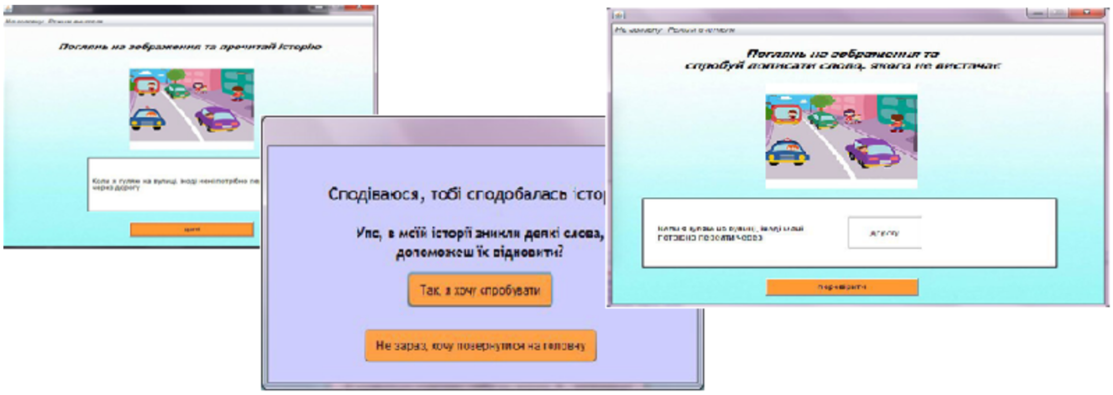

Figure 6: The episodes of work in the mode of social stories.

4. Conclusions

In accordance with the aims of the paper, it is covered essential peculiarities of the design of digital aids for ASD-students. They are distinguished coming from the analysis of common learning and social difficulties inherent to the trainees with autistic disorders; needs for their speaking habits development; advantages of special digital support in terms of facilitating ASD-students' training.

The distinguished features essential in the process of the digital aids disign are demonstrated on the example of the development of an e-simulator for young ASD-students' speech encouragement. The main stages of its design and functionality are characterised. In conclusion, we would like to emphasise that the developed digital simulator due to its functionality helps to overcome a number of problems faced by young ASD-students.

In particular, the simulator promotes concentration of their attention and relies on increased visual memory of such students; allows to boost significantly the vocabulary of both native and foreign (English) language via multiple repetition and involvement of both verbal and nonverbal learning; provides opportunities for gradual complication of tasks and a moderate variety of exercises, which allows not only the expansion of vocabulary by memorizing words, but also the speech stimulation by constructing their own sentences, processing social stories with visual support etc.

In addition, provided communication within e-simulator, the realized option to repeat different, but similar learning situations, studying at their own comfortable pace help to reduce the student's anxiety, simplify their adaptation to unfamiliar tasks and situations, which is really essential for autistic students due to their psychological peculiarities.

Finally, the essential function of editing by the student offered vocabularies for training ensures the adaptability of the simulator to the needs and requests of the trainee and enables the student to handle his own process of training. In fact, this function represents the developed e-simulator as a computer shell for design of individual simulators for ASD-students' speech training.

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Implementation of future agricultural engineers' training technology in the informational and educational environment

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Abstract

The article presents the implementation of future agricultural engineers' training technology in the informational and educational environment. To train future agricultural engineers, it is advisable to form tutorials for the study of each discipline in the conditions of informational and educational environment. Such tutorials are an assistance in mastering both theoretical material and course navigation, where interactive electronic learning tools are presented to perform tasks in the informational and educational environment. Higher education applicants perform such tasks directly in the classroom with the help of gadgets or personal computers. The final grade is formed from the scores obtained in the classroom and the rating of higher education applicants while studying in the informational and educational environment. The outlined approach is able to help in the quality of learning content. The use of interactive audiovisual online tools allows to get acquainted with the theoretical, practical and experimental provisions clearly, it is important for the training of future agricultural engineers. At the end of the experiment, it can be argued that the developed technology increases the level of motivation and self-incentive to work in the informational and educational environment. The application of the presented technology provides an opportunity to combine the educational process in the classroom with learning in the informational and educational environment, forms analytical abilities and competencies in professional activity. The reliability of the obtained results was checked using the λ Kolmogorov-Smirnov criterion. It is determined that when using this technology in the educational process, the indicators in the experimental group increased, which displays the effectiveness of training bachelors in agricultural engineering in the conditions of informational and educational environment.

Keywords

agricultural engineers' training technology, informational and educational environment

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1. Introduction

While training of agricultural engineers there is a need for new approaches that are associated with interdisciplinary training and the use of modern technologies [1]. This level of training of future agricultural engineers is provided in the informational and educational environment [2]. As learning practices and technological tools change, such learning continues to evolve [3]. In 2018, the emphasis will be on various aspects, starting with how higher education applicants gain access to content, as defined by the idea of a "curriculum" [4, 5]. Online technologies, engineering programs and Internet access facilitate the transition to learning in an informational and educational environment, but immersion in the learning environment goes beyond learning tools [6, 7]. Studying in the conditions of informational and educational environment maintains constant access to the educational process. With the advent of learning in the informational and educational environment, educational systems are changing. Higher education applicants have the opportunity to prepare homework by watching the video that tutor posted online [8]. An option with a greater degree of interaction is possible when using mobile devices during classes [9, 10, 11, 12]. For example, a tutor asks questions and higher education applicants will answer them using mobile devices. It is possible to get direct feedback while studying at home and to interact with higher education applicants during lectures. Organizations around the world recognize that there is a large amount of supporting content that is often available, but it is ignored [13]. Successful use of this content requires a curator who uses specialized knowledge to combine relevant learning tools and pathways for higher education applicants [14]. The use of audiovisual materials increases exponentially during training. Interactive video-based learning offers a much higher level of involvement and learning experience. Mobile applications are useful for creating educational content, as they are optimized for mobile devices. The use of gamification for learning is convenient with the expansion of educational content viewing via mobile devices [15, 16, 17]. Informational and educational environment is a system of available to the user sources of information, methods and means of its appropriation, as well as the conditions of information interaction of the subject with these sources [18]. And studying in an informational and educational environment requires the use of interactive audiovisual online tools such as video lectures, online workshops, educational computer interactive simulators [19, 20, 21, 22], it increases the clarity, effectiveness and feedback during the training of higher education applicants.

Given the above, the aim of the paper is to present an implementation of future agricultural engineers' training technology in the informational and educational environment.

2. Training technology of future agricultural engineers in an informational and educational environment

The learning environment is dynamic and pedagogical activities cannot be reduced to a limited set of mechanically combined procedures [23]. The set of methods used in the research process is represented by: empirical methods – survey, questionnaire, self-assessment, testing, direct and indirect observation of the learning process, pedagogical experiment [24], statistical methods – quantitative processing of indicators and verification of the reliability of the obtained empirical results using the Fisher criterion [25], Kolmogorov-Smirnov criterion [26]. The empirical methods contribute a dynamic tool for developing practice and provide accumulation, fixation, classification and synthesis of feedstock for any particular educational system development [27, 28].

It is presented the training technology of future agricultural engineers in an informational and educational environment (figure 1). Training of bachelors in agricultural engineering provides not only classical forms of studying in the classroom, but also is supplemented by preparation for lectures, practical classes, laboratory works, seminars, support of higher education applicants by independent work and practice. When studying the cycle of disciplines of the initial level (1-2 years of study) preparation for lectures is accompanied by interactive content of informational and educational environment such as audiovisual lectures, webinars and online glossary [29]. Preparation for practical classes in the informational and educational environment involves working with online glossaries, watching videos, solving engineering problems in workshops, working with presentations. Preparing bachelors in agricultural engineering for laboratory classes may include video instructions on execution, calculation parts, working with a glossary, and viewing presentations. Preparation for seminars in the informational and educational environment can include work with online glossary and video instructions. Independent work includes webinars and interactive content of informational and educational environment. Online support should be provided through chats and thematic forums.

When studying the cycle of bachelor's degree disciplines (3-4 years) in the informational and educational environment, preparation for lectures is carried out with the help of interactive multimedia lectures. Preparation for practical classes in the informational and educational environment includes round tables in thematic forums, online practical classes, interactive tasks, educational computer interactive simulators. It is expedient to apply interactive tasks, educational computer interactive simulators to laboratory classes in the process of preparation of bachelors in agricultural engineering. The preparation of higher education applicants in specialty "Agricultural Engineering" for seminars may include presentations, interactive tasks, video conferences and thematic chat conferences [30]. Independent work in the informational and educational environment is based on interactive multimedia lectures, practical tasks, educational computer interactive simulators and research projects. The internship is provided by video conference, thematic chat conferences, online support [31]. It is necessary to monitor the results of bachelors in agricultural engineering and to study the acquisition degree of professional competencies [32].

According to the proposed technology was developed a number of tutorials on disciplines for the training of future agricultural engineers in the informational and educational environment (disciplines "Mechanics of Materials and Constructions", "Theory of Mechanisms and Machines", "Engineering and Computer Graphics"), the work of which was tested with higher education applicants in "Agricultural Engineering".

The essence of tutorials for training higher education applicants in the informational and educational environment is that they can work both independently at home and in the classroom. Theoretical material, prototypes of practical works and questions for tests and exams are presented for work in the classroom. In the informational and educational environment, a wide range of tools is presented, namely: multimedia presentations for practical work, interactive laboratory work, audiovisual lectures, educational computer interactive simulators, online

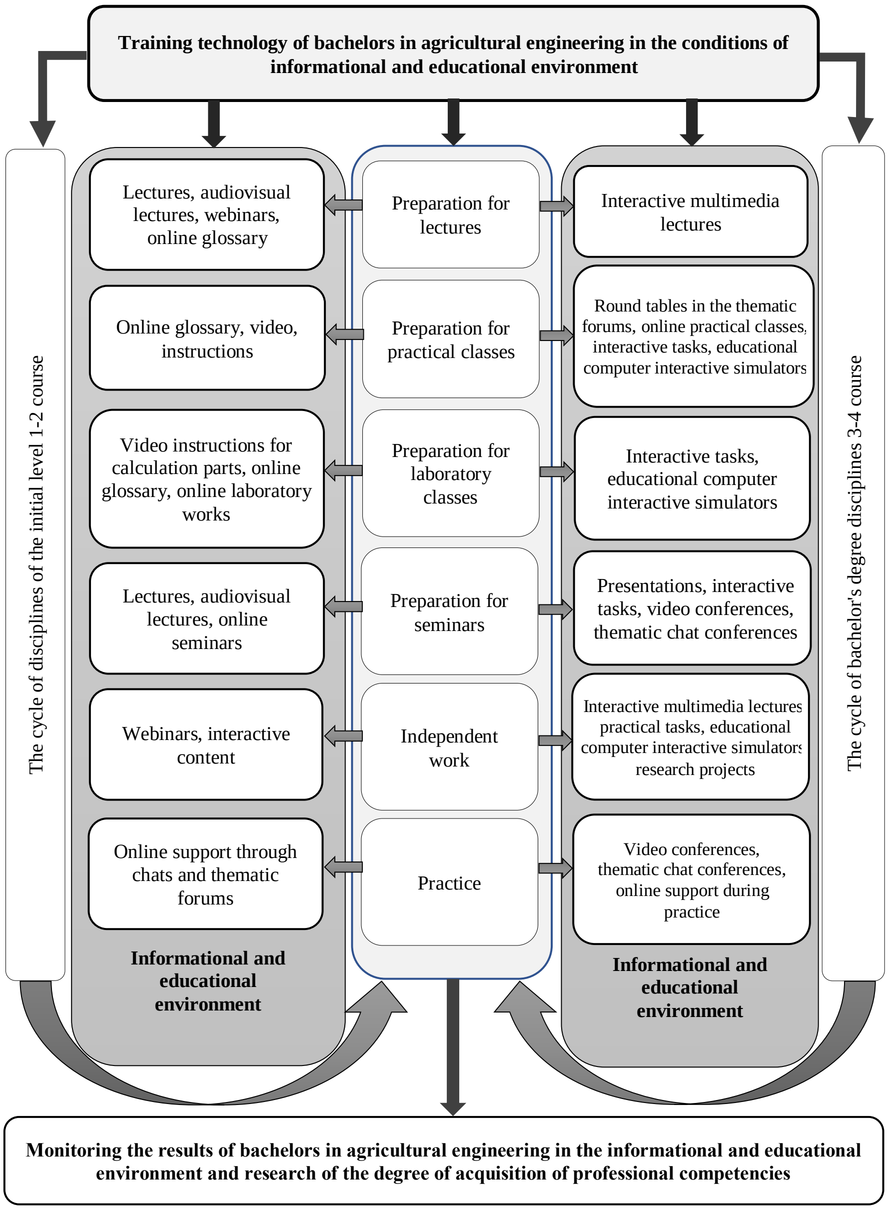

Figure 1: Future agricultural engineers' training technology in the informational and educational environment

glossaries, forums, webinar recordings, etc.

When attending classes, higher education applicants receive points for attendance, as well as for working in the informational and educational environment. Higher education applicants are acquainted in advance with the theoretical material. Then in the classroom, they begin the practical implementation of tasks that are presented in the tutorial using QR-codes [33, 34, 35]. Higher education applicants, with the help of applications for reading QR-codes enter the appropriate section of the course and begin to perform tasks using a PC or mobile phone, using presented interactive audiovisual online tools, such as: multimedia presentations for practical work, interactive laboratory work, lectures with audiovisual support, educational computer interactive simulators, etc. Audiovisual lectures include the use of images, video clips, which improves the quality of perception of educational information, and provide control of knowledge at the end of each informational block. Interactive multimedia lectures allow the use of dynamic interactive elements and may have links to external hypertext pages from the Internet, which improving the professional competence of higher education applicants [36]. Online practical classes in the informational and educational environment play a leading role in the formation of skills and application of acquired knowledge. Video instructions for practical tasks contain explanations on the use of special engineering programs required for the calculation and design of technical facilities, which is important for agricultural engineering education. Conducting video conferences and thematic chat conferences with further discussion of problematic issues increases the level of assimilation of the results obtained by bachelors in the field of agriculture during the internship. Educational computer interactive simulators have a wide range of applications, can be used to demonstrate a process or mechanism, and can be complex simulators of technological processes and equipment. The educational computer interactive simulator in the informational and educational environment can be considered as a training complex, a system of modelling, a set of computer and physical models based on the performance of a specific educational task. The higher education applicant performs certain operations and receives a response from the computer system of the informational and educational environment for self-analysis. Educational computer interactive simulators in the training of bachelors in agricultural engineering can be divided into three groups: test, graphic and gamified. The test training simulators are based on engineering test tasks that help to master the rules, methods, laws, theorems and other content in the field of agricultural engineering. Graphic training simulators include such training tasks, which are based on work with engineering and graphic images and the execution of drawings of parts in an informational and educational environment. Gamified training simulators basically have a game task, performing which develops professional agricultural engineering competencies. These include acquaintance with the parts and devices that are the basis of agricultural engineering, the principles of training in the operation of complex agricultural machinery; skills of installation, assembly of systems, and also at search of malfunctions and repair of agricultural machinery.

For each participant of the course it is possible to trace statistical data, on their basis the applicant of higher education receives semester points: monitoring of points for the executed tasks in the informational and educational environment, answers in the conditions of thematic forums and chat- conferences, points for mastering theoretical content, practical tasks, educational computer interactive simulators. After completing the task with the help of device, the informational and educational environment forms an assessment for higher education applicants and statistical indicators of the task for the tutor. Thus, for higher education applicants a rating is formed during training in the informational and educational environment, which affects the final assessment. The tutor controls the time of certain tasks and limits the number of attempts [37].

In the informational and educational environment, higher education applicants have the opportunity to acquire competencies that are attached to the tasks. As a result of taking the course, the applicant of higher education acquires the indicator of competencies acquisition, as a result of taking the course according to the curriculum during the term, acquires the indicator of competencies according to the curriculum template. On the basis of the received points and the acquired competences, on each applicant of higher education it is possible to form a rating in the conditions of the informational and educational environment.

3. Results

The main purpose of the experiment was to test the future agricultural engineers' training technology in the informational and educational environment. The experimental procedure included the following steps:

- selection of control and experimental groups (homogeneous);
- development of methodological tools for assessing the criteria and indicators of the current level of knowledge, skills, abilities of bachelors in agricultural engineering, reflecting the readiness level of the higher education applicants for professional activity;
- determination and ascertainment of the bachelors' readiness formation level for professional activity in the conditions of informational and educational environment;
- introduction of future agricultural engineers' professional training technology in the conditions of informational and educational environment;
- comparison of indicators of bachelors' readiness level for professional activity after the introduction of author's developments;
- generalization and conclusion about the efficiency of the proposed author's developments, which are characterized by the relationship of dependent and independent variables (methods and results in fixed conditions, etc.).

The purpose and objectives of the study determined the objectives of the pedagogical experiment and to justify the efficiency of the developed technology of training bachelors in agricultural engineering to professional activity in the informational and educational environment through practical implementation.

The control group used traditional tools to perform the tasks, and the experimental ones used interactive audiovisual online tools of the informational and educational environment. The obtained data were redistributed into two equal groups according to the corresponding number of initial score. To verify the homogeneity of the distribution into control and experimental groups, we used ϕ^* – Fisher's criterion. According to Fisher's criterion the groups are distributed uniformly. Numerical indicators for determining the bachelors' readiness levels for professional activity in the informational and educational environment was checked by testing, questionnaires, comprehensive tests, educational results.

The results of the bachelors' readiness levels for professional activity in the informational and educational environment in the experimental and control groups at the beginning of the experiment of the λ Kolmogorov-Smirnov criterion are presented in

Table 1 examining the levels of readiness for professional activity of bachelors in agricultural engineering in the informational and educational environment at the beginning of the experiment, it should be noted that the percentages between the experimental and control groups differed only in hundredths.

Table 1
Calculation of the λ Kolmogorov-Smirnov criterion for comparison the readiness level for professional activity in the informational and educational environment at the beginning of the experiment

Level	Empirical frequencies		Empirical particles		Accumulated empirical particles		Difference
	$f_{experimental}$ (number of respondents)	$f_{control}$ (number of respondents)	$f_{experimental}$ %	$f_{control}$ %	N_i	N_i^*	$d = \|N_i - N_i^*\|$
High	8	7	1.23	1.08	0.01	0.01	0.00
Sufficient	27	26	4.14	4.01	0.04	0.04	0.00
Average	126	128	19.32	19.72	0.19	0.20	0.01
Initial	491	488	75.31	75.19	0.75	0.75	0.00
Total	652	649	100	100			

We will form statistical hypotheses to test the level of readiness of bachelors in agricultural engineering for professional activity in the informational and educational environment.

H_0: the number of bachelors in agricultural engineering, in which the level of readiness for professional activity in the informational and educational environment in the experimental group is not higher than in the control.

H_1: the number of bachelors in agricultural engineering, in which the level of readiness for professional activity in the informational and educational environment in the experimental group is higher than in the control one.

We will check the reliability of the obtained results with the help of the Kolmogorov-Smirnov criterion λ with the help of the calculation table [38, 39] (table 1).

Determine $d_{max} = 0.01$ and the level at which this value falls, and calculate the value of λ by the formula:

$$\lambda_{empirical} = d_{max}\sqrt{\frac{f_{experimental} \cdot f_{control}}{f_{experimental} + f_{control}}} = 0.168298687, \lambda_{critical} = \begin{cases} \lambda_{0.05} = 1.36 \\ \lambda_{0.01} = 1.63 \end{cases}$$

Thus, $\lambda_{empirical} < \lambda_{critical}$, H_1 – deviates, hypothesis H_0 is preserved. The number of bachelors in agricultural engineering, in which the readiness level for professional activity in the informational and educational environment to the formative stage in the experimental group is not higher than in the control one.

The results of the readiness levels for professional activity of bachelors in agricultural engineering in the informational and educational environment in the experimental and control groups at the end of the experiment are presented in table (table 2). At a high level, the percentage in the experimental groups exceeds by 12% the control. In the experimental group at a sufficient level the percentage is higher than in the control one by almost 30%. At the average level in the control group the indicator is higher than in the experimental group by 18%. At the

Table 2
Calculation of the λ Kolmogorov-Smirnov criterion for comparison the readiness formation level for professional activity in conditions of the informational and educational environment at the end of the formative stage of the experiment

Level	Empirical frequencies		Empirical particles		Accumulated empirical particles		Difference
	$f_{experimental}$ (number of respondents)	$f_{control}$ (number of respondents)	$f_{experimental}$ %	$f_{control}$ %	N_i	N_i^*	$d = \|N_i - N_i^*\|$
High	134	54	20.55	8.32	0.21	0.08	0.12
Sufficient	296	109	45.40	16.80	0.45	0.17	0.29
Average	157	279	24.08	42.98	0.24	0.43	0.19
Initial	65	207	9.97	31.90	0.10	0.32	0.22
Total	652	649	100	100			

initial level in the experimental group, the figure does not exceed 10%, which is 21% less than in the control one.

We will form statistical hypotheses to test the level of readiness of bachelors in agricultural engineering for professional activity in the informational and educational environment.

H_0: the number of bachelors in agricultural engineering, in which the level of readiness for professional activity in the informational and educational environment to the formative stage in the experimental group is not higher than in the control one.

H_1: the number of bachelors in agricultural engineering, in which the level of readiness for professional activity in the informational and educational environment to the formative stage in the experimental group is higher than in the control.

We will check the reliability of the obtained results with the help of the Kolmogorov-Smirnov criterion λ with the help of the calculation table (table 2).

Determine $d_{max} = 0.29$ and the level at which this value falls, and calculate the value of λ by the formula:

$$\lambda_{empirical} = d_{max}\sqrt{\frac{f_{experimental} \cdot f_{control}}{f_{experimental} + f_{control}}} = 4.880661923, \lambda_{critical} = \begin{cases} \lambda_{0.05} = 1.36 \\ \lambda_{0.01} = 1.63 \end{cases}$$

Thus, $\lambda_{empirical} > \lambda_{critical}$, H_0 – deviates, hypothesis H_1 is preserved. The number of bachelors in agricultural engineering, in which the level of readiness for professional activity in the informational and educational environment to the formative stage in the experimental group is higher than in the control.

It is presented in the form of bar histograms a comparison of bachelors' readiness levels for professional activity in agricultural engineering in the informational and educational environment in the experimental and control groups at the beginning (figure 2) and at the end (figure 3) of the experiment.

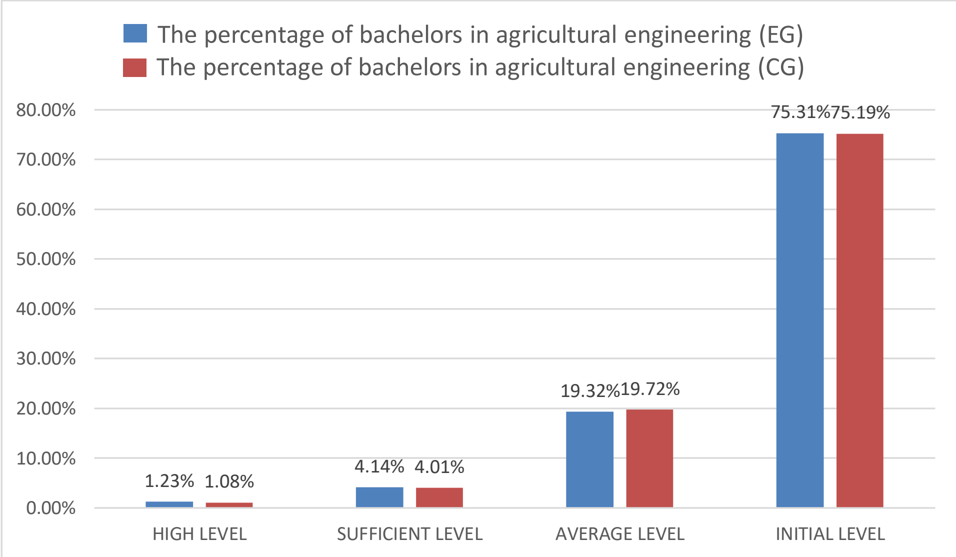

Figure 2: Comparison of the readiness levels for professional activity of bachelors in agricultural engineering in the informational and educational environment in the experimental and control groups at the beginning of the experiment

At a high level at the end of the experiment we have an increase of almost 20%, while in the control groups it is 7%. At a sufficient level at the end of the experiment, a rate of 5% was recorded in the experimental groups, which makes it possible to claim an increase of more than 40%, while in the control groups the increase is 12%. At the average level in the experimental groups, the increase is 5%, in the control it is more than 20%. At the initial level, at the end of the experiment in the experimental groups, the indicators decreased by almost 65%, while in the control groups only by 45%.

4. Conclusions

The implementation of future agricultural engineers' training technology in the informational and educational environment involves the integration of studying in the classroom and in the virtual space. To train bachelors in Agricultural Engineering, it is advisable to form electronic interactive tutorials for the study disciplines in the conditions of informational and educational environment. The final grade is formed from the scores obtained in the classroom and the rating of higher education applicants while studying in the informational and educational environment. The use of interactive audiovisual tools allows to get acquainted with the theoretical, practical and experimental provisions clearly, all this is important for the training of bachelors in Agricultural Engineering.

Thus, the main purpose of the experiment is to test the readiness of bachelors in agricultural engineering for professional activity in the informational and educational environment. The procedure of conducting experimental work included selection of control and experimental groups, development of methodical tools, definition and statement of readiness formation

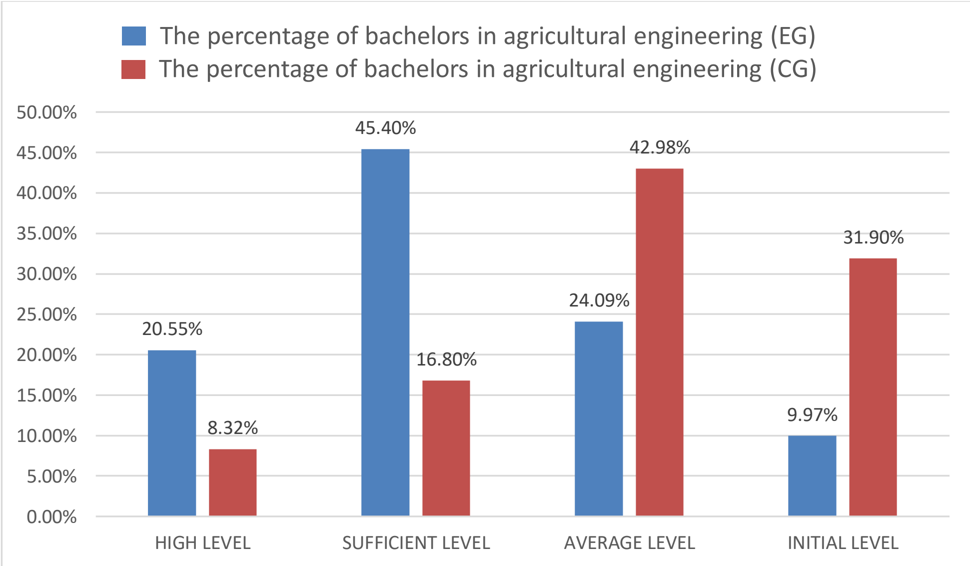

Figure 3: Comparison of the readiness levels for professional activity of bachelors in agricultural engineering in the informational and educational environment in the experimental and control groups at the end of the experiment

level to professional activity in the conditions of informational and educational environment, introduction of technology, comparison of formation levels after introduction of author's developments. Through practical implementation it is necessary to substantiate the efficiency of the developed technology. The reliability of the obtained results was checked using the λ Kolmogorov-Smirnov criterion.

Upon completion of the formative experiment, it can be argued that the future agricultural engineers' training technology in the informational and educational environment is effective. The developed technology of bachelors in agricultural engineering preparation increases the level of motivation and self-incentive to work in the informational and educational environment. The outlined technology provides an opportunity to combine the educational process in the audience of the bachelor in agricultural engineering with learning in the informational and educational environment, forms analytical skills and professional competencies.

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Blended learning in the context of digitalization

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Abstract

The realities of digitalization require changes in strategies for choosing educational technologies. The modern educational process is not possible without the use of digital technologies. Digital technologies have led to the arising and development of blended learning. However, its effectiveness is determined not only by technology. The human factor receives special attention in this direction. Analysis of the World Development Report 2016: Digital Dividends allows us to identify digital competence as a necessary condition for the successful use of digital technologies, and hence blended learning. Learning interactions designing in the process of implementing blended learning requires timely diagnosis of the level of digital competence. A popular tool for this is the Digital Competence Framework for Citizens. To clarify the peculiarities of its use was made an analysis of the experimental implementation results of blended learning in the industrial training in sewing for intended masters. During the research, it was revealed that the most important digital competence areas for the variable learning establishment in the training of future professionals are Information and data literacy, Communication and collaboration and Problem solving. In addition, competence for area Problem solving conduce to increase the level of competence for all other areas. The level of digital competence of the subjects mainly coincide to the characteristics of basic and secondary levels. The obtained data clarified the reasons for the difficulties, decrease motivation and cognitive activity that occur among students using distance courses-resources learning designed for blended learning. Thus, the use of the Digital Competence Framework for Citizens at the initial stage of implementing blended learning can make a rational choice of strategies for combining face-to-face and distance learning technologies.

Keywords

informatization, education, digitalization, blended learning, professional training, digital competence

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1. Introduction

The origin of innovation in the modern world is characterized by considerable rapidity. Most technological innovations are related to the development of digital technologies. They involve all socionomic spheres, changing society, contributing to the goals of sustainable development, creating new and changing existent technologies and products, producing new and modernizing traditional knowledge [1, 2]. Digital technology is associated with tools for collecting, storing, analyzing and exchanging information in digital format. The Internet and mobile phones have a significant impact on the development of modern society. Although the World Development Report 2016: Digital Dividends [3] has already outlined perspective areas for the use of digital technologies such as 5G, artificial intelligence [4], robotics [5], autonomous vehicles, the Internet of Things [6], 3D printing [7]. In addition, augmented and virtual reality has a prominent place in the research of new digital technologies [8, 9]. Under these conditions, the mission of education in the context of global digitalization is to prepare citizens for life and activity in the digital world. The most perspective way to implement educational activities in the modern world is the strategy of choosing educational technologies involving the active use of digital technologies.

1.1. Background

The current direction of innovative changes in education nowadays is the implementation of blended learning concept [10], which allows a symbiosis of pedagogical and digital technologies. Note that among the prerequisites for the emergence and development of blended learning (conceptual, technological-instrumental, financial and economic), influencing the content of the phenomenon, its components, characteristics, implementation conditions and opportunities for accumulation experience [11] is of particular importance integration of digital technologies into education process.

Many studies have been devoted to the problems of educational digitalization [12, 13]. Among the most significant should be noted the scientific achievements of Valeriy Yu. Bykov [14], Mariya P. Shyshkina [15], Natalia V. Morze [16], Oleg M. Spirin [17], Vladyslav Ye. Velychko [18], Myroslav I. Zhaldak [19] etc. Particular note for the results of comprehensive and collective development research, covered in the collective monograph "Theoretical and methodological principles of educational informatization and practical implementation of information and communication technologies in the educational sphere of Ukraine" [20], which ensured the development of theoretical basis of target, content, scientifically-organizational and normative-legal components of educational informatization implementation of ICT in a wide educational practice.

A significant contribution to the development of the theory and practice of blended learning in Ukraine has been made by Olga V. Bondarenko [21, 22], Kostiantyn L. Buhaichuk [23], Volodymyr M. Kukharenko [24, 25, 26], Svitlana H. Lytvynova [27, 28, 29], Oksana M. Markova [30], Iryna S. Mintii [31], Natalya V. Rashevska [32], Hanna M. Shalatska [33], Mariya P. Shyshkina [34], Oleg M. Spirin [35], Nataliia P. Volkova [36] etc. They proved the relevance and feasibility of implementing this innovation in the system of domestic education based on foreign experience and the results of their own practical activities. It is obvious that the implementation of blended learning requires a certain level of digital competence of trainers and learners that contributes its improvement in the implementation process.

The importance of digital competence in professional activities and the possibility of diagnosing the levels of its formation using the Digital Competence Framework for Citizens (abbreviated name DigComp) investigated by Oksana P. Buinytska [37], Artem O. Zaika, Vasyl I. Kovalchuk, Valerii V. Soroka [38], Tetyana V. Zaporozhets [39], Irina V. Ivaniuk [40], Oksana V. Mnushka [41], Oksana V. Ovcharuk [42], Natalia V. Soroko [43], etc.

Certanly, the involvment of digital technologies into the educational sphere is inevitable and necessary. However, they are not able to solve all urgent problems.

1.2. Statement of problem

In the process of studying the World Development Report 2016 research, we have identified a number of theses, the analysis of which allows us to outline the direction of our study.

1. The use of technologies lags behind the broad potential of their development opportunities [3]. Usually, technological innovation developers and users have a significant gap in the level of digital competence. It takes time for technological developments to become widely used. In our opinion, the reduction of time for the implementation of relevant innovations can be achieved by paying due attention to the development of digital competence by educational institutions.
2. Digital technology allows you to perform routine operations much cheaper, faster and more convenient. But in most tasks there is an aspect that cannot be automated and requires judgment, intuition and human reasoning (making decision) [3]. It means for us that although the functionality of digital technologies is constantly growing over time, they are not able to completely replace humans. This is especially clear in the field of education. Technology certainly can facilitate a significant number of actions in the learning process. However, the choice of technology for use, place, time, method belongs to the subjects of learning.
3. Technology can make workers more productive, but not when they lack the know-how to use it [3]. This thesis fill up the previous ones, asserting the truth that technology is not used for the sake of technology itself. They are made to increase the efficiency of work, which is achieved through perfect mastery of technological tools. Achieving accomplishment requires digital competence and constant practice.
4. “Access to the Internet is critical, but not sufficient” [3]. Most modern digital technologies require a reliable connection to the Internet. However, besides high-performance network technology requires the ability to use it effectively.
5. The best technology is one that people already have, know how to use and can afford [3]. As it was mentioned, to use technology, you need to have knowledge and ideas about it. In addition, the physical presence of process equipment is obvious. Over and above, the cost of such equipment and a license to use the relevant software is quite high. Therefore, we agree that the choice of technology should be justified not only in terms of functionality but also in terms of cost.
6. The success of the technology use in educational projects is achieved by: focusing on the “guided use” of technology, and not just providing tools for public use; providing

relevant curricular materials; sharing devices in educational establishments; adherence to the basics of didactics, pedagogical support and development; using technologies for practical significance; implementation of non-standard evaluation mechanisms [3].

7. Lack of clear ideas about the implementation of "technological"" solutions in educational practice can lead to a move in the wrong direction. However, this is not a failure of technology, but is the result of improper planning, inability to learn from failures and adapt [3]. This statement once again aver that the human factor is crucial in the process of using technology. Digital competence, readiness for continuous improvement, ability to think critically, analyzing of the situation, making decisions – are important factors in the effective use of technology.

Thus, the proper preparation of citizens for life and activity in the digital world requires the development of appropriate educational standards. To this end, the Digital Competence Framework for Citizens (DigComp 2.0: Digital Competence Framework for Citizens) [44] and an updated version of DigComp 2.1 (DigComp 2.1: Digital Competence Framework for Citizens) [45] have been created. It is used for developing strategy of using digital skills, reviewing and creating curricula, developing digital competence of teachers and supporting employment opportunities [42].

The purpose of the article is taking into account the main provisions of the Digital Competence Framework, researching how its structural elements are correlated with the requirements for implementation of blended learning in the training of future professionals.

2. Results

According to DigComp 2.1, the component composition of digital competence is formed by five areas (figure 1), each of which also has its own structure (figure 2). Eight levels of knowledge for each competence are defined on the basis of learning outcomes (using action verbs, following Bloom's taxonomy).

The first and second levels of literacy are determined by the ability to perform simple tasks by remembering and measures up to the basic level. Moreover, level 1 DigComp 2.1 is characterized by the need for guidance, and for level 2 – its occasional. The third and fourth levels – Intermediate are united by the cognitive domain of understanding. Furthermore, the third level is determined by the ability to independently perform standard and simple problems tasks, and the fourth – to perform depended and independent tasks with well-defined and non-routine problems.

Level 5 and 6 are intermediate. The fifth level is characterized by such a cognitive domain as understanding, the ability to solve various tasks and problems, guiding others. Instead of it the sixth level already requires the ability to perform tasks that require finding the most appropriate solution through evaluation, demonstrating the ability to adapt to others in difficult situations.

Seventh and eighth levels are highly specialized and united by the cognitive domain of creation. But if at the seventh level requires the implementation of tasks with limited solutions, while being characterized by the ability to promote cooperation in professional activities, leadership of others, then the eighth resolve complex problems with many interacting factors, proposing new ideas and processes to the field.

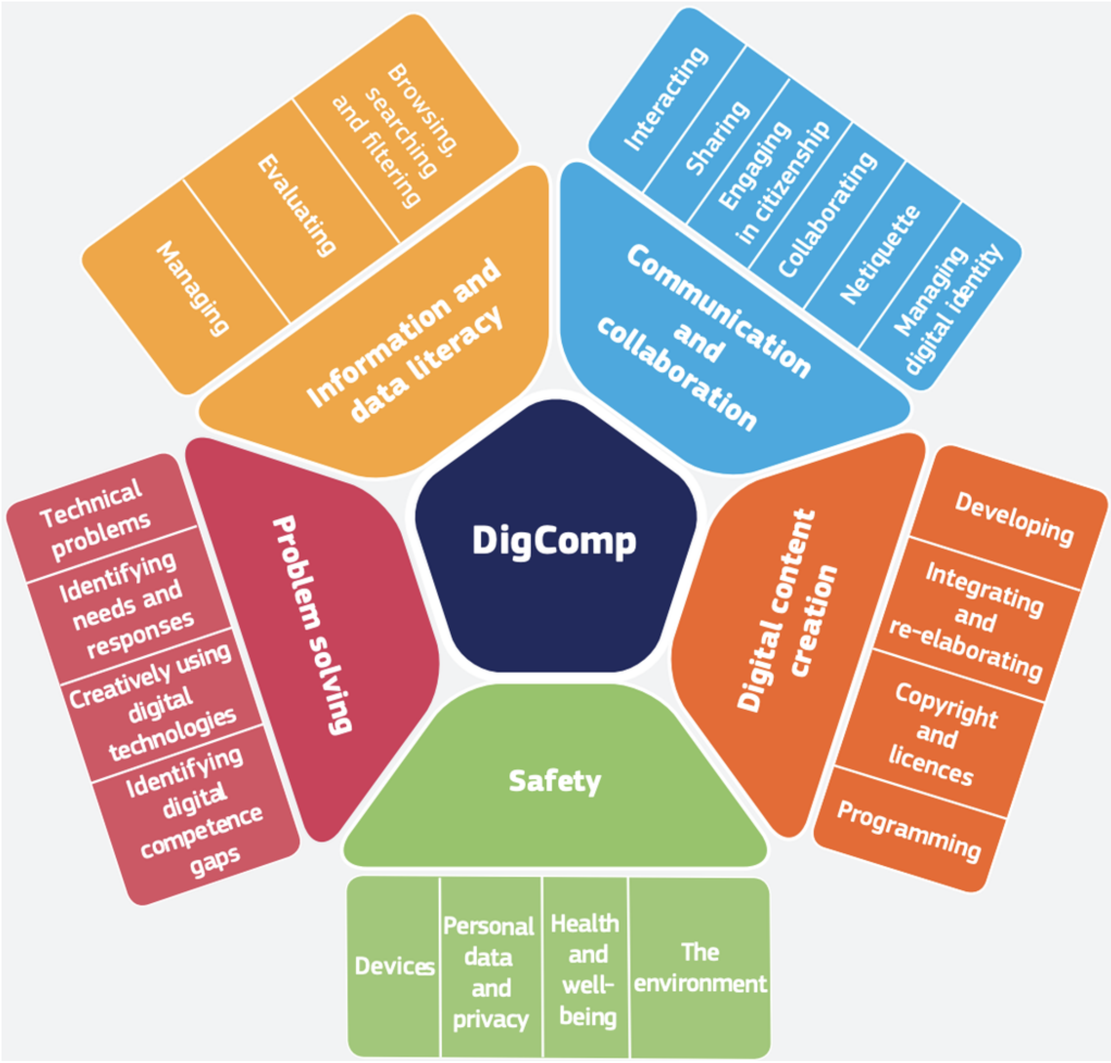

Figure 1: Five areas of digital competence

Observations of the digital levels manifestations of competence were carried out in the process of trial testing of the blended learning introduction in the masters industrial training in the field of sewing. Starting from 2018, students of the Vocational College of Oleksandr Dovzhenko Hlukhiv National Pedagogical Univerisity were offered distance learning courses-resources: "Fundamentals of clothing composition" (FCC), "History of costume design and material culture" (HCDMC), "Equipment and automatization of garment production" (EAGP), which were developed on the Moodle platform for blended learning.

The logic of making distance resource courses provided for the solution of the following tasks:

1. Providing students with a mandatory minimum of educational information.

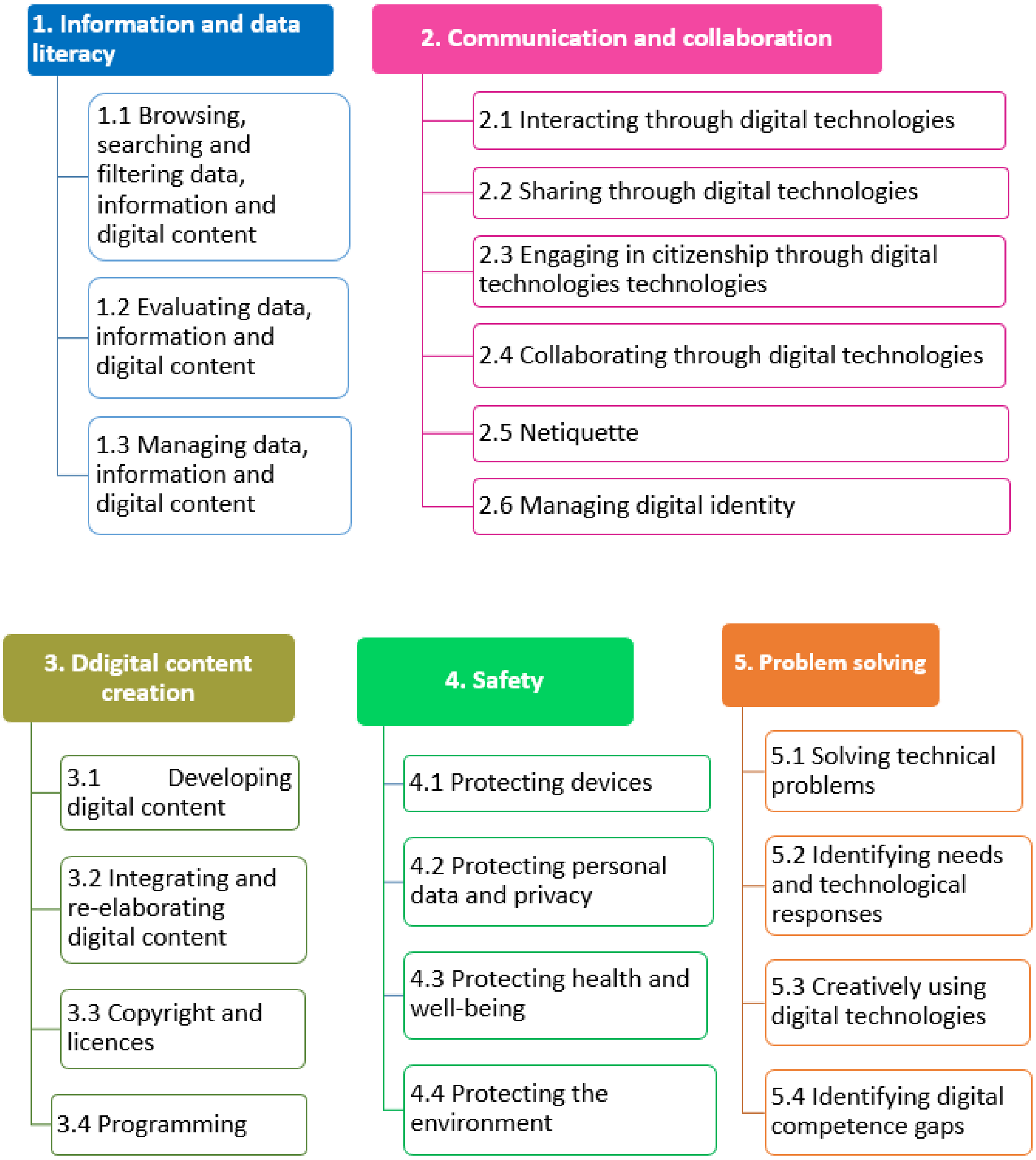

Figure 2: Areas of competences

2. Formulation of the purpose on separate subjects aimed at result.
3. Submission of a task list that contribute to the goal.
4. Providing the necessary instructions to perform tasks and identify the level of adequacy of their performance.
5. Ensuring the ability to follow learning progress, improving learning outcomes.
6. Providing opportunities for communication with classmates and teachers.

We should mentiion that only registered students in distance courses-resources have access to full functional potential. To complete the registration, students were required to form a digital competence in the area of 1 – Information and data literacy and 2 – Communication and collaboration, demonstrating the level of their competence.

For successful use of educational materials of distance courses-resources it is enough for students to have Basic level of digital competence in the field of 1. Information and data literacy.

Understanding the logic of goal setting within the thematic sections of the course requires students to demonstrate a level of digital competence not lower than Intermediate in areas 1 – Information and data literacy and 5 – Problem solving. Particularly relevant components of the fifth area in this aspect are: 5.2 Identifying needs and technological answers, 5.3 Creative using of digital technologies, 5.4 Identifying digital competence gaps.

The process of performing practical tasks makes special demands on the level of digital competence. The structure of tasks in resource courses was developed according to Bloom's taxonomy [46, 47]. Taking to the account that in the context of traditional learning, the differentiation of tasks is usually paying attention to the levels of cognitive activity (reproductive, interpretive and creative levels) by Tatyana I. Shamova [48], and their interpretation by Olena V. Sobaieva [49], we will assume that tasks of the reproductive level are tasks of the level in the cognitive sphere of "Knowledge""; interpretive tasks – "Understanding" and "Application"; creative level tasks – "Analysis", "Synthesis", "Evaluation".

Completion of tasks requires the following manifestations of digital competence in all five areas: for the reproductive level – not below the basic, optimally average; for interpretive level tasks – not below average, optimally Advanced; for the creative level – not lower than Advanced, optimally High.

The necessary stage of the tasks is self-control of their sufficiency in quantitative and qualitative indicators, we can follow the progress of learning, if it is necessary to refine it. As the key verbs of the relevant actions are analysis and evaluation, for their successful implementation, students must have formed a digital competence not lower than the extended level. It becomes especially relevant on this digital competence in the field of 1. Information and ability to work with data, 2. Communication and cooperation, 5. Problem solving. An important condition for successful learning is communication. From the level of digital competence in area 2. Communication and cooperation depends on the success of learning and the ability to increase the level of digital competence in all other areas. It is desirable that at the entrance to blended learning students have formed a level of competence in this area not below average, optimally – expanded.

59 students of different ages were involved in the study. The distribution of the number of people by age is given in the diagram (figure 3).

Depending on the needs and capabilities, future masters of industrial training in sewing had the opportunity to choose classroom (performance and defense of practical work in the classroom), distance lesson (performing tasks with remote reporting in the distance course or e-mail) or mixed (tasks using the materials of the distance course-resource with further protection of the results of practical tasks in the classroom) the format of practical tasks of these courses.

After providing information to students about the peculiarities of the use of distance course resources and the ability to choose auditorium, distance lessons or modified format of execution

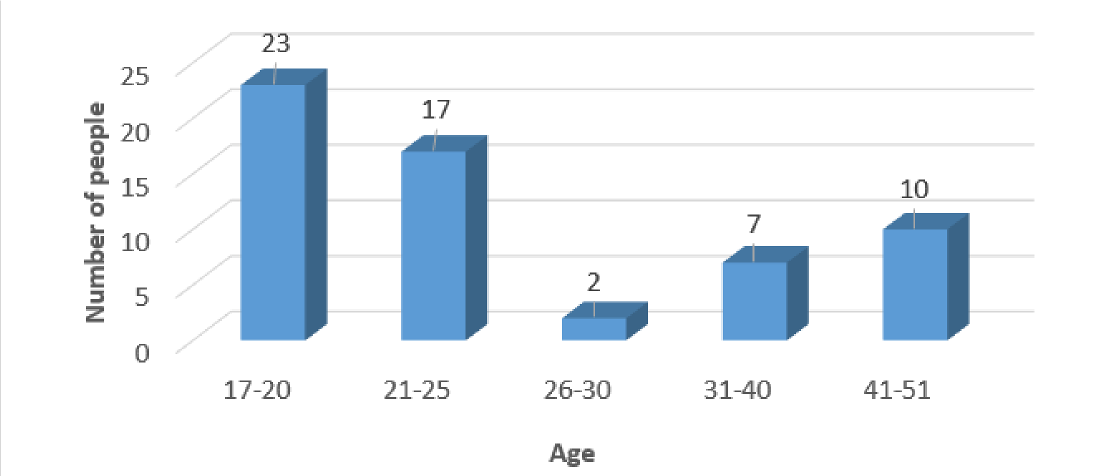

Figure 3: Averaging participants according to their age

and defense, 40% decide to work with the traditional audit method, 10% – distance studying, 50% – agreed the use blended format. The choice of student methods of implementation is mainly influenced by: social circumstances (health, ability to work, marital status), desire for independence, availability of digital devices and access to the Internet.

The first problem to the use of distance resource courses was registration. Despite the fact that students were provided with step-by-step illustrated instructions on how to complete the registration procedure by sending a link via Facebook (in 2018) and Viber (in 2019), only 8 people were able to register independently, 15 – used additional assistance, 7 – refused from registration and the idea of using distance learning course resources. These statistics allow us to state that at least 8 out of 30 people (26.6%) at the initial stage of entering blended learning met the criteria of the third level of DigComp in the areas of 1. Information and data literacy and 2. Communication and collaboration, and 15 (50%)) – the second, the rest (23.4%) – not higher than the first.

Due to the fact that out of 36 people who did not register for distance learning courses for various reasons, most of them in the learning process had a need to access the educational content of distance learning courses, along with the option “Self-registration” was added “Guest access”. The combination of these methods provided all interested students with the opportunity to use electronic textbooks, presentations, infographics, useful links and etc. to prepare for practical tasks and their defense. According to a survey of students, it was found that 50% (18 people) of students regularly, and another 10 people occasionally use “Guest Access”. This gives reason to believe that the Basic level of digital competence in area 1. Information and data literacy at the beginning of training is inherent for at least 51 out of 59 people (86.4%).

The level of logical understanding of goal setting within the thematic sections of the courses was traced by the results of students’ performance of level practical tasks. The average percentage of tasks on the reproductive level of cognitive activity with the use of distance course resources was 37.98%, on the interpreter – 34.53%, creative – 21.78%. The appropriate percentages show that at least 18 people demonstrated the level of digital competence in areas 1, 2, 5 not lower than the average, 11 people not below the extended, 22 – not below the basic. Progress of distance learning in distance courses is available for students to view in the Moodle module “Grades”. Furthermore, the teacher and classmates had the opportunity to leave feedback on the posted reports by students in specially organized forums. If the results of the assessment did not match the expectations, some students eliminated the identified shortcomings. Positive results of presenting tasks of interpretive and creative nature, taking into account the refinement, were regularly demonstrated by 9 people. According to the information given above, the level of their competence in the areas of 1. Information and data literacy, 2. Communication and collaboration, 5. Problem solving can be considered not lower than the extended level.

The process of blended learning certainly involves a variety ways of oral and written communication in the face-to-face meetings and communication through digital technology. In the process of learning to communicate on social networks with the help of mobile applications, 100% of students were reached. In addition, 40 students (41.6%) were involved in the process of pedagogical communication by e-mail, and 20 students (20.8%) were involved in forums among distance learning resource resources. After the termination of face-to-face meetings during the quarantine period related to the epidemiological situation in Ukraine and around the world, 14 students (14.5%) used the opportunity to communicate using the Google Meet service (9 of them (9.3%) went on video communication using a smartphone. Such results allow us to state that the basic level of digital competence in area 2. Communication and collaboration is typical for all subjects. In addition, the study found that five students systematically organized assistance to classmates using digital communications. This gives reason to believe that these 5 students (9.8%) have digital competence in area 2. Communication and collaboration at the advanced level.

3. Conclusions

The most popular areas of digital competence that allow students to join blended learning are areas 1. Information and data literacy, 2. Communication and collaboration and 5. Problem solving. In addition, competences in areas 1. Information and data literacy and 2. Communication and collaboration are mostly required, and possession of competencies in area 5. Problem solving allows successful increasing the existing level of competence in all other areas, achieving the desired results. Students who participated in the experimental study in these areas more often demonstrate Basic level (from 23% to 100%) and Intermediate (average) (from 27% to 35%) levels of competence in performing different types of educational activities. Only 10% to 22% of students demonstrated an Advanced level. Relevant indicators allow explaining the causes of possible difficulties, reduced motivation and cognitive activity of students in the process of blended learning.

According to the results of the study, we can say that the Digital Competence Framework has a significant number of tangents to the conceptual requirements for the implementation of blended learning. Therefore, diagnosing in time of the digital competence level of students based on its level structure at the initial stage of introduction of blended learning can form the basis for choosing strategies to combine face-to-face learning technologies and distance technologies. In our case, special training sessions were initiated. They are aimed at informing the participants of the educational process about the peculiarities of the implementation of blended learning, the use of available means of joint productive activities.

A perspective area of research is to establish the proper levels of digital competence of teachers, providing the process of blended learning, features and requirements of students in order to expand the possibilities of educational interactions that will stimulate mutual increase of levels of digital competence.

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Strengthening of e-learning at the leading Ukrainian pedagogical universities in the time of COVID-19 pandemic

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Abstract

Distance education has become the mandatory component of higher education establishments all over the world including Ukraine regarding COVID-19 lockdown and intentions of Universities to render valuable knowledge and provide safe educational experience for students. The present study aimed to explore the student's and academic staff's attitude towards e-learning and the most complicated challenges regarding online learning and distance education. Our findings disclosed that the online learning using Zoom, Moodle, Google Meet, BigBlueButton and Cisco has become quite popular among the students and academic staff in Ukraine in time of the lockdown period and beyond. Based on the Principal Component Analysis data processing we can conclude that students' satisfaction and positive e-learning perception are in a good correlation with quality of e-learning resources and set of apps which are used while e-learning and distance education. Also, education style, methods, and manner predict willingness of students to self-study. The self-motivation, time-management, lack of practice, digital alienation, positive attitude towards ICT, and instruction strategy belong to the most important challenges of COVID-19 lockdown based on the students and academic staff interviews. Online learning on daily purpose should be used in the favor of strengthening of classical higher education rather than replacing the former. Blended education is the best alternative to face-to-face education, because the communication with mentor in a live environmental even virtual should have ushered the learners to complete online learning and improve its results.

Keywords

E-learning, blended education, COVID lockdown, Moodle, Zoom, educational platform

1. Introduction

The novel disease COVID-19 caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has originated from Wuhan (China) and is heavily spreading worldwide [1]. According to report of CSSE at Johns Hopkins University, as of 13 September 2020, more than 28.7 million cases have been reported in more than 188 countries and territories, resulting in

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more than 920,000 deaths. Unfortunately, Ukraine is dealing with worse scenario of COVID-19 spreading than other European countries and takes 47-th place in the world due to new cases of COVID-19 per 100,000 people ([2]). The consequences of a pandemic include not only negative impact on physical health, but also mental health disorders [3], disturbance of economy [4, 5, 6] and some dimensions of education system [7, 8]. Almost 120 countries have stopped face-to-face learning and shifted to e-learning [9, 10]. All of these countries including Ukraine came out the policy of "learning never stops", which encourage higher education establishments efforts to provide safe remote learning on daily basis.

The specificity of teaching in modern universities in COVID-19 era determines the urgent demand for active implementation of distance learning along with traditional face-to-face and its combination with tradition type of education, developing special learning techniques in terms of learning methods and tools of both traditional and distance education [11, 12]. Distance education servers to gain students' knowledge and the academic staff skills and proficiency using ICT independently from external factors [13, 14]. The important feature of e-learning and distance education is the active involvement of students into educational process [15, 16, 17, 18]. They become active collaborators instead of passive learners, when teacher plays the role of guide and even advisor rather that instructor. On the present work we analyzed the perception, benefits and challenges of e-learning. Also, we would like to share some of the successful cases of e-learning and distance education at the leading Ukrainian Pedagogical Universities implemented during total lockdown of Universities while COVID19 pandemic.

2. Methodology

Online adapted surveys in terms of Google Form were carried out at Ternopil Volodymyr Hnatiuk National Pedagogical University (TNPU) and at the National Pedagogical Dragomanov University (NPU). The statistical representative sample included students from both Universities enrolled in online courses in different scientific fields, among them biology, maths, pedagogy, psychology, physics, history, English language, physical rehabilitation and IT. Following the margin of error at 3.7%, confidence interval at 95% and total number of students, the sample size was determined as 450. We gathered the opinions of students from TNPU and NPU who have enrolled to different majors. A majority (63%/37%) of surveyed students were women and represented young generation (19-22 years old). The online courses were available on the Moodle platform. Also, Zoom, Google Meet, Hangout, BigBlueButton and Cisco were used to support and enrich proposed courses. Students were welcomed to fill in the questionnaire that had prepared using Google Form in the mid and at the end of learning a subject. It was accessible via link in the Moodle and in the students Viber groups and Telegram channels for two weeks. The questionnaire contained several blocks of questions namely demographics (age, gender, nationality), peculiarities of education process (faculty, mode of study and enrollment, major area of study), experience with ICT tools and educational platforms, perceptions of the e-learning, perceptions of courses (content, deep sense of meaning, structure, clarity etc), perceptions of the tutor, and challenges and problematic points faced by students in e-learning (Adaptability Struggle, Technical Issues, Computer Literacy, Time Management and Self-Motivation).

We have also conducted survey of academic staff related to key points of success, effective ways of monitoring students' engagement and learning, and challenges they faced in e-learning and distance education (Adaptability Struggle, Technical Issues, Computer and Media Literacy, Time Management and Self-Motivation).

Data were tested for the normality and homogeneity of variances using Kolmogorov-Smirnov and Levine test, respectively. For the data deviating from normality or homogeneity of variances, Box-Cox or log10 transformation was used. If the transformations did not result in normal distribution, non-parametric tests were used. The effects of analyzed predictors on student success in distance education and e-learning were tested by ANOVA/MANOVA and multiple regression analysis. The Pearson correlation test was used to find out association and linkage between studied parameters. All statistical calculations were performed with Statistica v. 12.0 and Excel 2019 for Windows. Differences were considered significant if the probability of Type I error was less than 0.05.

3. Results

A total of 450 persons admitted for the enquiry. The perception of e-learning, tutor and courses are shown in the table 1. We observed that the most of surveyed students had positive perception towards e-learning and they were basically satisfied with e-learning and distance education (table 1). Zoom, Moodle, Google Meet, BigBlueButton and Cisco have been pertaining to the most popular educational platform among the students and academic staff of TNPU and NPU since the beginning of the COVID-19 lockdown period and beyond. Also, almost of them expected that in near future the e-learning would take the dominant place in the education market due to possibility of students self-regulation and clear and coherent structure of the learning material in online learning, as well as rapid penetration of ICT in teaching strategies.

Importantly, that the present research also underlined the students' appreciation of the e-courses presented in Moodle which had the third largest market share of institutions in the world (17.1%) [19]. E-learning at TNPU, as the example of Ukrainian pedagogical universities, was implemented more than ten years ago on Moodle platform. Now TNPU-Moodle counts 1863 courses in different subjects and for different majors. When a course creates, we follow several quality standards namely informative content, structure environment, communication and availability, cooperation and interactivity, student assessment, flexibility, functionality technical support, faculty qualifications in terms of using novel teaching and learning technology, reports and recommendations for course improvement, vision and institutional leadership, and resource allocation due to recommendation of Swedish National Agency of higher education [13]. As the result, our students positively assessed the user-friendly interface, structure of the material and courses designed, the learning management system, convenience and wide range of communication facilities, including Zoom integrated in Moodle. It allows conducting live online classes, web-conferencing, webinars, video chats, live meetings and business meetings, even voting.

Over half of those surveyed reported that e-learning highly supports instructor accessibility, allows to receive fast feedback. While e-learning fast and flexible creation of a minute counsel with peers and instructor/mentor is also possible. It means that e-learning allows students to stick together, exchange knowledge and innovative ideas with peers during quarantine, and

Table 1
Overall perception of pedagogical universities students on the implementation of e-learning/distance education

	Responses	M	%
e-learning perception and attractiveness	Positive/Higher than offline learning	320	71
	Negative/Lower than offline learning	130	29
future belongs to e-learning	Yes	342	76
	No	108	24
e-learning should combine with face-to-face education	Yes	293	65
	No	157	35
students' satisfaction with e-learning and distance education	EL/DE meet my personal learning needs	311	69
	I wouldn't like to recommend EL/DE to others	139	31
university courses should combine with non-formal education	Yes	378	84
	No	72	16
quality of teacher-student interaction (Student involvement, Practice feedback)	High	279	62
	Low	171	38
quality of e-learning/distance education (Accuracy, Integrity, Completeness, Course management)	High	293	65
	Low	157	35
overall quality of courses available in Moodle (content, deep sense of meaning, clarity skills, etc	Satisfied	315	70
	Inadequate	135	30

overcome communication crisis. Many students now prefer to contact their instructors via Viber chat or email rather than during office hours.

Strong evidences of positive impact of informal education as a component of University courses was found when our students intensively attended free-off-charge online courses provided by Coursera for Campus for delivering modern world-class job-relevant and multidisciplinary education. At the beginning of the COVID-19 lockdown Universities all over the world in the favor of Coursera obtained the possibility to enhance their core curricula, offer supplemental learning to students, and deliver lifelong learning to their faculty and staff. More than 11 500 lessons taken and more than 1600 courses were successfully finished by TNPU learners and 14324 and 1894 by NPU learners correspondingly. Coursera for Campus helps our students not only enrich their knowledge with up-to-date information, but also allow to gain their language skills.

Besides there are a lot of preferences and benefits of e-learning and distance education, many students and staff face numerous challenges and pain points while teaching and studying online (figure 1). Except the most common complicated points presented on the figure 1, some of them namely "Maintaining high academic quality standards", "Synchronous class activities", and "Insufficient free content and/or materials for virtual courses" were recognized by respondents as mid-risk issues (~35-40%).

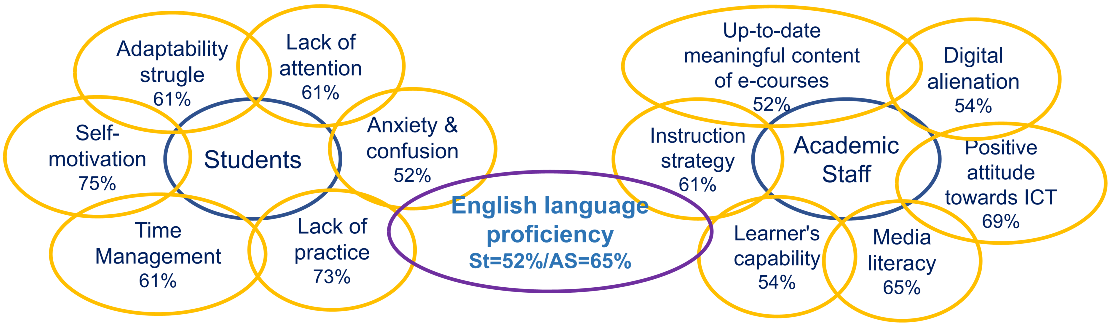

Figure 1: Challenges that students and academic staff faced as participants of e-learning/distance education.

We have applied Principal Component Analysis (PCA) to determine relationship between signs of e-learning perception and which determinants pose the most important influence to the student's decision to study online. The PCA identified two principal components (PC) with the eigenvalues >2 which explained 62.15 % of the variation in the data set (figure 2). The first PC had high positive loadings (>0.6) of the e-learning perception, students' satisfaction, e-learning resources completeness, e-learning material accuracy, practice feedback, and Future belongs to e-learning. The present group of parameters should be recognized as the "Future belongs to e-learning". The PC2 had a high positive loading of students' self-motivation to study and high negative loadings of the educational methods and styles.

Based on the PCA results we can conclude that students' satisfaction and positive e-learning perception are in a good correlation with quality of e-learning resources and set of apps which are used while e-learning and distance education. Also, education style, methods, and manner predict willingness of students to self-study.

To analyze the effects of specialty and maturity of students on their e-learning perception we processed data using discriminant analysis (figure 3). The current approach found that online learning perception and satisfaction don't depend significantly from their specialty ($F_{28,76} = 0.94$, p<0.56) or even year of study ($F_{28,76} = 0.48$, $p < 0.98$). Nevertheless we didn't observe significant difference between groups of interest, there is a clear trend that students of natural science and technical divisions responded in a different manner than liberal art students (Mahalanobis square distance = 2.4/2.2 versus 1.3 for difference between natural science and technical majors). It is interesting to note that students of first year study, Bachelor degree programs had a little bit different point of view than elder students (Mahalanobis square distance for IB compare to IVB and IM = 0.9 and 1.6).

4. Discussion

Nowadays, e-learning is becoming more-and-more popular. The latest survey conducted in the US proved that US companies with "comprehensive training programs" have 218% higher revenue per employee and 24% higher profit margins. IBM saved approximately $200 million

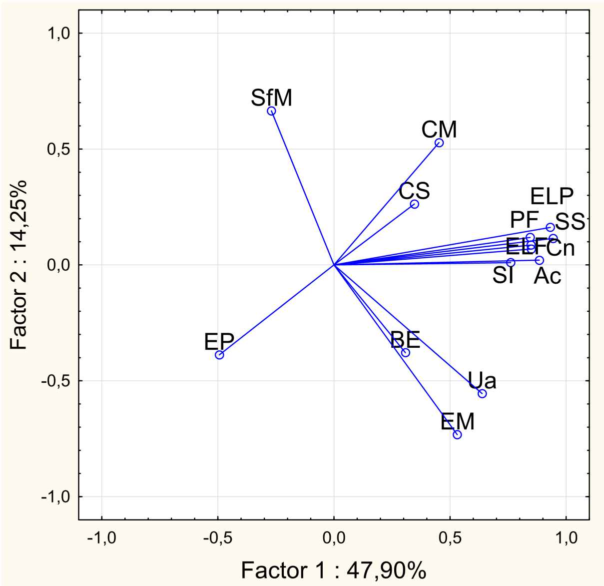

Figure 2: Principal component analysis of the results of the survey of students from Ternopil Volodymyr Hnatiuk National Pedagogical University and National Dragomanov Pedagogical University regarding e-learning perception and putative challenges. Factor loading is highly significant when more/less then +/-0.6. ELP – e-learning perception, ELF – Future belongs to e-learning, BE – e-learning should combine with face-to-face education, SS – Students' satisfaction, SI – Students' involvement, PF – Practice feedback, Ac – e-learning material accuracy, Cn – e-learning resources completeness, CM – Course management, CS – Course meaningful, EM – Educational methods and styles, Ua - Understandability, SfM – Self motivation, EP – English language proficiency.

after switching to e-learning. There is the expectation that the US e-learning market will grow by $12.81 billion between 2020 and 2024 [20].

E-learning is able to open new horizons for both educators and learners and offers a very effective way to conduct classes using electronic devices through educational videos [21], simulators [22], virtual laboratories [23], and virtual discussing. In this way distance education offers a new paradigm for teachers in which dynamic learning-centered courses rather than traditional ones with standard mode "lecturing – followed by testing" can be developed. As an option, students can build a team concept map collaboratively via Zoom or Google Meet and enhance their communicational and analytical skills simultaneously. Also, Think-Aloud-Pair-Problem Solving or Send-a-Problem mode can be used to gain students' thinking competencies. The conducted surveyed proved positive perception towards e-learning in students enrolled to study at Ukrainian pedagogical universities. In general, our results are in line with recently reported in literature. In particular, among 175 students, who are currently pursuing their undergraduate degrees in different colleges and universities in India, around 76% of the students are in favor of e-learning [24]. Indonesia students also perceived the e-learning web-based module to be useful in improving their understanding, independence, self-discipline, motivation to learn, and interactions with each other and with the teacher [25]. Nearly all participants of a secondary US history e-learning course maintained a belief that e-learning was best used

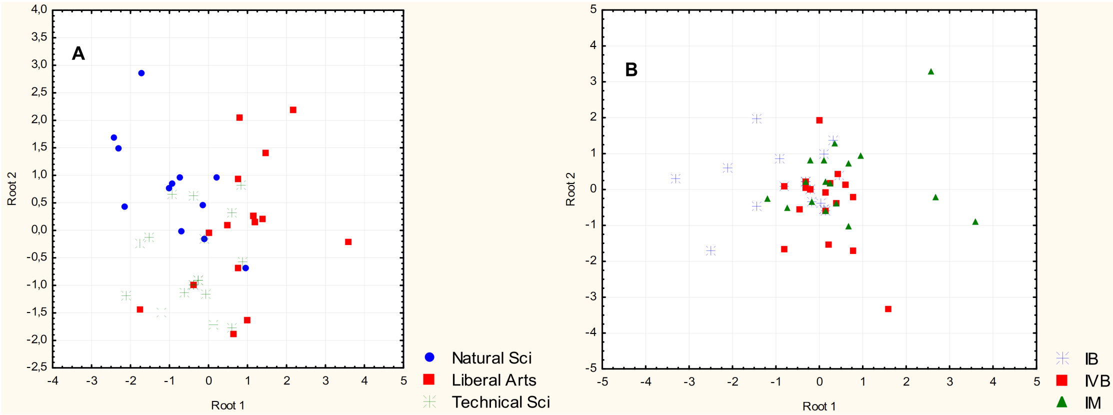

Figure 3: Graphical representation of discriminant analysis of the results of the survey of students from Ternopil Volodymyr Hnatiuk National Pedagogical University and National Dragomanov Pedagogical University regarding e-learning perception and putative challenges depends on the specialty (A) and year of study (B). IB – first year study, Bachelor degree, IVB – fourth year study, Bachelor degree, IM – first year study, Master degree

for information transmission and rote memorization rather than active or social learning [26]. According to Statista around 30% of students in the USA stated they had taken an online course in the 2018 and this number was dramatically increasing while COVID-19 lockdown [27, 28]. Indeed, positive perception on using e-learning technologies in future teachers is highly important not only for themselves, but for children will be taught. We are living in the modern world which is being shaped by rapid technological change and future teacher has to be ready to equip and prepare children for this brave digital world.

On the other hand, it has been recently shown that 77.4% students from Pakistan medical college showed negative perception about e-learning, out of which 86% students felt e-learning has little impact on their learning. Majority of the students preferred face-to-face teaching over e-teaching. Following survey results authors came out with conclusion that the students are not yet ready for e-learning [29]. Obviously, it can be connected to specificity of medical education regarding its practical orientation. In our case the response of students had enrolled to study at Natural Science and Technical majors resembled above mentioned. Medical ones regarding lack of practice. Due to that they formed their own cluster when processed by Discriminant Analysis (figure 3) and the practical feedback pertains to the most prominent parameters which predict the perception of e-learning and distance education (figure 2). It means e-learning can be used for all majors, but has to be tightly adapted to educational needs. The building and implementation of simulation apps and virtual laboratories should be helpful [30].

The PCA shows us that the e-learning perception, students satisfaction, e-learning resources completeness, e-learning material accuracy, practice feedback, and Future belongs to e-learning create their own cluster, because correlate with each other. Our finding broadly supports the statements of other research in the area linking students satisfaction. As an example, Granada University students satisfaction with e-learning was predicted by the course plan, contents and the system of evaluation. Moreover, the content was the most powerful determinant in the multiple regression model (coefficient = 0.9, p <0.001), then followed by interaction (coefficient = 0.531, p <0.001) and technical issues (coefficient = 0.471, p <0.001) [31]. Alqurashi also found that earner-content interaction was the strongest and most significant predictor of Temple University students' satisfaction with e-learning [32]. Indeed, the content of e-courses has to stimulate their interest for the course and help students to relate their personal experience to new knowledge.

Another important finding of the PCA is that self-motivation of students is in a negative relation to educational methods and styles (figure 2). This statement corroborates the results of the previous work and postulates of the self-determination theory. The learning style of students from University of Shahrekord (Iran) significantly correlated with motivation for higher education in general ($r = 0.69$, $p < 0.001$), but no information about self-motivation to study was presented there [33]. Self-study-oriented and autonomy-supportive Faculty initiate in their students intrinsic motivation, inquisitiveness, and the desire to solve logic problems and overcome practical challenges. The goal-orientated education and extrinsic motivation are also very helpful to catalyze students self-motivation to study.

Based on the response of our students "Future belongs to e-learning" should be recognized as the vision of youth of upcoming changes in the educational system. Substantially, e-Learning and distance education have capabilities to mobilize the educational, cultural, and economical communities in favor of accelerate systemic changes towards professional, intelligent and knowledge-based society. E-learning is much more accessible and in some aspects is more profound than physical learning. All studying materials are available online and you can access them as many times as you want. Moreover, technological performance in the era of e-learning and distance education together with novel challenges can push us towards some uncommon, but very interesting and useful practice. For example, during the COVID-19 lock-down TNPU in the tight cooperation with PreCarpathian National University have launched authorial between-university educational online platform "TerPEdu" for lectures which is based on the Cisco Webex. More than 2400 students from both partner universities attended lectures in different disciplines. Most of them gave positive feedback and emphasized on the interactivity of the presented platform when compared with well-known counterparts including EdEra, Coursera, Alison etc and the possibility to realize mobility in the frame of "internationalization at home". At the moment we are working on expanding partner network in Ukraine and beyond. We expect that we will involve "visiting professors" from partner universities from Germany and Poland by the end of 2020. We are on the way with Chinese courses for TNPU Students cordially provided by partner Shenyang Pedagogical University. Also, we are going to organize online summer school in the same way due to recommendations of the THEA-Ukraine DAAD Project.

Take into account different factors that should affect educational outcomes, our results and previous research findings [34] we can conclude that, on-line learning on daily purpose should be used in the favor of strengthening of classical higher education rather than replacing the former. The statement keeps in line with the point of view of the European University Association. The blended learning pretends to be the most useful scheme in that case. It combines the in-person and online components in suitable ratio depends on the baseline level and needs of learners and capability of teachers. Blended learning builds both a community of inquiry and a platform for free and interactive dialogue [35]. Also, blended learning allows to deliver learning material through both synchronous and asynchronous modes and break up it into smaller chunks [36].

This educational mode should be very useful for learners to process, understand, and keep in mind materials better than in standardized face-to-face ones. In accordance with the present results, numerous last students surveys all over the world proved that blended learning has to be widely promoted at the universities due to reduction of negative attitudes of learners toward digital instruments [37] and as the upcoming educational mainstream.

Nowadays, students' expectations are shifting rapidly from passive learning in class with a teacher as a main owner of information to blended education or even distance education which characterized by flexible schedule and fully accessible materials through online mode in gadgets. In other words, modern education mode allows students to learn at their comfort and requirement. In this context, education process is pretended to be strongly associated with digital and mobile paced. Meanwhile Universities and learners have faced due to that one of some challenges namely robust internet connection with the high band. And Ukraine was not alone in that way. A lot of surveys from different countries have denominated unsatisfied internet connection at the top of the pain list around distance education [12]. In particular, they emphasized that good internet connectivity is urgently needed to avoid buffering and lagging of the live stream, but e-learning is even worse in rural areas compared to urban due to lack of infrastructure that online courses require, and thus fail to attend with their virtual classes [24]. However, we have successfully overcame low-speed internet connection in students from rural area or even unexpected internet outage and conducted classes. Furthermore, we have successfully assessed students (including art students) via Zoom and Moodle at the end of courses in terms of final examination. Also, all Master and Bachelor thesis defense were conducted via Zoom, including foreign students from Greece and Slovakia. It was the very first attempt pushed by COVID-19 lockdown, but very valuable.

E-learning and distance education demands the educators and learners to be technology-friendly which is not the case always. "Digital alienation" and "Positive attitude towards e-learning" were chosen by academic staff as one of the most stressful points of e-learning (figure 1). Nevertheless technology has brought a little alleviation for the teachers so-called "Digital Divide", they recognized this as a challenge, but not as a benefit. Moreover, it is indeed not only in Ukraine, but over the world. In particular, 41% of US teachers stated the lack of ICT skills and knowledge was the biggest barrier to increasing the use of educational tech in their classrooms [38]. Stieler-Hunt and Jones concluded that whilst negative teacher attitudes towards the use of digital tools in the classroom persist, their potential impact in the classroom will not be fully realized [39]. This is especially true for elder generation of instructors and the average age of academic staff at Ukrainian universities varies between 50-55. To attenuate these painful points, we have proposed for TNPU's Faculty some training courses devoted to the most useful online platforms (Zoom, Google Meet, BigBlueButton), workshops about suitable tools for preparation of video lectures and virtual programs, and hotline via Viber channel where every person is allowed to obtain useful tips and advises due to e-learning. They were carried out by center of distance education of TNPU and recognized as very helpful.

Another challenge faced both by students and academic staff (figure 1) is that limited English language proficiency. Language skills are urgently needed for successful handling of ICT, acquisition new information, finding partners and creation of consortia in terms of realization of educational/research projects and searching better job opportunities. We have been tackling present challenge by way of implementation of English language courses for both students and academic staff and initiation bridging programs for life-science and technical master students that includes English proficiency. Also, we have launched the University call for the best bridging programs and now our Faculty are on their way of the course preparation for contest.

The next very important challenge is related to the theoretical meaning of e-learning and distance education. The distance education focuses predominantly on the theoretical imparting of the subjects when applied majors require practical classes and considerable hands-on skills. In last decades some investigations pointed that students tend to prefer real practical experimentation to computer simulations even though the latter cover similar ground [40]. Moreover, it was proved that personal interaction with equipment leading to the accumulation of knowledge and skills required in a practice-oriented profession [40]. Due to that we have been doing all our best to discover virtual programs and apps which should be very helpful for students who copes with practical issues in technical and natural sciences.

5. Conclusions

The COVID-19 pandemic have complex, unpredictable, and long-term implications for education and research that must be anticipated now. Remote e-learning solution can mitigate the immediate disruption caused by COVID-19 and establish novel approaches to develop more open and flexible education systems for the future. Nevertheless there were some challenges regarding e-learning, the most of surveyed students admitted to study at Ukrainian pedagogical universities had positive perception towards e-learning and they were basically satisfied with e-learning and distance education. Higher education e-learning marks very essential for both students and academic staff and universities have to make eager efforts for discovering the optimal way for reaching best learning outcomes. E-learning on daily purpose should be developed in parallel with the blended education which is a valuable concept to provide students with opportunities for autonomous learning and a decentralized transfer of knowledge in line with face-to-face communication. We have to strengthen the cooperation between Ukrainian universities and their abroad partners in the field of digital education regarding to reciprocation of educational protocols, virtual apps, as well as Faculty exchange in the framework of "Visiting Professor" institution.

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Operation system features and cloud services for lecturer work

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Abstract

The work proposes a conception of setup and use of teacher's or lecturer's workspace using common software and hardware products. The research object is a system built by using operating system capabilities in conjunction with office suite and public cloud service, as a foundation for teacher's digital workspace. Research is made on how to set up, scale, and operate such a system, by studying the experience of national and foreign scientists and teachers, and using our own experience in educational processes, and working with operating systems and cloud services. As a result, we got a system which is easy to set up, learn, and apply by teachers without significant experience working remote education systems, and could be used for initial learning of remote education principles. It could be used as an initial step before migrating to specialized remote education systems. In the future, the system itself could be improved by adding additional objects into the system and a higher integration level between objects and external subjects.

Keywords

cloud storage, operating system, teacher's site, distance education, office software, file manager

1. Introduction

Increased availability of modern computer hardware and high-speed communication systems made possible a more effective study process organization, to account for all interests of the modern generation of pupils and students, who are more accustomed to modern technologies if we compare with previous generations. It became especially urgent in modern conditions, associated with the objective impossibility of communication between teachers and students directly during quarantine activities. Researches, who support the blended education, consider, that in the process of the distance communication, as in the base of the distance education, arise new challenges related to the technical side of the process, which includes storage and providing access to education materials, providing feedback, knowledge assessment, etc. [1, 2, 3, 4, 5, 6, 7]

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Nowadays, many scientific researches are dedicated to the studying of using cloud technologies in the educational process. Aldakheel and Rajaei considers that the distance education is the main application of cloud services in education [8].

A lot of researches [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27] substantiate the feasibility of using cloud environments in the educational process. Alamri and Qureshi confirm, that cloud services must be apply in higher education for educators and students. They substantiate the implementation of the on-line education using cloud services to share numerous education materials such as reference books, videos,online lecture and virtual class rooms [28].

Customers now have a big choice of software platforms, both commercial and free. For example, most Ukrainian universities use a learning platform (LCMS) Moodle for mixed mode education [29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40]. But the biggest problem facing users now is learning new tools, which requires time and skills to use it effectively. This is especially the case for senior people and non-technical specialists. Mintii in the article [41] analyzes the results of the survey of lecturers on using the learning content management system (LCMS) Moodle in the educational process in Kryvyi Rih State Pedagogical University. The research shows that lecturers over 60 years old need methodic assistance in using Moodle. The results of the survey conducted by Institute of Information Technologies and Learning Tools of National Academy of Educational Sciences of Ukraine show the experienced lecturers, familiar with the latest technologies of distance education and communication, are not numerous [42, 43].

Prybylova notices that in the new approach to distance learning, the equipping of teacher and student workplaces also plays an important role, among other factors [44]. So there is a problem with lecturer personal workspace organization in case of absence of advanced personal computer skills.

2. Materials and methods

In the first phase, we did the theoretical analysis and abstraction of specialized literature. It was done to define the state research problem, determine it's actuality, and to formulate goals and objectives of the research. We also did pedagogical observations to determine common students and lecturer interaction patterns in a remote or mixed education environment.

In the process of building the model, we used the knowledge and experience of modern operating systems. The main attention was paid to Windows 10 OS, MS Office 2016 and 2019, cloud service OneDrive and their interoperations. Thus the model was built based on the actual teacher's needs and personal experience. After building the model and implementation we did a pedagogic experiment: we tested the implemented model on practice with students of the Faculty of Informations Technologies and Mathematics at Lesya Ukrainka Volyn National University.

3. Discussion and results

The main category of customers already is familiar with typical tools, which they already use in day to day life: operation system (working with filesystem objects), office suites, Internet browsers, cloud services (storage, access sharing, etc), electronic mail and messaging. It turns out that a minimal level of computer experience is sufficient to quickly and relatively effectively organize their workspace for distance education.

Windows 10 OS already has the majority of components required for a teacher's digital workspace. We will use this operating system as the most popular among users [45, 46] (figure 1). So the operating system could serve as the main gateway to all tools required for the educational process.

Let's consider this the whole system in detail.

It is possible to fill the cloud environment (OneDrive, for example) with files using the file manager of the operating system. As the OS contains the instruments for synchronization such data warehouse with the local folder, the teacher can operate. The OneDrive application allows you to create the account, if it is not created yet, use the backups of the important data, to restrict the bandwidth of the cloud communication channel and provide the interaction with office suites (MS Office, for example). Using this application, it's possible (if necessary) to get to the web-site, where you'll get a wider set of set-ups, for example, managing the access of other users to your information (figure 2).

File organization in cloud storage deserves additional attention. One may separate files related to assessments from reporting or documentation files. It's worth creating a dedicated folder that will be used for read-only access for others and separate it from backup files (sorted by some periods). This will allow the customer to avoid unnecessary work of maintaining additional access controls (or shareable links for browsers). Backup files will be stored separately because the file name will be not changed but it's content instead with the latest actual content. This is convenient for academic assessment reports which are changed every semester. The report itself is an Excel spreadsheet, which is easy to use for an average user and has large automation opportunities at the same time. These digital journals are easy to access both for the lecturer and a student. Gives opportunity for a central audit of student's scores and quickly spot lagging behind students. This system allows only to the lecturer to edit student's scores and provides better transparency of the education process. This spreadsheet can be rendered by every lecturer, based on his spreadsheet skills. Besides the usual students' list, assessments, dates, and topics one may implement the following:

- auto-sum of all current and control grades,
- continuation of rows by leveraging columns, which include rating indexes (to avoid dealing with fractional rates in 100-based rate system, or any other system where rate are multiplied by constant index),
- implement conditional cells, for example: pass or didn't pass for a test, auto-sum of question's grades for exam,
- auto-hide rows with students which already passed all tests and highlight only remaining students,
- generate exams or tests report with auto-filled values,
- color-grading and custom rows format based on a conditional cell's formatting [47, 48, 49, 50, 51, 52].

An example of such a spreadsheet is shown in figure 3. Full spreadsheet is available at our

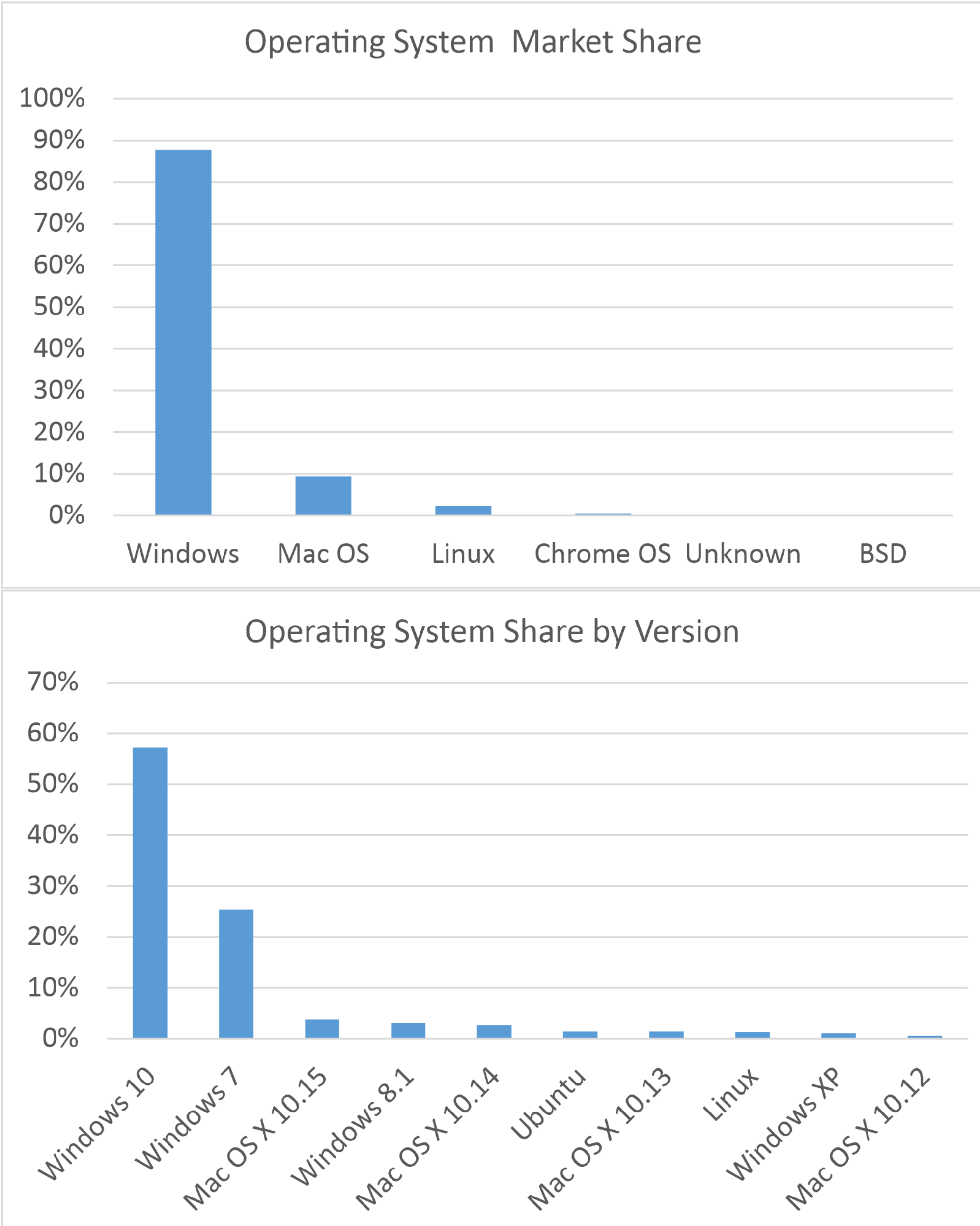


Figure 1: Operating system share (data is valid on 2020.10.14).

web-site [53]. The most convenient way to work with it is by using a local MS Office application, instead of Microsoft 365 Web UI.

To store large files, which usage is not very frequent (distance course materials if the form of methodical recommendations, specialized software, multimedia files etc.) one may use the other cloud services and their storages: Google Drive (15 Gb of free space) – for large documents,

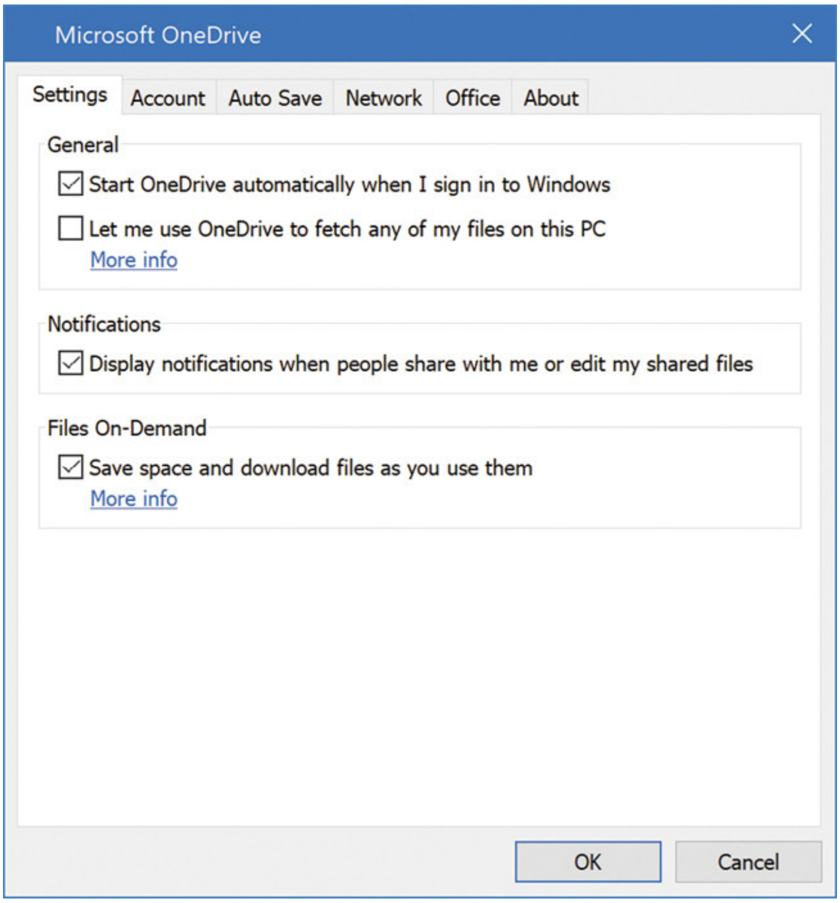


Figure 2: OneDrive addon setup, installed on Windows 10.

Mega.nz (50 Gb free space) – for multimedia files and software, Flickr (up to 1 Tb free space) – for photo- and video materials [54].

It is expedient to create folders with the access to rewriting for students on such storages, as they may upload their files with completed tasks. The structure of such folders and subfolders can be determined by demands of the specific course. Such files and folders will be rarely edited by the owner, that's why it's not necessary to synchronize them automatically. It's faster and more convenient to manipulate such files by the file manager in OS, that's why the additional software is not needed.

The interface of cooperation with pupils and students is a very important part in the development of the distance course. The most effective, in our opinion, is web interface – the teacher web-site. Such website may include minimum information about a specific distance course, as all the information stored in cloud storages. The structure of such a web-site may be very simple. It is possible to add there ordered lists of hyperlinks, linked to the different materials of distance courses: digital journal, manuals, software, links for messengers for fast feedback, e-mails, resources for responding completed tasks and so on. Our web-site VV&VL is

33 група	6	7	8	9	Поточний контроль	Бонус	Колоквіум	КР	Підсумковий модульний контроль	Загальна кількість балів	ECTS		Бажання здавати екзамен (1)	білет №	екзамен 10.01.2020 (9:00) консульт. 09.01.2020 (10:00)					Заг. к-сть балів	ECTS	
Солоха М.	5	5	5		34,00	5,00	17,00	10,00	32,00	66,00	E	на екзамен		9	10	10	6	34,00	26,00	60,00	E	задов
Положенцева К.	4	5	5	5	39,00	5,00	30,00	5,00	40,00	79,00	C	добре										
Клестова Д.	5	5	5		34,00	5,00	30,00	15,00	50,00	84,00	B	добре										
Річко Д.	5	5	5	5	40,00	5,00	25,00	5,00	35,00	75,00	C	добре	1		15	18	20	40,00	53,00	93,00	A	відм
Пономаренко О.	5	5		н	27,00	0,00	11,00	н	11,00	38,00	FX	на екзамен		н				27,00	0,00	27,00	F	на перездачу
Малаховський З.	н	5	5	н	14,00	0,00	18,00	5,00	23,00	37,00	FX	на екзамен		н				14,00	0,00	14,00	F	на перездачу
Романчук Ю.	5				20,00	5,00	30,00	15,00	50,00	70,00	D	на екзамен		10	20	20	0	20,00	40,00	60,00	E	задов
Невірець І.	5	5			27,00	5,00	30,00	20,00	55,00	82,00	B	добре										
Сащук В.В.	5	5	5		34,00	5,00	30,00	н	35,00	69,00	D	на екзамен		7	20	6	0	34,00	26,00	60,00	E	задов
Приймак А.	5	5	5	5	40,00	5,00	30,00	15,00	50,00	90,00	A	відм										
Касянчук О.	5	5	5		34,00	5,00	22,00	20,00	47,00	81,00	C	добре										
Марчук А.	5	5		н	27,00	0,00	23,00	20,00	43,00	70,00	D	на екзамен		1	20	10	3	27,00	33,00	60,00	E	задов
Михальчук Я.	5	5	5		34,00	5,00	25,00	30,00	60,00	94,00	A	відм										
Гордійчук Г.	5	5	5		34,00	5,00	30,00	30,00	65,00	99,00	A	відм										
Веремко Ю.	5	5			27,00	5,00	30,00	20,00	55,00	82,00	B	добре										
Максимум	5	5	5	5	40,00	<5	30	30	60	100					20	20	20	40	60	100		
	02.10.2019	09.10.2019	16.10.2019	23.10.2019			23.10.2019	04.12.2019							Пит 1	Пит 2	Пр.з					

Figure 3: The fragment of the digital journal, created with MS Excel spreadsheets.

an example of a teacher site. It is used for organizing distance studying courses during several years [53]. This web-site is simple and it was developed using Internet-services only, without any IDEs. Any lecturer (or teacher) may choose such a web-site or to develop it by himself and work with it, using browsers only.

In the first stages, we used Microsoft cloud services (Docs in particular) to create Web-site for our student users. However, Docs was discontinued in 2018 so we used Google Sites which has more design options and ease of use. One may consider using Microsoft SharePoint [55] or blog platforms, etc. Based on the technical experience and skills of a particular lecturer or teacher.

The structure can be organized in the following way:

1. Information about the teacher with contact data and other details, required for students and for colleagues, guests, others as well.
2. Sections by specialties, academic groups, subgroups. These sections contain links to electronic journals (stored in OneDrive), links to learning materials: lectures' contents, literature, subfolders with data for practical tasks (instructions, tasks, software, lists of questions for test or exam, links to useful resources) (stored in Google Drive or Mega.nz), links to available storage to submit completed tasks, completed tasks' contents, links to messaging platforms to discuss and get a consultation for a specific course, or specific academic group.
3. The section about research theses. It highlights subsections for abstracts, course works, diploma, and master research. After that, it contains a list of hyperlinks to examples and templates of documentation for research representation; requirements for research works;

list of available research subjects; previous years research works archive; destination folder with write access where students can upload their research results in electronic form (Google Drive, Mega.nz).
4. The section about different practicums: internship, pedagogical, graduate – and again with hyperlinks to tasks, documentation, examples, assignments upload forms, etc.
5. Section for lecturer's personal documentation, which is not accessible to students, but is visible to colleagues and management, and contains educational curricula, training reports and other document flow elements (Google Drive, Mega.nz).
6. News section. It may contain news subsections designed for specific branches, or academic groups.
7. Other sections, which may exist based on the requirements of a specific lecturer or course.

General system's scheme represented in figure 4.

According to the scheme above the system works in such a way. Lecturer loads the operating system and uses File Explorer (or any other convenient file management application) (1) to manipulate files and their contents, read and edit files in a local folder, synchronized with OneDrive storage (7). OneDrive application (5) must be installed in the OS. The office suite MS Office (2) is used for editing content of files in folders. But OneDrive app (6) is also needed for automatically synchronizing with cloud storage OneDrive (7).

Lecturer is able to set the synchronization type (interaction of this cloud storage with the office suite (8)) by changing the setting of OneDrive application (3). Also it is possible to manipulate by the storage using only web-browser (4, 9). It is able to give access to files and folders, to create hyperlinks, that may be used developing the teacher web-site (figure 5).

Also using web-browser the teacher fills other cloud storages (10), arranges these storages, creates hyperlinks and creates access permissions. Web-browser is the basic application in developing teacher web-site (based on hyperlinks created earlier), using Google Site (11, 12). Ant the student is able to use any web-browser to get the access to materials and resources placed in cloud storages and additional resources (e-mails, invitations to messengers, ets.) (13).

This scheme is extendable: add other resources, storages, services by adding corresponding hyperlinks on the web-site and depends on the lecturer's technical skills. For example, it could be Google Classroom courses, Moodle distance learning courses [56], but these do not belong to the typical user's tools spectrum.

Once in a while a need arises to perform backups, which could be done easily with the OneDrive folder synchronization feature. For other cloud platforms, dedicated synchronization software could be used, but it shouldn't be running permanently to save network traffic. It is possible to create a similar system based on the other operating systems. But the possibilities of such a system, its convenience and functionality depends on the components' integration degree into the system.

4. Conclusions

Our proposed conception to build workspace for teachers or lecturers is based on typical software and hardware components which is already used by typical user and doesn't require

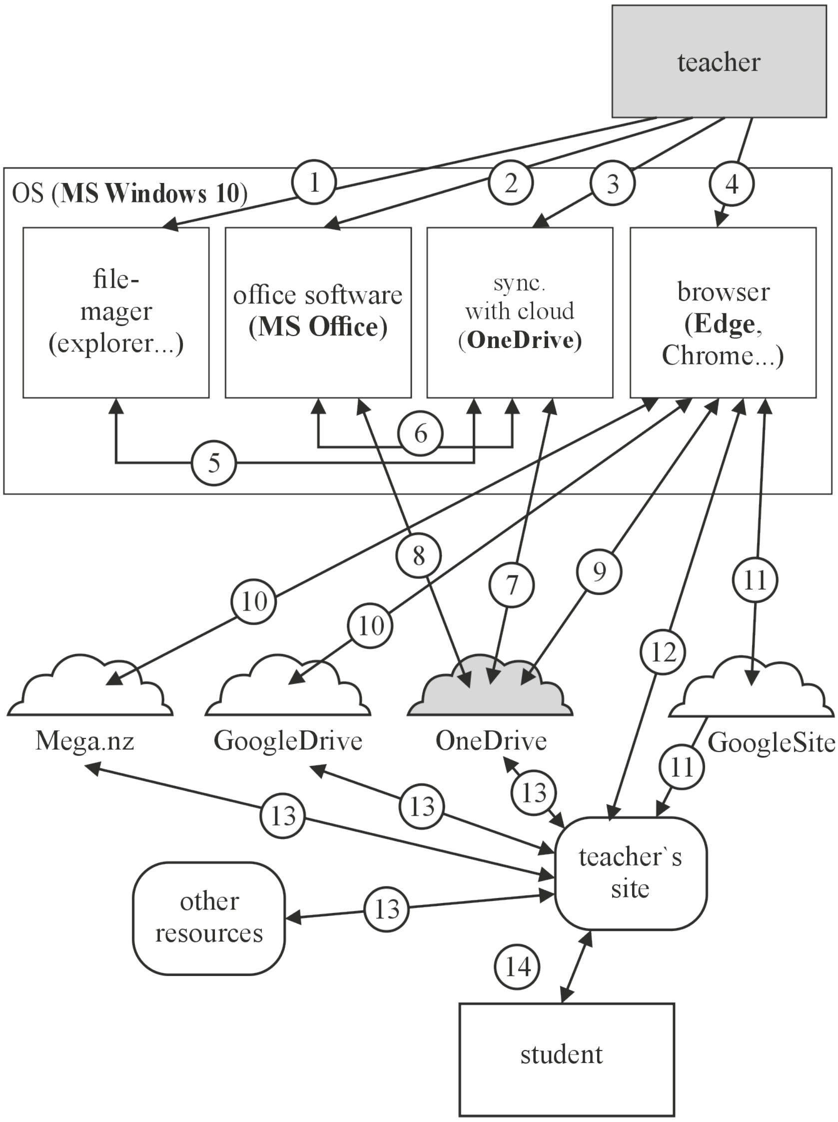
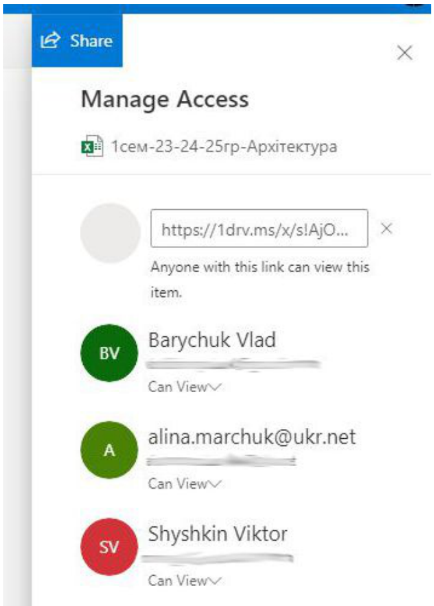
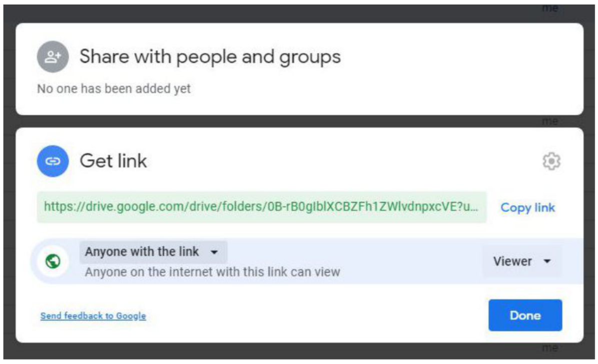


Figure 4: The fragment of the digital journal, created with MsExcel spreadsheets.

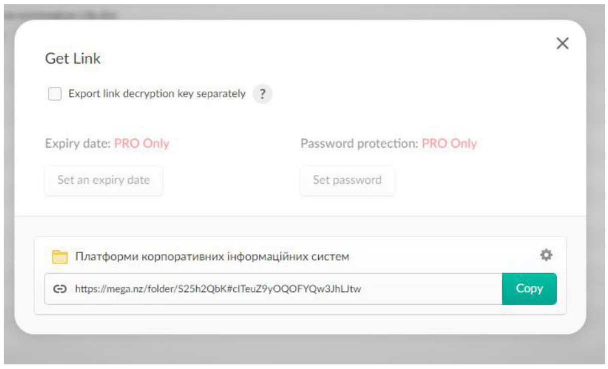
specialized components, designed for this purpose. However, if there is such a requirement, it's easy to include additional components into the system by adding corresponding hyperlinks, installation of corresponding software components and usage of special user interfaces. If a lecturer has all the necessary didactic materials for completing the distance course, he is able to create it, and doesn't spend the time studying to use specialized software, just using possibilities of the operating system. Such a system can be used by lectures and teachers to make their teaching activities during regular classes and for distance education. The system is scalable and easy to deploy and to implement. Of course, such a system doesn't have the online experience, but in exceptional cases, Microsoft 365 could be used, but with worse effectiveness and ease of



OneDrive



GoogleDrive



Mega.nz

Figure 5: Examples of how to create hyperlinks into resources hosted in OneDrive, GoogleDrive, Mega.nz.

use.

The system could be used in the initial phases of adaptation by non-experienced teachers, including phases of migration to the remote or mixed educational process. The system is easy to set up, learn, implement, but cannot be used as a single educational platform and should be considered the initial phase before switching to specialized educational platforms, which provide more features for students, teachers, managers.

In the future, one can make a more detailed research of teacher's digital workspace based on an operating system and public cloud services, implement more tight integration between the proposed system and specialized education platforms.

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Research on efficacy of webinars organized for faculty during lockdown of COVID-19

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Abstract

Online Faculty Development Programs/Webinars are the two buzzing words, which have become viral next to corona among the teaching fraternity during the lockdown period of pandemic situation caused by COVID-19. This work intends to throw light on, the reason for the outbreak of FDPs/ Webinars, their efficiency and the attitude of the participating faculty during the lockdown period from 16th March to 15th June 20. Information is gathered through an online survey having 31 research questions answered by 683 participants across India. The new found tool of online teaching has become the accepted norm and the urge to lead the bandwagon by each and every stakeholder in the education sector resulted in a sudden spurt of webinars and FDPs in such a short period. Study observed that global reach at no cost plus freedom of working from home spurred many faculty to experiment this mode and 40% from them have been found to be juggling with many courses simultaneously for certificate sake only, 45.1% attended on mandatory instructions and 38% have not even initiated the work. Quizzes and Polls during sessions besides assignments were found to be suitable active learning mechanisms to improve the efficacy of the online knowledge transfer methods.

1. Introduction

In the current dynamically trending disruptive technological world, it is essential to possess relevant skills, in tune with the changes in learning environment. However, nobody expected that the life in this world as it enters 2020 will be disrupted by a nano sized virus called corona, so violently that the World Health Organization (WHO) declared Corona Virus Induced Disease, COVID-19 as a pandemic. Initial measures to contain the spread of virus had resulted in compulsory lockdown across various parts of Globe and across India from 22 March 2020. The compulsion to be home bound in the lockdown coupled with the uncertainty in the minds of regulators in education domain in rescheduling academic calendar, has provided ample free time to faculty and students to learn through the only available medium i.e. online mode.

Stakeholders, including regulators like AICTE, respective state higher education wings, premier institutions like IITs, NITs, industry associations like CII, NASCOM, software, hardware industries, edutech companies and all professional institutions have offered FDPs (Faculty Development Programmes) and webinars on all topics. The most sought after besides subject are

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the domains related to Research and Patenting, Industry 4.0 technologies, pedagogical changes, future of education and industry incase pandemic situation persists for longer periods. Thus there has been a sudden spurt in this activity across the nation and luring the participants with digital certificates with no registration fees to attract wider participation. All the presentation platforms, hitherto, commonly used by the industry especially by the software industry for discussions across their onshore, offshore teams, have entered the homes of all teaching faculty. Digital migrants also joined the fray with the digital natives to teach as well as learn. The student in the faculty has woken up and is exposed to sudden spurt of activities. This lead to pertinent questions about the efficacy of these activities including motive of the participants and problems faced. The answers could add to the smooth introduction of new normal procedure of online mode of information dissemination.

2. Background and motivation

There is a lot of literature available on online mode of teaching used for academics to find the learning effectiveness at various levels of schools, higher technical education or universities with much focus at students' perception. Not much work is published on effectiveness of delivering short courses through FDPs and seminars via web called webinars with the audience being teaching faculty. "A systematic search of the research literature from 1996 through July 2008 identified more than a thousand empirical studies of online learning. Analysts screened these studies to find those that a) contrasted an online to a face-to-face (F2F) condition, b) measured student learning outcomes, c) used a rigorous research design, and d) provided adequate information to calculate an effect size" [1]. One can find works comparing students reading achievements through online and off line modes in article by Setyawan [2]. In the work carried out by the Baig [3], researcher tried to prove the effectiveness of Online Learning Environment (OLE). The experiment was carried out targeting school children of tenth standard, where in the effective learning of students in the subject of Physics in OLE and F2F is evaluated and proved that on line teaching is more effective if done with animations, videos with high interactivity that motivates context of learning. The experimentation was done considering 40 students of which 20 were subjected to get trained in online mode and 20 were trained using Face 2 Face mechanism. Where as in the work done by Pusuluri Srihari [4], 88 engineering and English course students' perception was considered and it was identified as most of the students prefer only 30% online and 70% Face to Face teaching in blended learning. The researchers interested in this area can also see work by Chen and Guthrie [5]

An interesting experiment was conducted by Madhavi et al [6] where 5000 engineering students and 320 faculties were probed to identify the importance of Learning Management System-Moodle and ICT practice in TLP. The acceptance of GRIET-Moodle was identified using adapted Technological Acceptance Model (TAM) in their study. Lall and Sing [7] through their study on 200 students of Graphic Era Hill University – Uttarakand, report that 74% of their respondents were enjoying e-learning. The above mentioned works motivated authors of this paper to carry out research in the area of on-line teaching learning environment and in contrary to the above experimental situations of students and small samples considered, the authors choose to study the efficacy of digital environment based knowledge transfer in case of large number of faculty attending webinars, FDPs where personal interaction of resource person with all individual participants is highly impossible.

3. Proposed work

With the intention to support teachers understand pain points of participants as well as get insights of multitude and myriad problems prevalent in the field of online education, authors proposed to conduct an online survey to check for efficacy of online FDPs and Webinars for faculty of different colleges across India.

An online survey was developed using Google Forms and is rolled out with 31 questions pertaining to different dimensions of the problem. Authors were jubilant to see 683 faculty responding to the survey till the time of write up. The target group comprised of the faculty mainly from engineering colleges and a few from degree colleges. https://tinyurl.com/yajye9cv was the survey link, which was shared using emails and WhatsApp groups.

3.1. Demographic analysis and duration considered for survey data

For the demographics, data collected is limited to Location, State, and Age. The anonymity was promised to respondents to make them feel comfortable in giving unbiased response. Authors are happy to note that the respondents' representation is from pan India, making it possible to get inputs from participants of different mindsets. The age group of respondents ranged from 22 to 67 years, which enabled us to get inputs from fresh faculty members to richly experienced people of field as participant.

Focus was on the period of lockdown, as rate of conduction and attending to online FDPs/webinars was high in that duration. Hence the respondents were asked to furnish the information pertaining to the three month interval from 16th March to 15th June 2020.

3.2. Categories of research questions

In order to understand the efficacy of the FDPs and webinars during the considered period from the point of view of the faculty who are learning, it is necessary to analyze the status of the learner in all aspects of teaching-learning in addition to their physical, mental and financial status. These aspects are categorized so as to develop appropriate Research Questions (RQs) as elaborated below:

a) Online Teaching Learning Process Effectiveness
b) Intention of Participant
c) Health/Household Impediments
d) Online Platform Effectiveness
e) Device and Service Provider Support
f) Financial Aspect

RQs are meticulously structured to get unbiased and definite information and are optimized to 31 in number, so that the time spent by the respondents for the survey is also reasonably low.

Category wise RQs, along with the survey data and their analysis are elaborated in the following section.

4. Results and discussion

4.1. Online TLP effectiveness

In general, faculty are expected to attend at least one FDP and a couple of webinars in a semester, but the spurt in activities have attracted nearly fifty percent of the respondents to attend 10 or more in the short period of three months as evident from data received and summarized in table 1 for RQ1, making them to be attempting multiple sessions on the same day. This is corroborated by RQ2 shown in table 1, that nearly 50% are anxious about losing concepts due to divided attention. The overdose of information however did have a positive impact of majority initiated to effectively put the new knowledge into practice. This is evident by RQ3 data as shown in table 1, as only 38.5% of participants have not yet initiated their work in the direction of concepts discussed in the sessions. One of the reasons for not initiating could be due to absence of involvement of participant during the session, which is indirectly supported by the data of RQ4 as recorded in table 1, that around 28.8% of participants either never or rarely raised doubts in sessions. The self involvement of participant also gets reflected in the confidence with which the participant solves on their own a Quiz/Assignments given post the session and the same is probed with RQ5 and surprisingly only 44.5% respondents as observed from figure 1, confess that quiz/assignment solutions were never shared among friends, with approx.55% accepting to share the solutions among the peers.

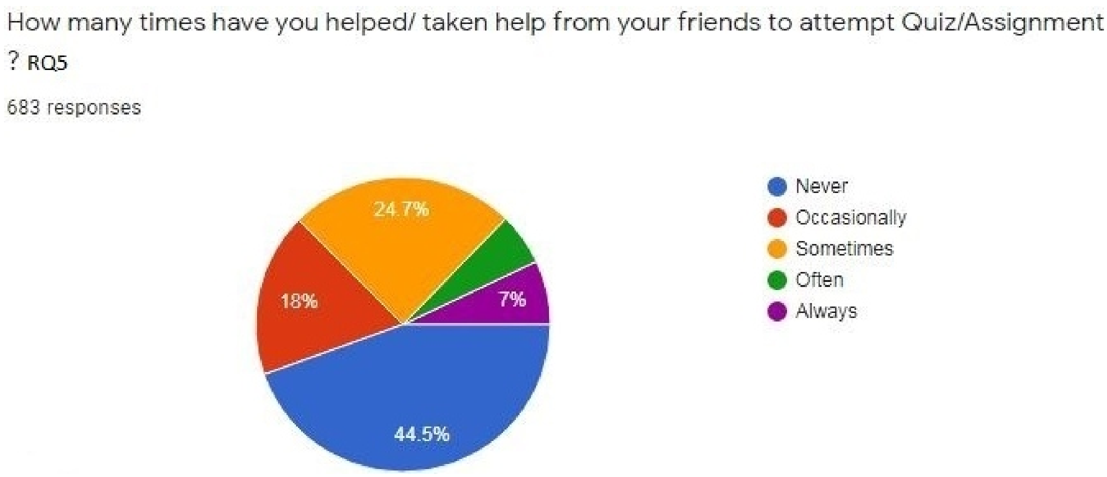

Figure 1: Analysis of respondents' data for RQ5.

A participant of online sessions has to respect the honor code and refrain from copying or sharing answers with/from others else can indicate that participants haven't learnt effectively in online mode. This observation once again unearths the caveat that majority of participants are not taking assignments given after the session seriously but taking help from others in

Table 1
Respondents' data for RQ1-RQ10 (excluding RQ5)

RQ1. How many webinars and/or FDPs you attended during lockdown period using Digital platform? Approximate number.					
Option Response in %	1-5 15.7	5-10 21.4	10-20 28.8	20-30 22.4	>30 11.7
RQ2. How many times you were anxious of loosing subject concepts being delivered in one session as you are listening side by side to another session at that moment?					
Options Response in %	Never 41.4	Sometimes 46.3	Quite Often 7	All Sessions attended 5.3	
RQ3. Have you practiced/implemented/ developed/adopted concepts discussed during any session you attended?					
Options Response in %	Not Yet 23.1	Initiated 61.5	Need more training 15.4		
RQ4. How many times you raised the hand for doubts/questions?					
Options Response in %	Sometimes 56.3	Regularly 15.8	Rarely 21.7	Never raised the hand 6.2	
RQ6. Have you categorically maintained all the information sources like PPTs/Recorded links shared to you for the sessions you attended?					
Options Response in %	Yes 82.1	No 17.9			
RQ7. Which of the following methods can maximize the efficacy of online sessions?					
Options Response in %	None 13.5	Assignment 19.9	Poll Questions 29.3	Quiz 47.3	
RQ8. What is the optimum duration you think an on line webinar/FDP session should be without break and excluding Q&A session?					
Options Response in %	45 min 45.1	60min 34.6	90min 15.1	120min 5.2	
RQ9. What is the maximum number of days an online FDP should be conducted, as per your opinion?					
Options Response in %	2-Week 2.9	1-Day 5.8	2-Day 8.9	3-Day 24.3	
RQ10. In summary, what is the utility of online courses during lock down?					
Options Response in %	Yes,100% useful 60.3	Yes, Somewhat Useful 38.1	No, This format is not useful 9.6		

completion of same affecting the overall learning in online mode, the same has also been observed by the respondents' data for RQ7 as recorded in table 1, asserting that Assignments are less preferred way to improve the overall efficacy of online FDP/Webinar and suggested Quiz (47.3%) followed by Poll Questions (29.3%) during session to improve the overall efficacy. However, the positive side of coin lies in the fact observed by analyzing responses of RQ6 mentioned in table 1, where in 82.1% of participants has categorically maintained the shared content like PPTs/Datasets/Recorded versions of session so as to enable them to refer back again. With the advent of disrupting technologies, it is evident that concentration levels of human being are drastically reducing day by day and too long session of around 120 min doesn't permit the participant to gain much. The same can be observed from the data of RQ8 recorded in table 1, where only 5.2% suggesting the effective duration of webinar session without a break could be as 120 min. whereas 45.1% has opted for 45 min. as optimum time duration. Also, in the opinion of participants, the duration of FDP in days is not expected to exceed one week as evident by the analysis of data for RQ9 shown in table 1, exhibiting 58.1% opting for 1-week long FDP and another 24.3% have supported for conducting 3 day FDP. It's encouraging to see from the data analysis in table 1 having data for RQ10; around 60% of participants feel the overall utility of online courses during lock down is 100% useful. Yet, a good 39% of participants feel it is somewhat useful or a minor part as this format is not useful indicating scope of improvement in this format to enhance efficacy of online sessions being held.

4.2. Intention of participant

Though the sudden rise of online activities have given ample chance to attend, yet multiple sessions being attended by any participant on a single day will leave the participants in a confusing state than helping in gaining knowledge and also too many online sessions on a single day indicate the greediness of the participant to gain more certificates. The analysis of data from table 2 for RQ11 shows that 87.5% of respondents have attended maximum three webinars or online sessions on a single day, which is quite comfortable for a learner to acquire knowledge or concentrate on online session on a single day. The question would be whether they attended sessions one after other or logged in to multiple sessions in which case the efficacy of learning drastically goes down.

Logging in to too many sessions at once using multiple devices or attending too many webinars in short span only precipitates intention of bagging a certificate rather than knowledge. RQ12, RQ13, RQ17 & RQ19 try to address this issue. The data of respondents for RQ12 shown in table 2 straight away points that only 43.3% of respondents were having self policing and limited themselves to login in to only single online session at a given time. The data projects that greater than half of respondents (56%) logged in into multiple online classes using different digital platforms using same or different devices, raising a strong point on efficacy of online sessions being held in identifying whether participant is there for certificate sake or showing keen interest in assimilation of concepts being delivered. This does warrant need of some mechanisms to stop such lapse. RQ13 helps us to identify from the data shared by respondents; only 33.4% have chosen the option of always single platform as depicted in figure 2. In the sense, around 67.6% respondents have chose to attend sessions simultaneously that can lead to a deep nose dive in the content assimilation of what is being discussed in the online sessions attended side by side.

Table 2
Analysis of respondents' data for RQ11, RQ12, RQ14, RQ16, RQ19, RQ20

RQ11. What is the maximum number of webinars and/ or FDP sessions you attended on a single day?					
Options	1	2	3	>3	
Response in %	19.8	41.1	26.6	12.5	
RQ12. How many times you logged in into multiple online classes at once using different digital platforms (on same or different device)?					
Options	0	Not more than 3 times	Some times	Quite often	
Response in %	43.3	16.7	30.3	9.7	
RQ14. What % of overall webinars/FDPs you attended, do you think are completely relevant to or interesting topic of your choice?					
Options	0	20	40	80	100
Response in %	0.7	7.8	17.3	57.1	17.1
RQ16. Do you feel you are over burdened with webinars/FDPs during this period?					
Options	Definitely Overburdened	Somewhat over burdened	No, enjoyed		
Response in %	10.1	40.1	49.8		
RQ19. Mention number of on-line sessions you attended where participation certificate was not offered__					
Options	0	Only 1	Between 1 to 5	Between 5-10	
Response in %	26.1	18.7	43.2	12	
RQ20. Do you really think the certificate you earned by attending online webinars/FDPs during lock down period helps you in future?					
Options	Yes	No	Don't bother me		
Responses in %	77.2	8.8	14		

The data for RQ17 as depicted in figure 4 shows on an average each respondent has got around 20 certificates and the values for certificates gained by each respondent range from 0 to 200. It is observed around 24 people who received more than 75 certificates. 39 respondents received more than 50 certificates and 114 respondents mentioned they received more than 30 certificates during the observation period. Even if we consider the total days of duration excluding weekends, it comes to be around 67 days. In 67 days, advisably one can cover a maximum of 13, 5 day FDPs. We observe from the data of table 2 for RQ19, that only 26.1% of candidates have attended in range of 5 to 10 sessions that did not offer certificates and around 73% of respondents have attended in range of 0 to 5 sessions which did not offer a certificate, irrespective of speaker, organization conducting, or the topic of session. The count of certificates obtained by respondents does hint that certificate was a major driving force for individuals to attend sessions and also people seem to be engaged in a race to collect more certificates for myriad reasons. We can just imagine the number of people, who would attend if all the webinars conducted during lockdown period had not offered a certificate!

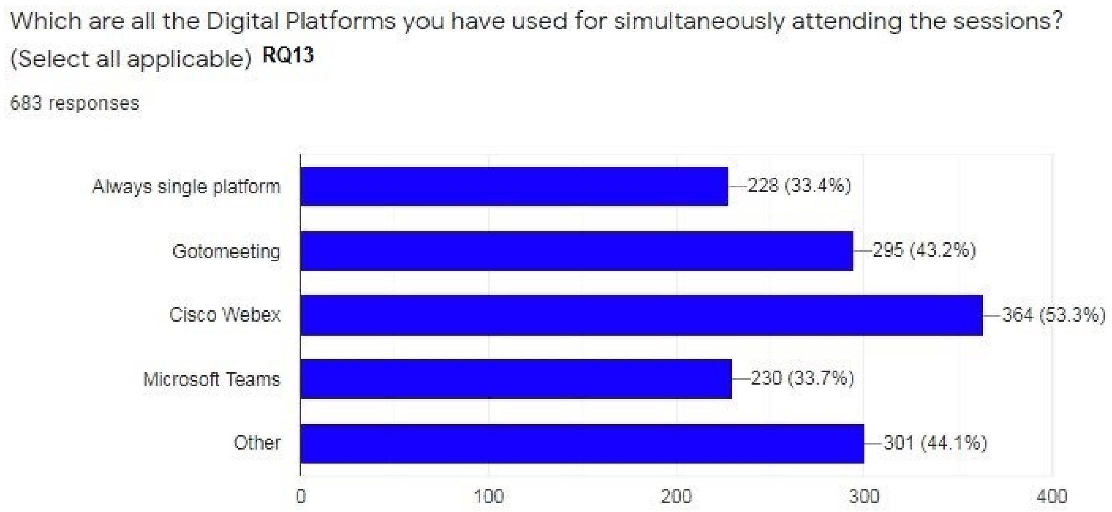

Figure 2: Analysis of respondents' data for RQ13.

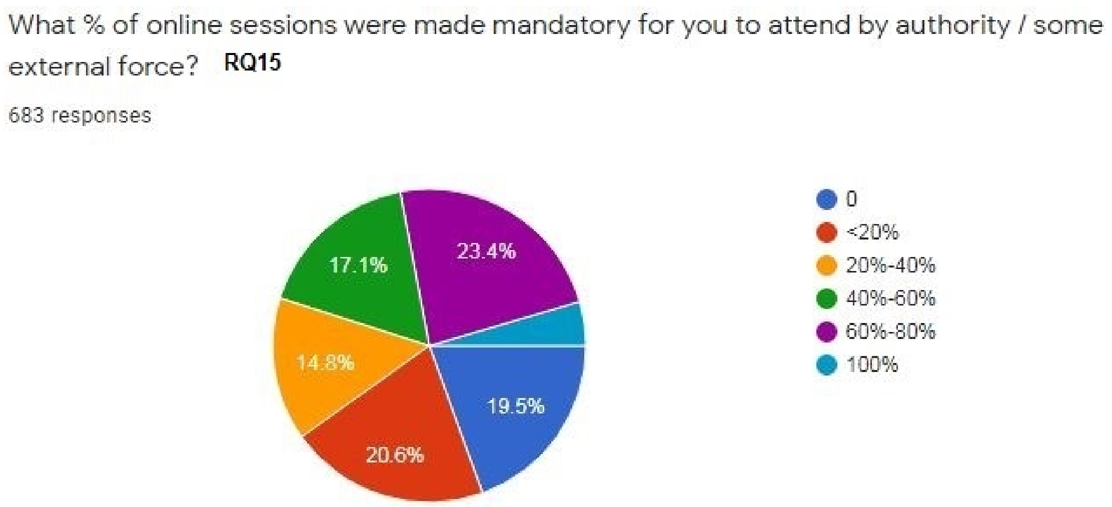

Figure 3: Analysis of respondents' data for RQ15.

The data gathered as shown in table 2 for RQ14, it can be observed that around 74.2% of overall respondents have attended in range of 80%- 100% of online sessions relevant or interested topic of their choice. This also indicates that around 26%, i.e. almost quarter of respondent confess that majority of sessions they attended were not of their choice of interest or relevant in which case the degree of knowledge gain can be assumed to be very less, raising a question on online session's efficacy once again. The data collected for RQ15 unearths a raw fact that great number of people are attending the online session out of compulsion from some external force but not voluntarily. From the collected responses shown in figure 3, it was evident that around

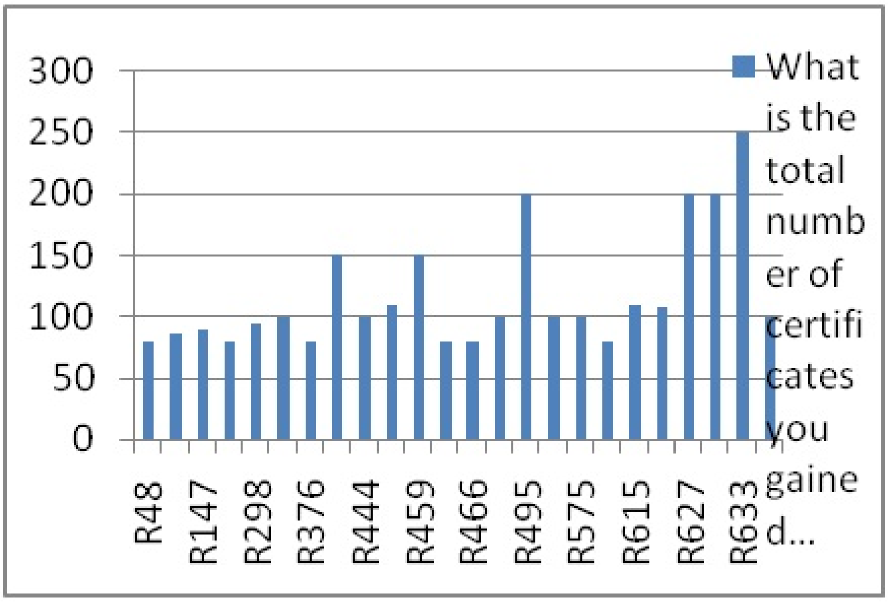

Figure 4: Analysis of respondents' data for RQ17 with respondents being represented as R1 to R683 on X-axis and number of certificates each one obtained on Y-axis.

30% of respondents confess that in range of 60-100% out of total sessions they attended were on some compulsive force. In such case the learning factor of the candidate can be expected to be very low or even for name and certificate sake the candidates might have logged in. Only 19.5% of respondents feel that 0% of their total sessions attended were made mandatory and a fraction of approx. 7% respondents confess that 100% of all sessions they attended were because they were made mandatory by some external force. From the table 2 data for RQ16, the response for this question is almost evenly distributed with "No, enjoyed" option being opted by 49.8%, which is almost 50% and remaining 50% consider they are somewhat over burdened with webinars or online FDPs. This response does open horizons for interested researcher to explore TLP so as to reduce the mental stress of participants and make them free from the feeling of *somewhat overburdened or Definitely overburdened.*

It is very clearly visible from the figure 5 for data of RQ18, that Research and Patenting sessions were most sought after sessions for maximum participants other than technical topics in the process of holistic approach of knowledge gaining. Quality related sessions pertaining to NBA, NAAC procedures etc were next in demand, where participants were keen to attend. The value perception of certificate by the respondent would bring in more interest for participating candidate and enhance involved learning by the participant. The respondents' data for RQ20 showed in table 2, once again emphasis on the importance of certificate in their view point. It could be observed that a total of 77.2% of respondents feel the certificate they earned would fetch them some returns in near future. There are only fractions of approx. 14% of respondents who are not bothered whether the certificate they gained is helpful or not on future but it is for the sake of knowledge gaining and honing their skills they attended online sessions.

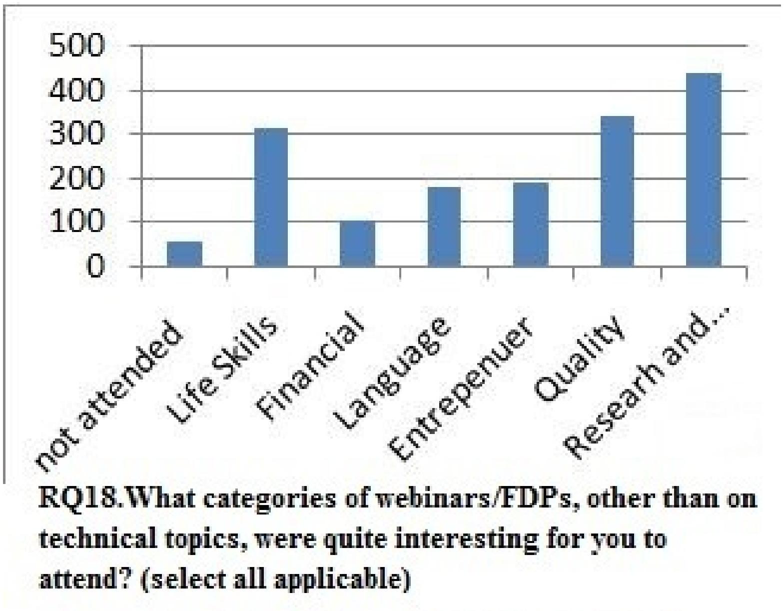

Figure 5: Analysis of respondents' data for RQ18.

4.3. Health/household impediments

It is a known fact that a healthy, calm mind can concentrate on the session, apply his thought process in gaining more insights of the subject as well as participate actively in solving quiz or assignment etc tasks. The analysis of data received for RQ21 through survey as depicted in figure 6, points out that majority of people are suffering with one or more ailments owing to continuous screen exposure and a good 53.3% of respondents have mentioned they suffered Eye pain and putting it on top of health concerns that can arise because of too many online sessions, The problem of headache was next to eye pain with 306 out of 683 respondents claiming they suffered with the problem. In the decreasing order of maximum respondents facing problem the issues can be listed as Eye pain, headache followed by Neck pain and Back pain almost being reported by same number of respondents. The authors opine that dwindled efficacy of online TLP is possible once participant feels sick that distracts the concentration. Hence this issue needs further consideration by researchers of Human Computer Interaction field.

Majority of the respondents opine that Home is suitable place to attend online webinars/FDPs, where as approx. 35% respondents feel both home and Office are effective in attending the online sessions as observed in the table 3 having data of RQ22. It is observed from the table 3 of data for RQ23 that a good 41.6% of respondents were able to concentrate throughout the session despite chaotic pandemic situations at home but that leaves around 58% of respondents who could not concentrate on session at a stretch owing to issues at home front. In this 58%, 25% were able to concentrate for about 50 min. This analysis once again points out the requirement of smaller online sessions at a stretch.

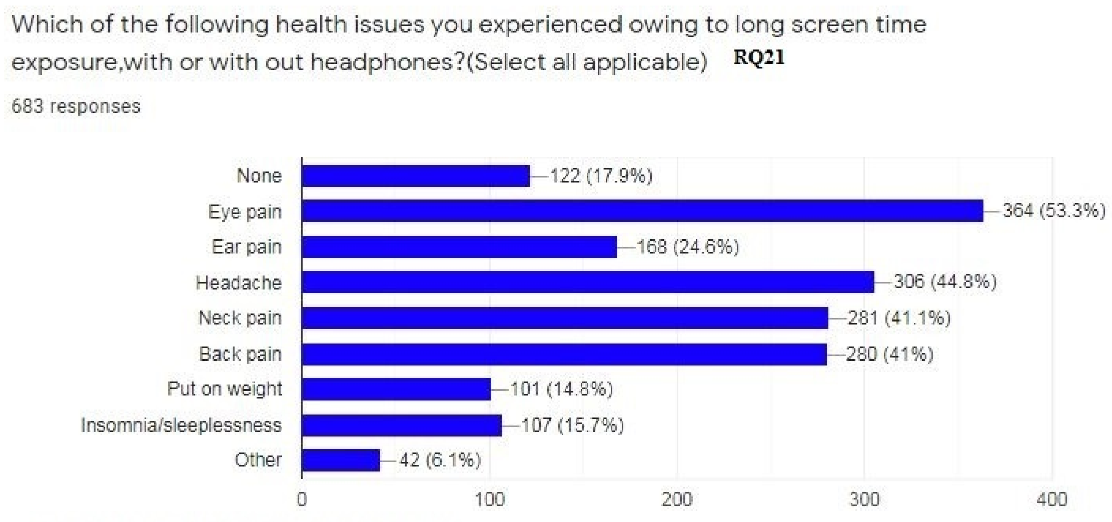

Figure 6: Analysis of respondents' data for RQ21.

Table 3
Analysis of respondents' data for RQ22, RQ23

RQ22. Specify your location preference for attending the Webinar/FDP?				
Options	Home	Work Place	Both are effective	Both are ineffective
Response in %	48.8	11.6	38.5	2.1
RQ23. How long you were able to concentrate at a stretch on any session attended?				
Options	50min	45min	30min	Throughout the session
Response in %	25	19.2	14.2	41.6

Table 4
Analysis of respondents' data for RQ26

RQ26. Which device you generally prefer to use for attending online sessions?				
Options	Smart Phone	Laptop	Tablet	Desktop
Response in %	46.6	46.7	6.7	

4.4. Online platform effectiveness

Choice of Digital Platform is the prerogative of organizers, but user experience is sought from the learners on various platforms. The ease of usage of any platform does act as a hygiene factor that, its absence readily felt in promoting ineffectiveness of the entire proceedings. Data received for RQ24& RQ25 from the respondents as shown in the figure 7 and figure 8 respectively points out that, in spite of concerns, majority of respondent preferred ZOOM platform (51.7%) to attend sessions. Cisco-Webex(21.7%) was next sought after platform by many organizers in conducting online sessions. Similar observation can be done in the work of Sreehari [4].

Table 5
Analysis of respondents' data for RQ30

RQ30. How many online sessions pertaining to your area of interest/research have you registered for which there was a nominal registration fee of say Rs.100/- or Rs.200/- or more, during this lock down period?					
Options	0	1	2	3	>3
Response in %	30.2	18.6	22.4	11.9	17

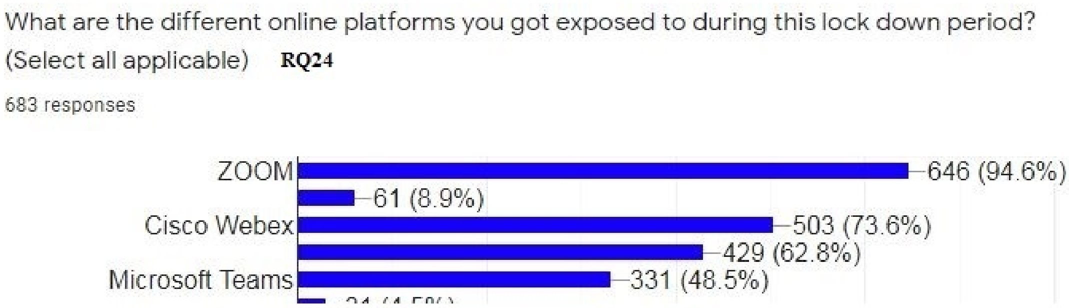

Figure 7: Analysis of respondents' data for RQ24.

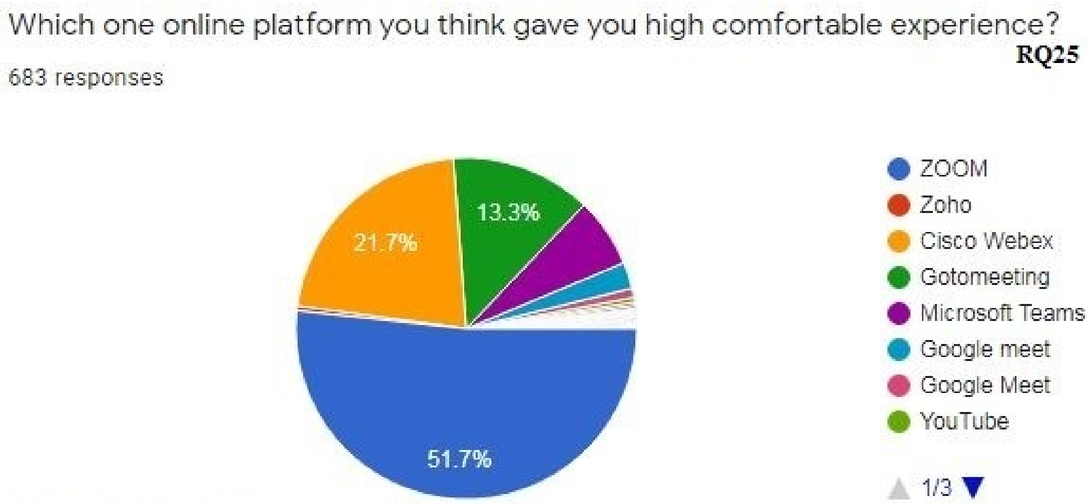

Figure 8: Analysis of respondents' data for RQ25.

4.5. Device and service provider support

The receiving or/and concentration levels of a participant in case of online sessions would be highly dependent on the comfortable display screen and audio output mechanisms the opted device is providing. RQ26 has a focal point on this aspect. The data by respondents for RQ26 gets categorized almost equally between Laptop and Smart Phone with only a minor percentage of people opting for Desktop and a very small percentage opting for Tablet as can be observed from table 4. The choice of Smart Phone by 46.6% does have a say on the health issues observed earlier and also 46.7% respondents using Laptop also adds to it, suggesting avoidance of these 6” or less screen device so as to reduce health effects that can further have a say on overall concentration of participant of online session.

Network quality is the next major hygiene factor, that its absence will immediately break the continuity in reception and hence concentration of the learner. The RQ27 focuses on the pains respondent proactively has taken to continue learning despite of blockages owing to network issues. The data collected for RQ27 needed cleansing as many respondents did not mention the service provider name. Authors received only 385 responses which clearly mentioned the name of service provider or respondent has faced no issue related to service. The analysis of available data is depicted in the figure 9.

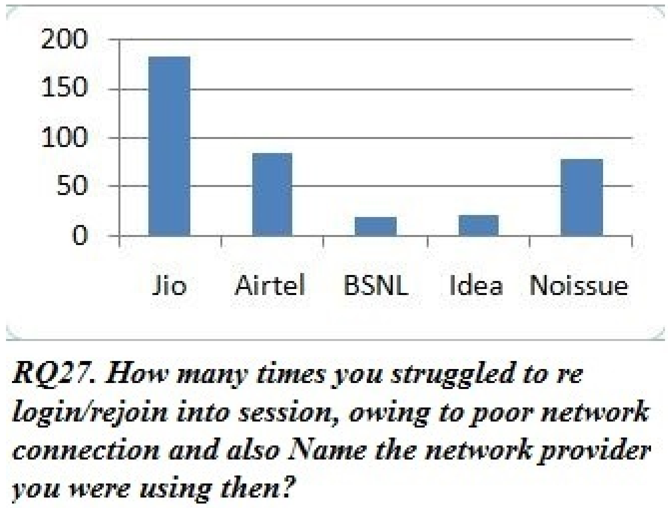

Figure 9: Analysis of respondents’ data for RQ27 considering only 385, those who mentioned the name of service provider or no issue.

The authors hope respective network service provider takes this as a respectable opinion of respondents so that some corrective measures can be done in improving network issues, which in turn can improve the TLP without intermittent service. It is very encouraging to see from respondents’ data for RQ28 as depicted in Figure 10 below, that around 243 people have mentioned as 0 times they lost the session due to Limited Data Plan being Used but that comes to be only 35% of total respondents, which means around 65% of people have faced data limit problems and lost session ranging from 1 time to multiple times. This issue needs to be addressed and we hope Data providers would come out with an economical data plans for online webinars and FDPs interested candidates without causing much financial burden to participant.

4.6. Financial aspect: willingness to pay/spend

RQ29 of survey, aiming to know the money spent for rectifying repairs/ buying a device/ spending a small registration amount of not more than Rs.500/-, to attend online sessions in

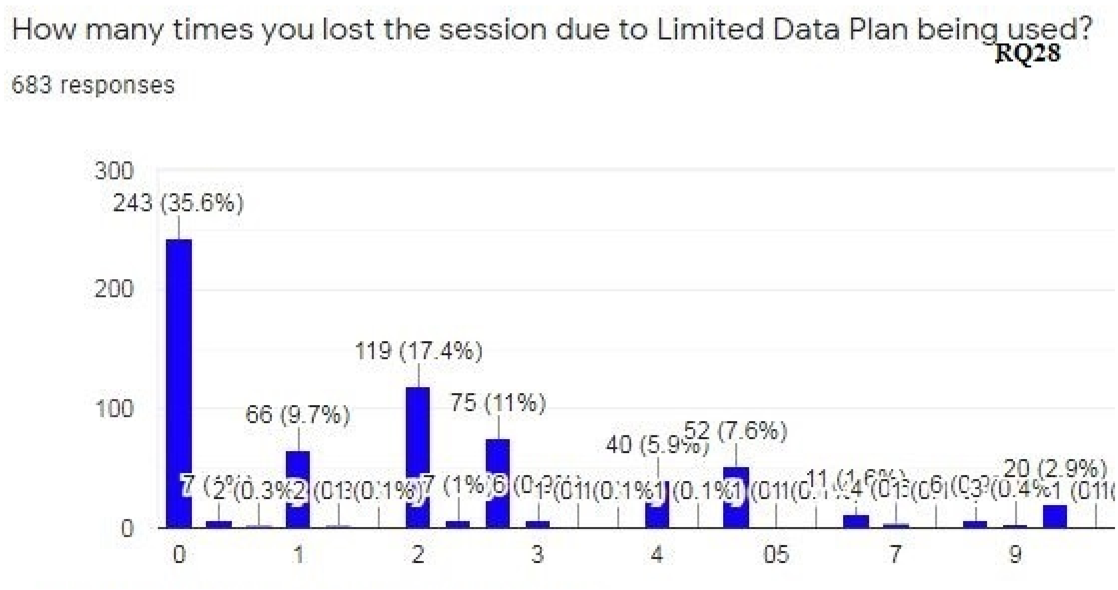

Figure 10: Analysis of respondents' data for RQ28.

process of skill enhancement helps us in knowing that average amount spent by respondents as shown in figure 11, stands at Rs.3130.43 with a small set of outlier cases where respondents have mentioned of spending around Rs.10000/-. This is really appreciable point on the part of faculty fraternity as during lockdown period the income sources were much dysfunctional. As per the data collected a whooping amount of Rs 2,138,090/- in total has been pumped in to lockdown market by 683 teaching fraternity to enable them to attend online FDPs/Webinars.

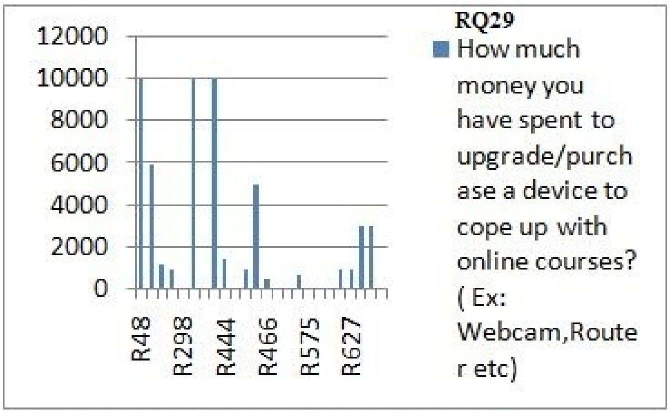

Figure 11: Analysis of respondents' data for RQ29.

It is a point of concern that from data for RQ30 shown in Table 5 below, 30% of the respondents has confessed that they never (0 times) registered for an event with nominal fee even though it fit in to the area of interest, despite in certain cases the sessions were conducted by organizations like NITT, NITs during the period considered. Only 17% of the total respondents mentioned as, they attended more than 3 such events by paying nominal registration fee. The average amount spent for data recharges by each respondent to attend online webinars/FDPs, as evident from the data submitted in survey for RQ31, comes to be Rs.1306.99/-. The authors did observe a single outlier case of Rs.10000/- being spent as depicted in figure 12.

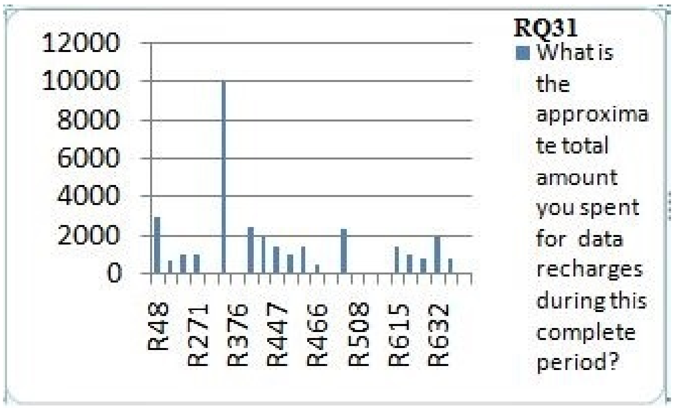

Figure 12: Analysis of respondents' data for RQ31.

4.7. Major observations

From the above analysis the following major observations were made:

- Participants feel Pools and Quiz would improve efficacy of online sessions. (RQ7)
- Many participants are not confident to start work with the concepts learning through online. (RQ3 – 38%)
- Participants are juggling by attending sessions parallel. (RQ2 – 58.6%, RQ12 – 40%)
- Very small fraction of participants opted to pay for Online FDPs (RQ30 – >3 – only 17%)
- Participants opine that an FDP or webinar is best to be for 50 min and can be organized for 1 week. (RQ&RQ9)
- 25% of participants opine they have attended irrelevant sessions but received certificate. (RQ14)
- 45.1% of respondents have attended majority of sessions on mandatory instructions. (RQ15)
- 50.2% of respondents opine either they are somewhat or definitely overburdened by webinars. (RQ16)
- Around 490 participants out of 683 respondents have opted to attend Research and Patents related sessions besides Technical sessions. (RQ18)
- 45% of respondents haven't shown interest to attend sessions which doesn't offer certificate. (RQ19)
- Around 53.3% respondents have complained of Eye pain. (RQ21)

Based on the analysis made above for all questions and the strapping results observed, the authors would like to advocate following mechanisms to further strengthen the efficacy of online FDP/Webinar sessions:

1. Conduction of sudden Quiz on the screen and attendance marking for those who complete the Quiz within given short stipulated time.
2. In case of FDP, besides above recommendation, small day-wise assignment based on the topics delivered on a specific day.
3. Strongly recommending participants to switch on their Video camera and once in a while during sessions it is better if the resource person picks up couple of names and address the participants by name so that everyone becomes alert.
4. Issuing of Certificate subject to clearing a final graded quiz for an FDP, which also considers day wise quiz as a part of Internal marks.
5. In case of FDPs, by 2nd or 3rd day, forming groups of participants and giving them group assignment and one hour session being dedicated to discuss which group responded, which has not submitted.
6. In a country like India where the economic levels are so varying, authorities have to make the availability of effective network at affordable costs spreading to every rural corner of the country.
7. Even the authors of this article suggest the organizers to rethink on Two Week FDPs and reschedule those as One Week FDPs with sessions of 45 min. as observed earlier so as to improve the learning factor of participants.

5. Conclusion

Culminating the analysis of data gathered from 683 respondents of different regions, backgrounds across India in this work, it is clear that on-line mode of Webinars/FDPs for working people during pandemic COVID circumstances did help in gaining a bit of skill set, but, is not completely effective as it was presumed. It was observed, respondents of around 40% were juggling with other activities, 45.1% attended on mandatory instructions and 38% have not even initiated the work, Learners still want knowledge transfer to happen free only, as only 17% are willing to pay and certificate is a sure attraction for greater participation. As online mode of teaching for students or conduction of Webinars/FDPs for faculty is indispensable in inevitable social distancing situations that can prevail further for months to come, this research work has contributed in bringing to day light the more competent mechanisms as need of hour for efficient online sessions and also suggested a few. Further this work can be extended by categorizing the respondents based on age or experience as the young faculty opinions may not agree with the digital migrant or older professionals in the field and also webinars that are to be targeted to attract fresher would vary from those targeted at more experienced professionals. The analysis can be extended based on predictive analysis approach of machine learning to cross check the results obtained in this work.

Acknowledgments

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Cloud resources use for students' project activities

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Abstract
The modern educational system proclaims learning aimed at acquiring practical skills and based on the activity approach. Educational research projects are the necessary component of curricula in physics, computer science, biology and chemistry. There is a problem of specialized equipment and facilities using for the implementation of such projects in distance learning. Therefore, the issue of cloud resources using for distance learning organization in robotics is relevant. The article presents a brief overview of the current state of projects development in Ukrainian schools and approaches used in foreign educational institutions in teaching robotics distantly. The article describes the stages of robotics projects development such as organizational, communicative, project work, summarizing. The peculiarities of the stages in distance learning and the possibilities of cloud technologies in robotics are also considered. The authors' experience in projects developing in this environment for students and future teachers is described.

Keywords
project training, cloud technologies, robotics, Tinkercad

1. Introduction

Due to the pandemic all educational institutions have to transfer the activities in online and conduct distantly [1, 2, 3, 4, 5, 6, 7]. Cloud interaction tools, especially visual communication, have become relevant. Interaction during such classes in group projects or events has its own specifics. In particular, a survey [8] conducted among 3,000 students about online learning found that most students were dissatisfied with communication during large-scale events or group projects. The authors advise not to carry out projects distantly. But the application of cloud technologies in educational activities and developing of new ways of providing, processing, producing and storing information will help develop an environment for cooperation and new projects [9, 10, 11, 12, 13, 14, 15]. Cloud technologies will transform the educational process and apply new methods and techniques taking into account the use of technologies in educational and extracurricular activities [16, 17, 18, 19, 20, 21, 22].

There are some difficulties in conducting laboratories and practical works for certain specialities. They require special equipment, facilities, devices or reagents. For example, to implement robotics projects requires electronic equipment, elements of electronic circuits. There is a problem of cloud resources using that will help students in performing laboratory and practical

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work, calculation projects in robotics.

Educational robotics is a new trend in education because it has great practical significance in the use of robots and robotic devices in the modern world. But despite the benefits of robotics classes, there is still no consensus on its place in the education system. Some teachers implement it in the educational process and use it directly in lessons. Some schools create facultative (courses) classes in robotics. Extracurricular robotics classes in the non-formal education system have become popular in Ukraine. There is no such separate subject as robotics in school curricula. Its educational opportunities are still poorly understood and not all teachers are ready to conduct such classes. In distance learning it becomes problematic to conduct such classes, the availability of components and electronic devices is critical. Thus, these factors lead to decreasing the number of children involved in robotics and a gradual loss of interest. Therefore, today it is an important task to adapt robotics classes to the distance format, as well as to support teachers who use educational robotics in the educational process.

The purpose of our work is to identify and describe the possibilities and methodological features of cloud resources to organize the robotics projects developing distantly.

2. Related works

Distance learning is a popular and well-developed topic. There are a lot of researches into the capabilities of distance learning systems, such as Moodle. The authors consider the tools of distance platforms, ways of classes organizing, types of work and communication forms in distance learning [23, 24]. In Ukraine, there are scientific schools that explore the possibilities of distance education and the principles of its organization. Researches of Bobyliev and Vihrova [25], Franchuk and Prydacha [26], Havrilova et al. [27], Hniedkova [28] Kozlovsky and Kravtsov [29], Kravtsova et al. [30], Kukharenko and Oleinik [31], Kushnir et al. [32], Lénárt [33], Petrenko et al. [34], Polhun et al. [5], Prokhorov et al. [35], Shokaliuk et al. [36], Syvyi et al. [37], Tarasov et al. [38], Vakaliuk et al. [39], Yahupov et al. [40], Zinovieva et al. [41, 42] and others devoted to development of distance learning methodologies and distance learning systems.

But classes in robotics have the peculiarities. The classes are practice-oriented. Existing examples of robotics introduction in the educational process show the practical side of integration of practical activities and knowledge acquiring process. Ventä-Olkkonen et al. [43] demonstrate aspects that should be considered at conducting practice-oriented researches, and point out gaps in current understanding of the practice. The authors emphasize that existing researches are focused on theoretical learning but not very practice-oriented. They support the idea of "nurture durable making practices that become weaved into the fabric of everyday life" and emphasize the importance of material aspects: the tools and equipment, if available in the longer run, capture and transmit aspects of the practice.

So, it is important to make a detailed description of cloud technologies possibilities in the practical activities.

Bekker et al. [44] use Reflective Design-based Learning (RDBL) framework, which extends the existing Design-based Learning (DBL) model. Framework includes project characteristics, design-elements, teacher's role, assessment and social context. As methods were used frequently switching between design activities and reflecting on action at switching between activities.

Authors note “the RTDP is intended for university-level students, and provides a high degree of freedom in how they go through the design process. More structure is needed for younger pupils, at least at first, to guide them through the design process”. As tools were used various existing toolkits, such as Makey Makey, Circuit Scribe, PicoBoard, Lego WeDo and little Bits.

Chu et al. [45] considering the problem of Making practice say that “making is poised to become a generalized rather than a specialized practice, essentially literacy”. They describe the practice of electronic devices development using the Arduino microcontroller board and the ArduBlockly interface (a block-based visual programming interface).

The paper [46] deals with the remote path control of the motion of mobile robot. They give example of Automatic Control Telelab (has been developed in Siena) to support the distance learning of mobile robot control. It describes the developed remote experiments based on well-known software enviroment, such as MATLAB, Simulink and LabVIEW.

Project training of students in technology in the modern world acquires a new meaning [47, 48, 49, 50, 51, 52, 53, 54, 55]. There is a growing interest in robotics not only among children but also among teachers who are trying to apply new methods and technologies in the professional activities. Strutynska [56] identifies the following different types of distance learning in educational robotics: distance learning courses, MOOC, webinars and video resources, thematic channels on YouTube, thematic groups of social networks, online emulators of robotic platforms, virtual laboratories, blogs, and electronic manuals. The article also lists the resources that can be used for these types of training. Goncharenko et al. [57] presents an integrative study of robotics in summer intensive courses, a program for the study of integrated topics in physics and programming. Alyeksyeyeva et al. [58] discusses some practical aspects of using the Arduino platform in professional training of computer specialists.

The problem of projects developments in robotic systems in Ukraine is quite new. Only one report on this topic was presented during the 2019 Cloud Technology Conference [59]. In the scientific works of Ukrainian scientists, this topic is presented in separate publications. For example, Tulenkov et al. [60] describes the features of the remote laboratories usage as an open online resource for engineering education are considered. In [61], we described the stages of robotics projects development and cloud resources that can be applied at these stages. The issue of the possibilities of cloud technologies for the organization of distance learning in robotics is not sufficiently covered in scientific publications. Therefore, this issue is relevant and will be described.

3. Results

Distance classes in robotics require effective organization of the educational process. It is due to the peculiarities of the performed activity: research, developing of model description of robotic systems, organization of experimental activities, statistical processing of empirical data etc. The study of robotics training showed the project activity has stages [61]:

1. *Organizational* – acquaintance with the topic, definition of goals and objectives. In the organization of environmental research and analysis of empirical data, it is necessary to provide a distance course in robotics with tools that effectively help: conduct researches, develop models of systems describing, organize experimental activities, conduct statistical

processing of empirical data. Research of theory and practice can be linked through the use of simulators and virtual labs.

2. *Communicative* – determining the sources of information, ways to collect and analyze information, building of solution, determining the final product of the project, developing special interactive sections of the course, instructions on how to search information. The course can include dynamic links to databases. It is possible quickly and efficiently to find the material.
3. *Work on the project* – this stage is determined by the practical orientation, and requires specialized equipment and tools. It is also necessary to use specialized programs, technologies, in particular, robotic, programming environments; selections of technical means that best conform to the solution of professional tasks.
4. *Summing up* – feedback is a prerequisite for successful learning; the course should provide constant communication about the performed tasks and the results of actions. It allows students to evaluate the results of their work and be more motivated for further study. Assessment should include measurable assessment forms of content understanding, determination whether the student has achieved the desired competencies [62**?**]. One example is the use of student assessment by other students, followed by the publication of reviews and discussion. It helps critically to comprehend the evaluation criteria and the presented material, as well as to evaluate one's own achievements [63].

In general, all stages can be implemented on a distance learning platform, such as Moodle or Google Classroom. But the stage on the project requires special means. In the article [43] the review of 45 publications on the organization of students' practical activity is made. The authors of the article concluded in most cases, all these means can be divided into five categories:

1. *Electronic components* (21/45): micro-controllers, battery packs, rotating motors, vibrating motors, LEDs, paper electronics, paper circuits, programmable projections, circuits, copper tape, conductive thread and fabric, coin cell batteries, sensors and actuators, Arduino board;
2. *Crafting materials* (18/45): cardboard, wood, paper, paint, scissors, tape, glue, pipe cleaners, fabric, colored pencils, recycled materials, Play-Doh, graphite, aluminium, beads, sequins, acrylic;
3. *Devices* (15/45): computers, 3D printer, laser cutter, 3D scanner, headphones, and speakers;
4. *Toolkits* (14/45): Arduino, Lilypad Arduino, Makey Makey, CircuitScribe, PicoBoard, Lego WeDo and little Bits, TALKOO kit, fundakit, Dolly 2.0, Spark!, ID toolbox, Lego RCX, Crickets;
5. *Software* (10/45): Scratch, Meshmixer, Thingiverse platform, Tinkercad, graphics design software.

Cloud technologies allow organizing robotics training distantly. Tinkercad program attracts special attention. Tinkercad is a free, online 3D modelling program. It has been running since 2011. Tinkercad has been known as a 3D object development program. However, there is a tool Circuits, it allows to develop electronic circuits (figure 1). This ability appeared only in 2017, so this feature is quite new for teachers. Since then, the program has gained popularity among teachers of robotics.

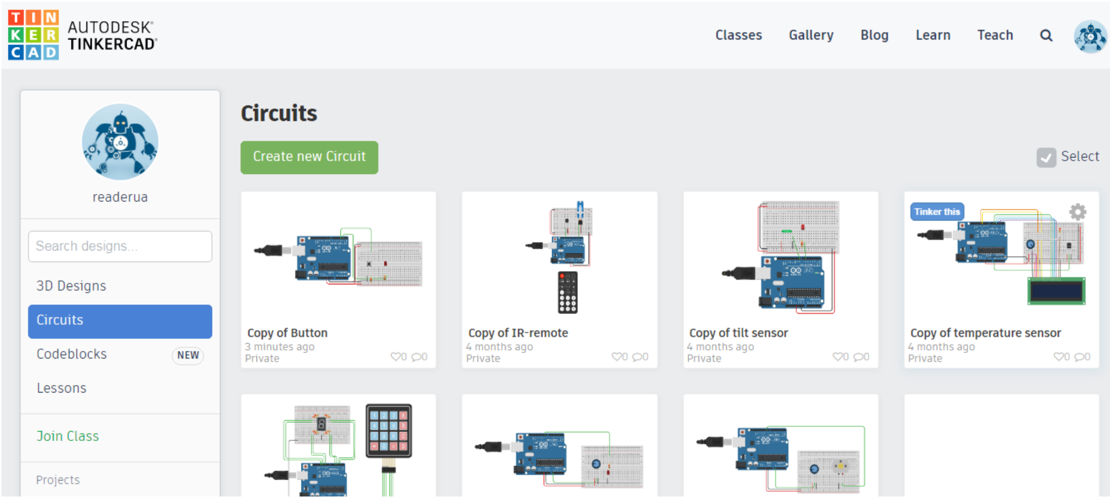


Figure 1: Interface of Tinkercad editor.

Tinkercad has advanced capabilities for use in lessons. It has a number of significant advantages, described below.

1. Tinkercad supports authorization at the level of separation of teacher and student rights. Teacher's account gives access to a special menu item. The teacher has access to students' accounts. He can moderate and comment. It makes the ability to enable a Safe Mode for any of their moderated students. This mode prevents students from viewing or creating comments on Tinkercad designs, and limits their gallery view to a curated list of designs approved by teachers. Classes in Tinkercad allow placing examples of electronic circuits and exchanging data on the course pages.
2. The Class Gallery allows seeing all student projects at once. In addition, students can see each other's projects and participate in their discussion.
3. Ability to share projects with friends. Public project can be integrated into another project by following the link. Such integration is an important element of the usability interface. The public project is available to all participants in the class, but remains private to external users. It is also possible to join the class by following the link, without authorization in Tinkercad system. It can be used in teachers' seminars or other irregular meetings.
4. A significant advantage is the teacher's ability to create separate classes and the function of integration with Google Classroom. Public Tinkercad designs can now be shared or assigned as homework using the popular Google Classroom platform.
5. It contains the library of ready-to-use lesson plans. These lesson plans contain a complete description of the project and allow the teacher to use them for distance learning. Each project contains step-by-step instructions.
6. It contains a sufficiently complete basic set of electronic devices, sensors and motors for modelling electronic circuits based on the Arduino microcontroller.

7. It supports modes: modelling, programming, reproduction of work of devices, the monitor of output of the information and the monitor of diagram's construction, a mode of making up of electronic circuit set (figure 2).
8. It contains grouping of projects in different folders. This approach allows making a distinction between didactic materials for different topics and subjects.
9. It has sharing editing of electrical circuits. Providing shared access to the project makes conditions for organizing teamwork of students. It is also possible for the teacher to view and edit student's data.

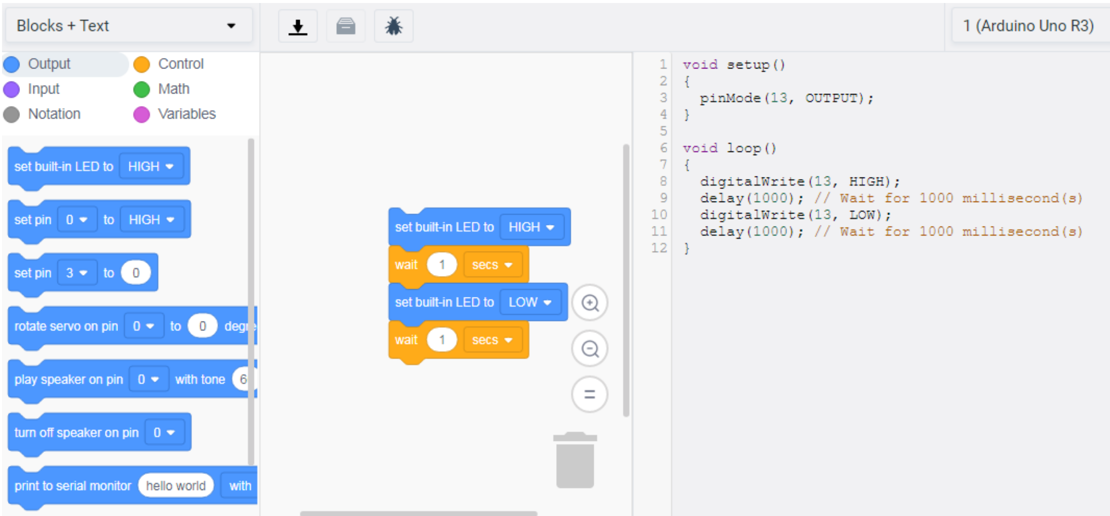
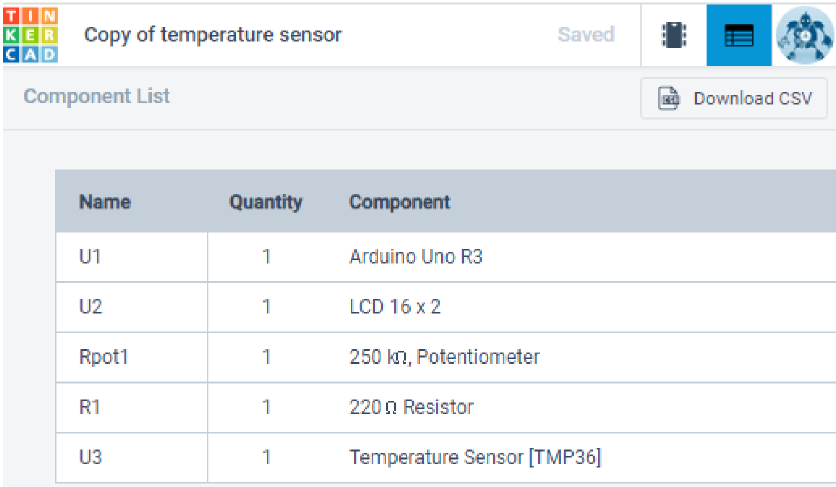


Figure 2: Example of Tinkercad programming environment.

This functionality makes the conditions for the use of the cloud environment as a platform for various activities. The ability to share projects allows exchange of experiences in extracurricular activities, such as a competition or festival. You can organize the development of different types of projects: applied projects (explanation of physical phenomena, solving problems in electronics, computer science), research projects (solving environmental problems or smart city technologies developing), information projects (studying the characteristics of electronic devices and components)

The particular interest to teachers is the ability to design software for robotic systems in the Tinkercad system. Tinkercad supports C++ programming language for Arduino. It is also possible to develop software in the visual programming editor Codeblocks (figure 2). This feature allows conducting classes for younger students. Visual programming commands, like Scratch, support Drag and Drop technology; it simplifies the process of program developing.

Building robotic projects in Tinkercad system helps to make real robotic devices [64]. The mode of the electronic circuit set of devices (figure 3) automatically develops the list of components that were used in the constructed circuit. It helps quickly to estimate the number of items and their cost. It is possible to export the table in CSV spreadsheet format. It is important for making of prototyping devices for subsequent acquisition of circuit elements.



Name	Quantity	Component
U1	1	Arduino Uno R3
U2	1	LCD 16 x 2
Rpot1	1	250 kΩ, Potentiometer
R1	1	220 Ω Resistor
U3	1	Temperature Sensor [TMP36]

Figure 3: Display of a set of electronic circuit devices.

A significant advantage of Tinkercad is the ability to demonstrate the operation of the electronic circuit. There is a special mode Smart Simulation, in which the electronic circuit begins to "work" (figure 4). In this mode, it can be verified the device connections are correct and the application is working properly. Smart Simulation is important for developing programming skills. There is experiment with code changes by changing the program code.

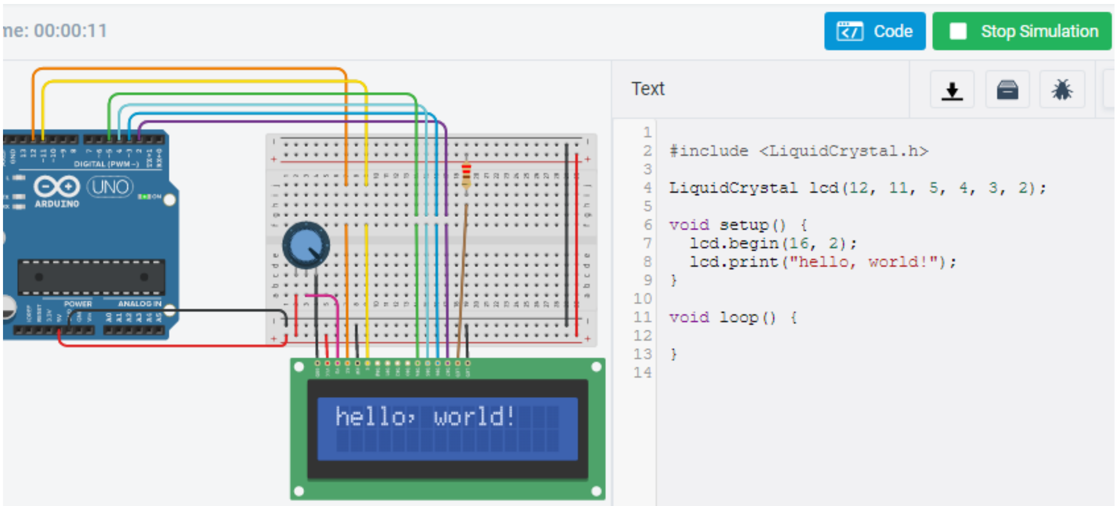


Figure 4: Example of basic project in Tinkercad.

We have developed a course of distance learning in robotics for students. The content of the course is a set of tasks with a practical component. Each of the tasks has a clear practical significance. In class, students developed the projects of things that exist in the real world. For example, they designed a prototype of alarm system, code lock safe, garland, meteorological centre, distance control of the robot.

The catalogue of elementary connection diagrams of robotic devices and sensors was created (figure 4). Execution of a series of basic tasks allows intensifying cognitive activity on related topics: physical properties and laws, structures and programming algorithms, structural engineering, etc.

So, in the process of using the Tinkercad cloud environment, you can create prototypes of electronic devices, test hypotheses about the structure and connection of project components, options for device control programs. But in the process of creating the course materials, we made sure to highlight projects consisting of devices that are in the Tinkercad library.

The use of Tinkercad is due to several reasons: first, the lack of access to robotic construction sets, due to poor material support or a pandemic; secondly, the possibility of creating a model and testing it for further acquisition of the necessary components in independent research activities

Among the disadvantages of Tinkercad are the simulated physical parameters of the electronics in the program work perfectly, without "noise" and external influences. It does not accurately convey the process of setting up a real electronic element. The following types of errors or malfunctions in students' work are possible during the work of an electronic device development:

- at the stage of physical model of device developing – incorrect connection of elements, lack of contact in the circuit, broken wire, malfunction of batteries or electronic components, etc.
- at the programming stage – no element initialization, incorrect program code.

The process of assembling and connecting the electronic circuit requires control over the contacts and closure of the electrical circuit. The simulation environment also eliminates elements of accidental device failure. Such faults must be checked by a special tester. Such errors often occur in students at real electronic circuits making.

Thus, the use of Tinkercad in robotics classes engages students in active activities and stimulates additional motivation to develop projects. At the expense of modeling of the project in a cloud carrying out of experimental and research work is provided. The project testing mode will provide savings in the purchase of electronic components.

Therefore, in the Tinkercad cloud environment, prototypes of electronic devices, test hypotheses about the structure and connection of project components, variants of device management programs can be developed. But in the course materials creating, we need to single out projects that consist of devices that are in the Tinkercad library.

The use of Tinkercad is due to several reasons: first, the lack of access to robotic designers, due to poor logistics or a pandemic; secondly, the ability to create a model and test it, to further acquire the necessary components for independent research. The teacher has the opportunity to: organize teamwork in the project, integrate tasks into Google Classroom, create a gallery of works and organize a discussion or competition of ideas and their implementation. Repositories for both teacher and students and access within the group are created. The teacher's work should take into account: formulation of the project task, organization of discussion of ways to solve the problem, highlighting the consequences of the project (both positive and negative), checking the results of the project, forming a response.

4. Conclusions and future work

The preparation and implementation of the project in robotics contributes to the formation of a scientific approach to solving problems, technological literacy, skills in the use of modern digital technologies, integration of scientific concepts and understanding of interdisciplinary links. Due to the inaccessibility of robotic designers for the quarantine period, Tinkercad cloud environment was selected for the work and a number of projects were developed. They simulated various robotic systems in a virtual environment.

The purpose of construction of the course material is to form conceptual connections between theory and practice, to plan the study of fundamental disciplines, to create the interaction between the participants of the educational process. In the course of project activities, students formed a holistic view of the problem as a scientific complex task that requires the knowledge integration from different fields and has a practically significant component. They allow developing an integrated approach to learning based on a combination of different courses in science and mathematics.

Further research on the use of cloud technology in robotics classes is related to the use of control environments for robotic systems through cloud resources.

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The support of the process of training pre-service mathematics teachers by means of cloud services

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Abstract
The training of pre-service mathematics teachers is a complex process due to the specifics of the field. Informatization of education affects all the areas, and pre-service mathematics teachers can not be left out. The article is devoted to the problem of supporting the process of professional training of pre-service mathematics teachers by means of cloud services. Examples of the use of cloud technologies are given. The analysis of a survey of pre-service mathematics teachers on the use of information and communication technologies in the training process is done.

Keywords
training of pre-service teachers, cloud services, mathematics teachers, training system

1. Introduction

During the constraints caused by the COVID-19 pandemic, education was forced to switch to e-learning as a matter of urgency [1, 2, 3, 4, 5]. The transition revealed problems not only in the material part of the organization of education (lack of access to digital technologies for a significant number of both students and teachers) in the lack of electronic educational resources needed for educational activities. There were problems with the appropriate training of pre-service teachers. It cannot be said that this issue has not been raised by the educational community and government agencies, however, the results indicate a formality in resolving these issues.

2. Statement of the problem in general

News reports, social networks, reports at webinars of teachers and educators speak not only about the possibility of achieving the goal of learning through e-learning. It also speaks to

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the problems that arise. These questions concern each of the subjects of educational activity: students, teachers, parents and the administration of educational institutions.

Let's consider what problems teachers have when moving to the online space. Going online and transferring even one course taught in a higher education institution or a general secondary education institution is a huge long-term work of a whole team of professionals. The examples are Cousera or Prometheus resource courses. All videos are recorded by professional cameramen in the studios, with a professional overlay voice of the lecturer of the presentation on the video, with a very careful and competent distribution of information over time. The course consists of 20-30 minute informative videos, for which tests, a large amount of materials for self-study, tasks such as peer to peer review and so on are prepared.

In order to implement such functionality, it is not enough for a teacher to have information and communication technologies, to have the necessary material base for shooting, editing videos, informational material, etc. Such work takes much more time than preparing for lectures or conducting a lesson and creating presentations for them. The results of mastering the material from most subjects, disciplines or courses cannot be assessed by passing tests, there is a need to check written works, listen to auditions and so on. It significantly increases the amount of mechanical work that is added to the responsibilities of a teacher or lecturer. For clarity purposes, you can, for example, open 20 e-mails, download 20 completed works and save them in the appropriate folder. We see that even such primitive mechanical operations are very time consuming.

In addition, there is a big psychological problem if during online classes students are a passive cluster that is not even displayed on the screen. Not every teacher is able to tell 40 minutes on the black screen without any impact on the audience, even if from time to time there are single answers in the form of voice messages. It is also important to hold the attention of the audience during the lesson.

Another unresolved issue is the results of scientific and methodological work. It is required by the job responsibilities of educators. In the situation of excessive creation of electronic educational resources it is extremely difficult to get good results. It is also important that e-learning resources have no less functional teaching compared to planned, verified, proven full-time learning.

Researches and statistics from mass open online courses have found that distance learning is effective for 20-25% of students. This is the number of them who successfully complete the distance course compared to the number of registered ones. There is another side – the specifics of the selection of material for distance learning, which is determined by the professional competence of the content curator. The search for educational material, its systematization, processing in accordance with the level, goals and content of training forces to process a huge amount of existing digital content.

Students are no less stressed. There are several problems in this category of participants in the educational process:

- the construction of the procedure for evaluating the completed tasks, especially those of a final nature, is not clear;
- learning at home relaxes rather than mobilizes and motivates learning activities, and leaves visual control on the part of the teacher;

- lack of own room for working remotely (presence of parents, younger or older siblings) and therefore, the simplest solution that students come to is not to participate in online classes;
- cases of lack of access to Internet resources due to lack of devices and lack of communication channels.

General secondary and higher education institutions make great efforts to organize learning with the help of distance platforms. Seminars, webinars, trainings on forms, methods and means of distance learning for teachers are held in an accelerated manner. Teachers communicate with their students by any possible means, from e-mails, instant messaging, available distance learning platforms to telephone communication. It should be noted that due to the different activity of participants in the educational process there is a big discrepancy in the results. Thus, it is extremely interesting for us to explore the issues of professional training of pre-service teachers of mathematics for educational activities in the distance form of organization of the educational process.

3. Review of the current state of the problem

The issue of application of information and communication technologies (ICT), and cloud technologies in particular, in the process of professional training of pre-service mathematics teachers is the subject of active research by Bobyliev and Vihrova [6], Clark-Wilson et al. [7], Drijvers [8], Kiv et al. [9, 10], Kramarenko et al. [11, 12], Kumar and Bhardwaj [13], Lovianova et al. [14], Merzlykin et al. [15], Mulenga and Marbán [16], Ndlovu et al. [17], Papadakis [18], Perienen [19], Ponomareva [20], Popel [21], Purnomo and Jailani [22], Pyper [23], Semenikhina et al. [24], Vlasenko et al. [25, 26, 27, 28, 29, 30, 31, 32, 33], Yang [34]. We will consider in more detail some of them related to our study.

Professional training for the widespread use of ICT in the educational activities of pre-service mathematics teachers begins long before entering higher education. During their studies in a general secondary education institution, pre-service mathematics teachers can already clearly observe the forms and methods of application of ICT. The study of the results of the use of ICT during training in general secondary education was presented in a study by Vakaliuk et al. [35]. Useful for our study is the answer to question #13 of their study: "Did any information and communication technology tools (curricula, multimedia, simulators, games, virtual laboratories, etc.) be used in the school / college by non-CS teachers?". Unfortunately, only 48.5% of respondents answered this question positively. The result suggests that every second pre-service teacher while studying in a general secondary education institution has not received the necessary experience of using ICT in educational activities. However, the variety in answering question #14: "If the answer to the previous question is "Yes", in what lessons did the teachers use such tools?" (see figure 14, [35]) indicates that some subject teachers, including teachers of language and literature, mathematics, physics, history, chemistry, biology and geography have found not only the possibility of using ICT in learning activities, and this application was successful, otherwise it would not be remembered by students. Thus, due to the introduction of ICT in the secondary school education system, pre-service mathematics teachers are occasionally familiar with the use of ICT in educational activities.

Let's consider the approaches used in e-learning based on the results of the study of Proskura and Lytvynova [36] for bachelors of computer science. The conducted semantic analysis of scientific achievements of colleagues and based on their own experience allowed the authors to develop the model of Web-based learning of Computer Science Bachelors (see figure 1 in [36]). Considering such structural components as learning environment, web-oriented environment, control and evaluation unit, levels of student's educational achievements, the authors determine the content component of e-learning. Among the components of e-learning there are such as cloud computing, working together classroom, web-automated knowledge validation systems and others. These components are implemented through network technologies as means of data transportation. Their appearance is caused by the availability of network technologies and they belong to cloud services. Thus, the need to use cloud services to support the training of pre-service mathematics teachers is one of the current educational trends.

A logical continuation of our study is to identify specific cloud tools to support the training of pre-service mathematics teachers. The specifics of professional training is determined by the specifics of the field of science. The specificity of mathematics lies in its abstractness. The study by Vlasenko et al. [37] examines the requirements for modern web-based online training courses for pre-service mathematics teachers. Researchers have analyzed the ways of presenting mathematical text through to the specifics of its formation, and the creation of mathematical content with a focus on network use.

Shyshkina and Marienko [38] determined the content of necessary general skills and specific skills needed for pre-service mathematics teachers (see table 2 in [38]) based on professional functions, typical tasks of mathematics teachers (see table 1 in [38]). Using the example of Web-SCM CoCalc (formerly called SageMathCloud), the authors conducted an experimental study that revealed the benefits of using the CoCalc cloud service in the training of pre-service mathematics teachers.

Fedorenko et al. [39] studied the problem of studying free software using cloud services. The results of this study had a positive result, for the training of pre-service mathematics teachers in particular. Researchers have discovered the didactic capabilities of cloud services that allow you to run a free mathematical software.

4. Research results

According to the Law of Ukraine "On Higher Education", the educational process at the university is carried out in the following forms: classes; individual work; practical training; control measures [40]. The most common types of training are lectures. A lecture is a clear, systematic presentation of a particular scientific problem or topic. Its additional purpose is to help students with mastering the methods of independent work with textbooks, manuals, primary sources. This is one of the most important factors in the organization of educational activities of students and occupies a significant place in the training of pre-service professionals receiving higher education.

The normative-directive documents, which determine the content and organization of the educational process in higher education institutions of Ukraine, substantiate the main requirements for this type of classes. Their implementation allows to fully use the significant educational and upbringing opportunities of this form of education, to increase the impact of each lecture on the consciousness and feelings of students [41]. However, the lecture to some extent accustoms the student to the passive appropriation of other people's thoughts, does not stimulate the desire for independent learning, does not provide an individual, differentiated approach to learning.

The leading role of the lecture in the teaching of academic disciplines is related to their content aspect, organizational principles and methodological features. The main content is the central methodological, theoretical and practical problems. Not all issues of the topic are revealed, but the most important, most significant ones that require scientific substantiation.

The pace of development of modern technologies has a significant impact on teaching methods and learning models in general [42]. This allows to expand the ways of implementing the paradigm of competence in order to improve the quality of education. The model of blended learning has the greatest potential for optimizing the learning process [43]. This model allows you to implement new technologies without abandoning conventional teaching methods. Blended learning is a model of organization of the educational process, as "it allows to increase the motivation of future teachers to learn, makes it transparent, interactive and manageable, provides constant involvement of students in the educational process" [44].

A blended form of learning is the individualization of learning, the creation of a favorable psychological climate, continuous training. The purpose of this form of learning is to combine the benefits of face-to-face learning and electronic educational resources through a combination of distance and traditional communication in integrated learning activities. The integration of traditional and computer-based learning in the educational environment will lead to a purposeful process of acquiring knowledge, skills and abilities in the classroom and extracurricular learning activities of the subjects of the educational process through the use of ICT. The existence of this form of learning is possible due to the effective combination of different ways of presenting educational content, teaching models and styles. It is based on the interaction between all participants of the educational process.

One of the forms of blended learning is realized through flipped learning (flipped classroom) [45, 46]. There are different ways to implement the model of flipped learning and they are all based on one basic principle: traditional learning is carried out outside the classroom, and practical work and application of knowledge is classroom. In general, the essence of flipped learning is to regroup the key components of the learning process. With the help of this model of learning "the content of new educational material is independently mastered in the electronic environment, and then the acquired knowledge is applied in practical classes or discussions" [47].

Reduction of classroom hours (lectures, practices, seminars, laboratory classes) leads to a violation of the traditional logic of the educational process. This fact leads to a loss of quality of education. One of the ways to "restore the balance of the learning process is to use a mixed learning model with Flipped Classroom technology" [48]. At the same time, the key components of the learning process change places: the basic components of the new material are studied independently at home, and in the classroom the studied material is consolidated and together with the mentor more complex issues and practical application of the mastered information are considered. Flipped classroom technology is characterized by the fact that the necessary "theoretical knowledge is obtained outside the classroom, and in the classroom individual tasks are performed or a group project is developed" [49].

Flipped classroom technology was used by us in the study of mathematical disciplines "Mathematical Logic and Theory of Algorithms" and "Elementary Mathematics" in the 3rd year of the Faculty of Physics and Mathematics of Donbas State Pedagogical University. Taking into account the fact that students majoring in "Secondary Education (Mathematics)" specializing in "Computer Science" in the 3rd year have significant learning experience, and the level of self-awareness is sufficient to use elements of Flipped classroom technology in not only logical but also appropriate way. In addition, this model of study does not contradict the work program, in which the main number of hours is set aside for independent work of students.

Based on the practical experience of use, the following structure of the approach to each topic was formed:

1. Formulation of the theme and purpose.
2. Determining the place of this topic in the work program of the discipline.
3. Offering sources of information.
4. Definition of types and content of control.
5. Monitoring and evaluation.

While introducing the flipped classroom technology during teaching the course of "Mathematical Logic and Theory of Algorithms" it is advisable to consider the following topics:

1. Boolean n-ary functions;
2. Zhegalkin polynom;
3. Complete systems of Boolean functions;
4. Mathematical theories of the first order.

For each of the proposed topics, the place in the work program and sources of information are determined, the content of tasks for control and its types are selected.

For example, to study the topic "Complete systems of Boolean functions" students receive the following information in table 1.

The main reasons for the introduction of a blended learning model with flipped classroom technology in the educational process of the university are active cooperation between students and teachers and, as a consequence, increasing students' success and motivation. A feature of this model is the possibility of using group classes where students can discuss key aspects of lecture materials, test their knowledge and interact with each other. The task of the teacher is to explain the problematic issues, to comment on the work of students.

Another example of supporting the training of pre-service math teachers is the use of computer math systems in the form of cloud services. One such free service is the Math Partner computer math system, which is available at http://mathpar.com. This service allows you to create your own cloud mathematical "Notebook", in which the user performs the necessary mathematical calculations. To ensure quality and comfortable work, this service provides access to a large amount of reference material with examples. The language of this service is the Mathpar language, which is based on the widely used language of mathematicians and physicists TeX, which is usually used for typing mathematical texts. It is possible to save both the problem statement and its solution. You can save both text and images.

Table 1
Tasks for studying the topic "Complete systems of Boolean functions"

Theme	Complete systems of Boolean functions
Meta	Learn the concepts of classes of functions that store zero, store unity, self-dual functions, monotonic and linear. Master the criterion of completeness.
Sources of information (independent selection of sources of information is encouraged)	• Bondarenko M.F., Belous N.V., Rutkas A.G. Computer discrete mathematics: textbook. – Kharkiv: SMITH Company, 2004. – 480 p. • Khromoi J.V. Mathematical logic. – Kyiv: Higher School, 1983. – 208 p. • Kaidan N.V., Pashchenko Z.D. Methodical instructions for practical classes of the course "Mathematical logic and theory of algorithms. Section "Mathematical Logic" for the specialty 014 Secondary Education (Mathematics). – Slovyansk: B.I. Motorin Publishing, 2019. – 92 p. • Rosen K. H. Handbook of Discrete and Combinatorial Mathematics, 2000. – 1183 p. • Discrete Math. Lecture: Criterion of completeness of the system of Boolean functions (https://www.youtube.com/watch?v=CYL7o4Ru35c) • Game simulator "Collect crystals" (http://www.ggpk.by/virt_cab/102/Files/logic.zip) • Exercise machine "Logical elements" (http://www.ggpk.by/virt_cab/102/Files/log.rar) • Quine – McClassky logic function minimization simulator (http://www.ggpk.by/virt_cab/102/Files/KMK.rar) • Construction of the truth table. SDNF. SCNF. Zhegalkin polynomial (https://programforyou.ru/calculators/postroenie-tablitci-istinnosti-sknf-sdnf) • Truth table (https://allcalc.ru/node/745)
Types of control	test for mastering the material (conducted remotely outside the classroom), an individual task to determine the completeness of the system
Date of control	conducting a test for self-study of the material

In particular, Math Partner allows you to effectively solve such common problems as finding the smallest distances between all vertices of the graph and finding the shortest path between the vertices. For the first task the command $\backslash searchLeastDistances(A)$ is used, and as a result the matrix of the shortest distances between vertices will be received. For the second task, use the $\backslash findTheShortestPath(A, i, j)$ command, resulting in the shortest path between the vertices i and j. It should be noted that this service is convenient to use to check your own solutions, because it provides the answer itself, without access to intermediate results of calculations.

Another relatively new service is Graph Online, which is available at http://graphonline.ru. This is a free cloud service designed to visualize the graph and find the shortest path on the graph, finding the Euler cycle. Creating a graph is performed on the adjacency matrix or incidence matrix. In addition to finding the shortest path, you can search for connectivity components. The service supports work with oriented (digraphs) and non-oriented graphs. The result of the work, the constructed graph can be saved thus you can continue working with it later.

In addition, the cloud service Graph Online provides the user with many auxiliary functions to facilitate work. Available to save and load a graph with support for saving the visual representation, fast conversion between all supported types, determining the appearance of vertices, arcs, background, constructor mode, etc.

Let's consider the example of the use of the presented services in solving the problem of finding the shortest distances between the vertices of the graph, which are often found in practice. It is clear that in order to be able to find the shortest distances, there must be at least one path from vertex 0 to every other vertex, i.e. the graph must be connected. For this problem, the most well-known solution algorithm is the Dijkstra algorithm. The idea of this algorithm is that first for each vertex other than vertex 0, we set the distance equal to $+\infty$, and then step by step we reduce these distances until we find the minimum distance $d(v)$ and the shortest path $p(v)$ for each vertex v.

Condition: Suppose that in a weighted graph $G = (V, E)$, the set of vertices $V = \{0, 1, 2, 3, 4, 5\}$, and the set of edges E is given by a matrix of weights:

$$E = \begin{pmatrix} - & 8 & 7 & - & 10 & 12 \\ 8 & - & 5 & 1 & 4 & - \\ 7 & 5 & - & 3 & - & 4 \\ - & 1 & 3 & - & 2 & 1 \\ 10 & 4 & - & 2 & - & 3 \\ 12 & - & 4 & 1 & 3 & - \end{pmatrix}$$

Using the Dijkstra algorithm, construct a skeleton tree of the shortest paths from vertex 0 to all other vertices of the graph G and find the shortest distances.

Solution: The progress of the Dijkstra algorithm is shown in the table 2.

Table 2
The progress of the Dijkstra algorithm

1	2	3	4	5
8	**7**	10 **9**	**10**	12 11 **10**
$0;1$	$0;2$	$0;2;3$ $0;1;3$	$0;4$	$0;5$ $0;2;5$ $0;1;3;5$

When performing the Dijkstra algorithm, the current vertices were in the following order: 2, 1, 3, 4, 5. Thus, the shortest distance to the vertex 1 is 8, $d(2) = 7$, $d(3) = 9$, $d(4) = 10$, $d(5) = 10$. The shortest to the top 1 is the path 0.1; $p(2) = 0.2$; $p(3) = 0.1.3$; $p(4) = 0.4$; $p(5) = 0, 1, 3, 5$.

Using the Math Partner service we have the opportunity to check the correctness of the results in figure 1.

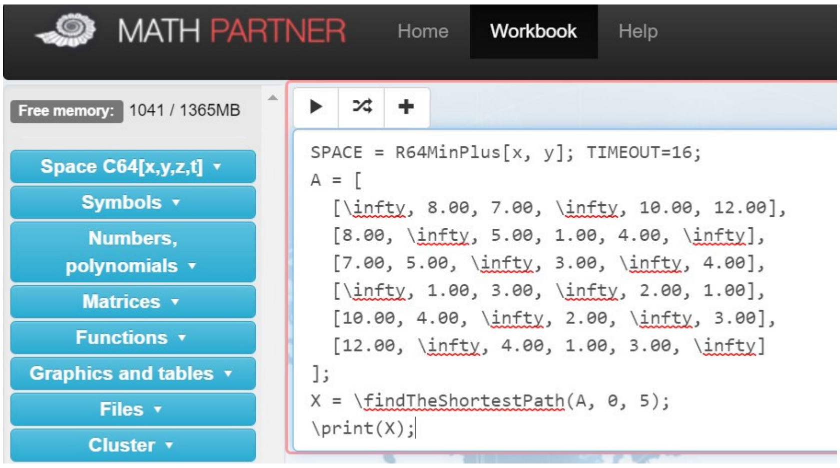

Figure 1: The shortest distances from vertex 0 to all other vertices of graph G in the Math Partner service.

But graph visualization is better performed by Graph Online (figure 2).

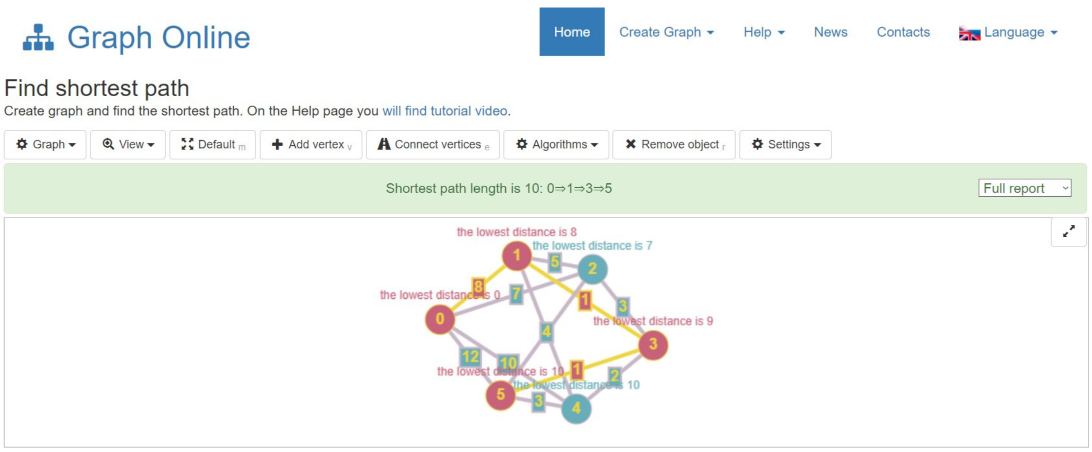

Figure 2: Graph G visualization and the shortest distance from vertex 0 to vertex 5 of graph G in the Graph Online service.

Among the students of 2-4 courses of the specialty "Secondary education (Mathematics)" of the Faculty of Physics and Mathematics of Donbass State Pedagogical University was conducted a survey to find out which tools of computer training are used by pre-service teachers of mathematics in professional training, including self-education. A total of 120 students were involved in the survey. We asked the respondents the following questions:

1. Did you use e-learning resources while studying?
2. Did you use cloud services during your training?

3. Have you used cloud services during self-education activities?
4. If the answer to 2 or 3 questions is yes, then which cloud services did you use?
5. If the answer to 2 and 3 questions is no, then what software did you use in the learning process?

The following results were obtained:

- 100% positive result on the first question. This result suggests that pre-service mathematics teachers understand the concept of "electronic educational resources" despite their diversity.
- 82% of respondents answered positively to the second question. The result of the answer to the second question shows that not all respondents identify the concept of cloud service. We came to this conclusion when discussing the results of the survey with the respondents. After all, during the practical classes that we described in the study, all students were involved in the use of cloud services.
- 46% of respondents answered positively to our third question. This percentage is a good result of self-educational activities.

The answer to the fourth question is shown in figure 3.

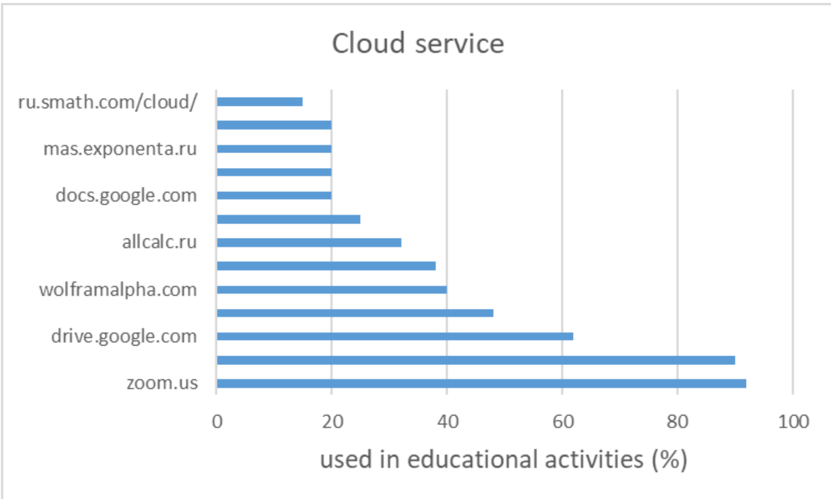

Figure 3: Cloud services used by pre-service math teachers.

It is important to note the significant advancement of cloud communication services due to quarantine measures caused by the COVID-19 pandemic and cloud file storage services. A positive result of the survey is the availability of cloud services for mathematics.

The answers to our question 5 are presented in figure 4.

At the first glance, pre-service math teachers use a regular calculator and calculator on mobile devices and make presentations and reports in a word processor. Note that the presented list includes purely mathematical programs, which are extremely necessary in the training of pre-service teachers of mathematics.

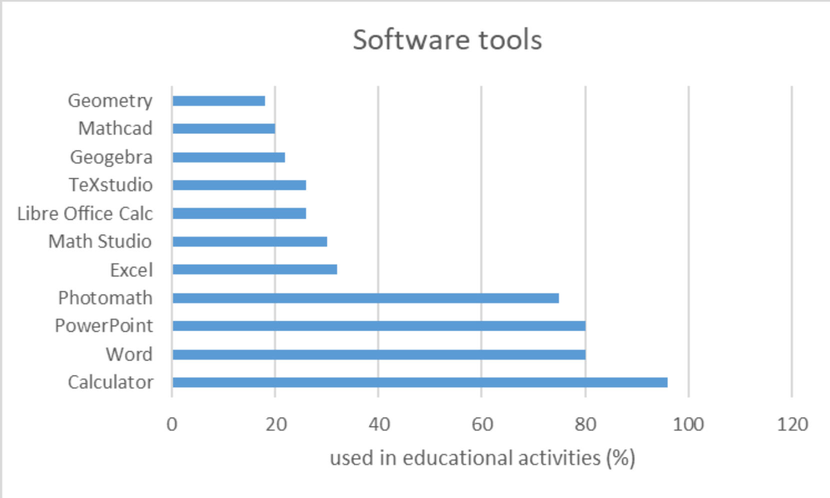

Figure 4: Software used by pre-service math teachers.

5. Conclusions

The learning process in higher education is implemented within a diverse integral system of organizational forms and methods of teaching. Each form solves its specific task, but the set of forms and methods of teaching creates a single didactic complex, the functioning of which is subject to the objective psychological and pedagogical laws of the educational process.

The results of the study provide an opportunity to claim that cloud technologies are used in the teaching of mathematics in high school. Pre-service mathematics teachers have the opportunity to use cloud technology during their training. Available cloud technologies have a wide range of applications in mathematics education.

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Management of online platform development and support process

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Abstract

The matter of building an optimal model of managing the online platform "Higher School Mathematics Teacher" is considered in this article. The existing researches on the management of online platform development and support process have been analyzed in this paper. The model developers described the process of building an online platform according to the Software Development Lifecycle rules. The researchers described an online course platform creation and functioning process that corresponds to a five-stage pedagogical ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) of online course preparation. The research describes the roles and objectives of online platform team members. These results allowed the authors of the article to model the organizational structure of online platform management. The method of survey among the team members of the online platform "Higher School Mathematics Teacher" and its participants was used to prove the efficiency of the offered model. The results allowed us to confirm the actuality of the research in the management of educational platforms, the convenience of teamwork in online platform management, and successful model implementation.

Keywords

online platform management model, organizational structure of online platform management, teamwork

1. Introduction

Among the experts [1], who help newcomers to cope with the challenges of teaching online courses, the importance to determine creative strategies to manage large online classes is

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stated. These strategies include the use of a strong syllabus, clear instructions, well-organized learning materials, and prompt feedback. A great issue for online moderators must be that the nature of online education increases the importance of the right solution to these management issues, adding several additional obstacles. Among them – the selection of the right tools of communication and protocols, the solution to technological issues, management of students' expectations, and community building. And these are only some of the issues that can cause difficulties among online moderators. For instance, teachers who cannot organize weekly face-to-face meetings with students in the class, claim that the management of online course workload is much more difficult than the class course management. While organizing education on the online platform "Higher School Mathematics Teacher" [2], its objective, concept, and development principles that are described in the researches [3, 4], tutors also faced certain problems of managing the support process of the online course development.

2. Analysis of scientific researches

While describing the stages of online course development Puzziferro and Shelton [5] emphasized that the teachers who are experts in their subject cannot be expected to become experts in educational design during the course development. According to the researchers, online course development requires a systematic process that analyzes the goals of course learning, provides the content, interactivity, and assessment. Considering the challenges of online learning, Gillett-Swan [6] described the obstacles that students face while completing the course tasks online. The scientist paid attention to the importance of a clear division of roles and tasks among the team members who organize an online education. Muriki [7] examined the readiness of tutors from Kenyan universities for online education and pointed out the necessity of constant team members' interaction that ensures the online educational process. The research results given by Alam [8] showed that students often feel anxiety while doing their first online course. The scientist recommends helping students feel more confident and secure by doing that at a controlled level.

According to the Gagné's theory 'Conditions of Learning' [9], there are several different types or levels of online education. The significance of these classifications is that each different type requires different types of instruction. Gagné identifies five major categories of learning: verbal information, intellectual skills, cognitive strategies, motor skills, and attitudes. The theory shows how to manage an online course. Merrill [10] in his research selected 5 principles of instructional design that allow increasing the online education efficiency. The scientist highlighted the use of Software Development Life Cycle (SDLC) as a basis for these principles.

Sacchanand and Jaroenpuntaruk [11] also showed the considerable efficiency of SDLC use with a combination of the waterfall, phased, and prototyping approaches while developing web-based applications for distance learning. Later Hughey in [12] pointed out the disadvantages of SDLC use for system development. He assumed that Agile methodologies use, in particular, Scrum methodology allows to improve significantly the whole development process. Considering all the existing researches on the management of online course development and support, the aim of the research has been formulated. It included the determination of the structure and sequence of online platform team development stages; it also offers and describes an optimal model of managing the online platform "Higher School Mathematics Teacher" [2].

The objectives of the research were the following:

1. To determine the roles and objectives of online platform team members.
2. To describe the process of online platform development, assign the objectives and roles for online process participants at every stage.
3. To offer the stages of the online course platform creation and functioning, indicate team members' roles and describe the necessary objectives.
4. To develop the organizational structure of online platform management.
5. To check the efficiency of the organizational structure of online platform management.

3. Method

3.1. Roles and objectives of online platform team members

The first objective implied the analysis of the existing resources [1, 6, 7, 8] and experts' recommendations [5, 13, 14]. A group of researchers [1, 6] described management problems that can be experienced while creating an online platform. They determined the requirements for the development technologies and its organization, formulated the conditions of interaction with participants, described team and systematic approach to online course development, defined team members' roles and objectives. According to the researchers, the efficiency of online platform creation and functioning depends directly on the work clarity and synergy of all the team members. In order to ensure this task, it is necessary to determine the leading role of an online platform coordinator. The online platform coordinator carries out project management, ensures the coordination and functioning of staff work at all the stages of Software Development Life Cycle (SDLC) [15]. The main objectives of the online platform coordinator are:

1) compilation of requirements for the platform and problem statement;
2) selection of online platform development technologies and methodologies;
3) task implementation planning;
4) involvement in team creation and coordination of its daily activities;
5) creation of the course template.

In order to create an online platform, in particular design and its software, it is necessary to have a developer or a group of developers in the team. The developer provides software tools to create, manage, and assess the course and also is responsible for software modernization during its lifecycle.

The main objectives of online platform developers are:

1) selection of software tools for online platform development (front end technology, back end technology, system of data storage);
2) determination of system requirements for the online platform;
3) creation of the online platform design according to its usability;
4) online platform program implementation;

5) online platform software testing;
6) software modification according to modern tendencies of information technology development;
7) software modification according to the users' recommendations to improve its elements;
8) online platform workability and reliability maintenance;
9) security.

The course developer (teacher) or a group of developers are responsible for course content design and development and management of the learning process. At the same time, it is recommended [1, 5] to consider that the process of course creation should be done following ADDIE models (Analysis, Design, Development, Implementation, and Evaluation) [16], Bloom's taxonomy [17], the conditions of learning by Gagné [9], and Merrill's principles [10].

The main objectives of the course developer are:

1) course learning goals and problem statement;
2) creation of the learning program according to the aims and objectives;
3) development of structure, content, form, and methods of knowledge control;
4) determination of knowledge assessment criteria, description of requirements for task implementation;
5) learning process control;
6) communication with the course participants during private and group online consultations.

Considering the fact that teachers are not experts in educational design, there should be a content manager in the team for the technical support of content management while creating and using a course. They provide technical assistance in publishing course content on the platform and during all the time of its use.

The main objectives of the content manager are:

1) text content uploading on the platform;
2) ensuring high quality of the course content design;
3) creation, transformation, optimization, and posting of graphics, video, audio, animation content of the course;
4) posting of knowledge control elements, such as testing, surveys, and interactive tasks;
5) ensuring the right workability of the course elements during all the time of its use.

Moreover, an important factor of the educational platform functioning is the presence of its clients - participants. In order to ensure the search for and service of course participants, the presence of a client manager in the team is recommended.

The main objectives of the client manager are:

1) users' signing up for the course and providing access to it;
2) incoming calls and emails processing;
3) mailing management;
4) signing a contract for the course;

5) forming participants’ group;
6) course scheduling;
7) course certificate issuance;
8) course advertising and promotion.

In order to check the course content correspondence to intellectual property law, it is necessary to introduce the role of a copyright specialist. They have legal control over the use of image, video, and audio information and other course elements. They analyze the course plagiarism and ensure legal support of online platform work.

3.2. The process of online platform development

The process of developing an online platform “Higher School Mathematics Teacher” [2] was implemented according to the rules of the SDLC rules [15] that described the stages of this process. This method is successfully implemented while creating software for online education [11, 18, 19]. It includes such stages as Requirement Analysis, Designing, Developing, Testing, Deployment in the Market, and Maintenance. The use of the waterfall model methodology [15] during the platform development turned out to be inappropriate because this model does not consider possible requirement changes during the development cycle. Also, it was considered that the project implementation can take much more time than the development using iterative methodology [20]. Due to this fact we used a flexible development methodology Agile [3] in particular Scrum process [3].

Scrum-development process is designed for teams that usually include up to 10 people. This number of people corresponds approximately to the permanently functioning team of the online platform “Higher School Mathematics Teacher” [2]. The process itself allows providing a functioning product with new capabilities for the final user during strictly determined and short intervals (sprints).

Considering that the online platform after all the development stages will be continuously improved, we are planning to use this method during all its functioning. Based on the outlined methods, online platform lifecycle stages were offered. Following every stage, the participants’ roles and the main objectives of the process were determined (table 1).

3.3. Creation and functioning process of the online course on the platform

Every online course [2] has a template structure, determined at the stage of requirement analysis. Accordingly, the process of online course creation and functioning should also have a versatile lifecycle from its formation until the end of the learning process. The process of the online course creation and functioning should correspond to the pedagogical models.

ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) [16] is the most spread model of online course development that includes 5 design stages. Considering these stages we also use the system offered by Merrill [10]. The scientist highlighted 5 principles of instructional design: demonstration, application, task-centered, activation, integration. Moreover, he recommended Conditions of Learning, pointed out by Gagné [9]. The expert outlined nine instructional events and corresponding cognitive processes:

Table 1
The process of developing an online platform and participants' role in the waterfall development model

Development stage	Participants' roles	Description
Requirement Analysis	Online platform coordinator Online platform developer Online platform coordinator Online platform developer Course developer Course developer	Requirement analysis is the most important and fundamental stage. It is performed by the most experienced and advanced team members. The participants discuss the requirements for the online platform. This stage aims to determine detailed requirements for the system. Moreover, it is needed to make sure that all the participants have understood correctly the set the objectives and how exactly every requirement would be implemented
Designing	Online platform coordinator Online platform developer	The designing stage implies the selection and description of online platform software architecture, modularity, and determination of data storage structure, description of users' options, design creation and coordination according to its usability
Developing	Online platform developer	The factual development takes place at this stage and the online platform is created. The programming code is written according to the predetermined requirements. Data storage structure is created. The server and other online platform hardware are set up
Testing	Online platform developer	This stage includes fault determination (bugs, errors) of the online platform. They are determined, monitored, corrected and tested again as long as the platform achieves the quality standards determined at the stage of requirement analysis
Deployment in the Market and Maintenance	Online platform coordinator Online platform developer Course developer Content manager Client-manager	After testing and determining the online platform readiness, the deployment stage takes place. The platform is posted on the Internet. Team members, who upload the content, ensure feedback with users, and organize the learning process. In case of finding post-release bugs (errors) the information about them is given to the developers who carry out their corrections in reports

1. Gaining attention (reception),
2. Informing learners of the objective (expectancy),
3. Stimulating recall of prior learning (retrieval),
4. Presenting the stimulus (selective perception),

5. Providing learning guidance (semantic encoding),
6. Eliciting performance (responding),
7. Providing feedback (reinforcement),
8. Assessing performance (retrieval),
9. Enhancing retention and transfer (generalization).

Bloom's taxonomy was chosen to manage the assessment system. In the Bloom's taxonomy [17] the cognitive domain is broken into the six levels of objectives: remember (knowledge), understand (comprehension), apply (application), analyze (analysis), evaluate (evaluation), and create (synthesis). Considering the chosen models and their conditions of use, we were focused on the stages (table 2), where team members' roles and necessary objectives were indicated.

3.4. Organizational structure of online platform management

After the distribution of roles and objectives among online platform team members we represented an organizational structure of its management (figure 1). The online platform consists of separate independent online courses. Every online course is created by a course developer and is posted by a content manager under the course developer's control. After the course posting a copyright specialist checks the content's correspondence to the intellectual property law. In case of detecting inconsistencies, the copyright specialist gives this information to the course developer who makes corrections in the course with the help of the content-manager. The platform coordinator ensures control over the course quality and posting terms, and also solves non-standard situations that can arise during the communication among team members.

While posting the course content managers use software tools that were created in the development process by online platform developers. In case of necessity, online platform developers consult content managers on technical issues of using a particular tool. If it is necessary to add or improve course posting tools, the developer modifies the programming part of the platform.

4. Results

In order to carry out the analysis of the offered organizational structure model of managing an online platform and check its efficiency, we held a survey among the team members of the online platform "Higher School Mathematics Teacher" and the participants who had or have online courses on our platform.

We offered 13 questions for team members; every question was processed on a scale from 1 to 5. The rating of every task was defined by calculating the total number of points among all the respondents and its division into the number of respondents (table 3). Overall, 15 team members took part in this survey; the majority of them are teachers (online course developers).

In general, all the survey questions were highly assessed, which confirms the research actuality in the management of educational online platforms. As it is seen in Table 3the survey participants gave the highest rating to convenience of teamwork while developing an online platform and an online course on the platform, which can indicate the efficiency of this model. The need of having a copyright specialist in the team was highlighted as the least important

Table 2
Process of online course creation and use

Stage	Participants' roles	Description
Development of the course curriculum	Online platform coordinator Course developer	Creation of the course structure, problem statement, and results of its research, list of knowledge and skills that will be received as a result of its research. Description of types and criteria for the studied material assessment. Determination of communication method
Course material preparation	Course developer	Preparing text, graphic, video, audio course content. Preparing individual or group tasks to assess the studied material (tests, situational tasks, practical or laboratory tasks, etc.)
Course posting on the online platform	Course developer Content-manager	Converting the prepared course material into the type which corresponds to the requirements of platform usability and their deployment in the platform system. For instance, optimization of graphic files and their modification to "the best" format to increase the downloading speed via the Internet
Course testing	Course developer Content-manager	Checking the course completion and content conformity to the program. Checking "broken" links in the text. Checking the correctness of video opening, animated elements workability, tests, etc. Testing by simulating the entire course taken by a participant
Legal course verification	Copyright specialist	Checking the conformity of the used images, video and audio information, presentations, and other course elements to the intellectual property law. Plagiarism check
Course clients' search and registration	Client manager	Course advertisement and promotion on the Internet and social networking sites. Participants' registration and group forming, course schedule. Signing course agreements if necessary
Learning process	Course developer Client-manager	Learning process management. Carrying out communication with participants. Carrying out knowledge assessment. Preparation and issuance of course certificates
Course participants and control system assessment	Course developer	Developing tests and practical tasks. Checking practical course tasks using those ones that include checking course-mates' tasks and peer assessment, along with discussing it on the forum
Course modernization	Client-manager Course developer Content-manager	Carrying out surveys among the participants on course readiness, its design, and usability. Carrying out survey analysis. In case of detecting problems, modifying the course

requirement, the fact that proves that most course developers can monitor independently the observance of intellectual property law. Considering that several teachers have special skills to post independently online course materials on the platform the content manager's role does not have a high rating. The use of ADDIE model, Merrill's principles, Gagné's levels of learning, and Bloom's taxonomy in the online course have the highest rating, which proves that the platform

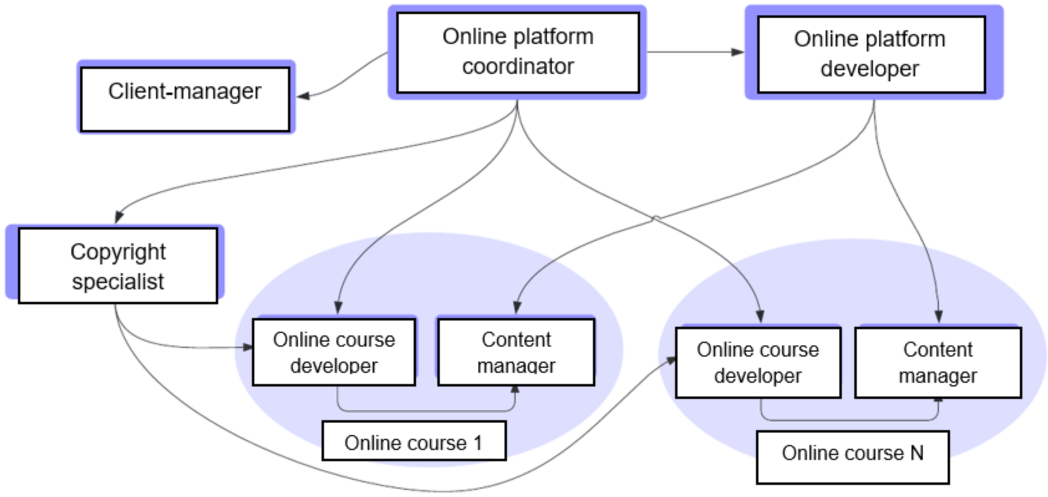

Figure 1: Organizational structure model of managing the online platform "Higher School Mathematics Teacher" [2].

teachers have a certain experience of online course creation and management. Participants of the online platform "Higher School Mathematics Teacher" were given 10 questions, each of which was assessed on a scale from 1 to 5 points. The average rating was calculated using the same method as the previous one. 127 respondents took part in this survey. The survey results are represented in table 4.

The survey participants gave the highest rating to the convenience and quality of the online platform "Higher School Mathematics Teacher", which proves that the model we offered can be successfully put into practice. The participants gave the highest rating to the online platform structure quality and to the quality of representing the text content that is in our opinion very important in the whole area of educational software. The participants gave the lowest rating to the quality of visual design on mobile devices and the convenience of the interactivity system during the course. It stimulates us to work over the improvement of adaptive design for modern mobile devices, the functions of which constantly improve, as well as to search for methods to improve the online course interactivity.

5. Discussion

The actuality of developing a matter of educational online platform management is conditioned by a constant extension of demand for online education.

The authors' idea about using a team model of online management is supported by the researches on the system of online course development process [5], and search for solving problems that students face during online education [6, 8, 21], and research on tutors' preparation for online education and interaction between online platform team members [7, 22, 4]. The research analysis ensured the development of a model to implement an organizational

Table 3
Survey results among team members of the online platform "Higher School Mathematics Teacher"

Question number	Questions	Average rating
1	Convenience of teamwork during online platform development	5,00
2	Convenience of teamwork during online course development	5,00
3	Quality of organizational structure management	4,85
4	Necessity of a coordinator role	4,69
5	Necessity of a content manager role	4,62
6	Necessity of a client-manager role	4,77
7	Necessity of a copyright specialist role	4,38
8	Quality of lifecycle stages of online platform development	4,46
9	Convenience of Scrum methodology while working with the online platform	4,62
10	Necessity to use ADDIE model in the online course	4,38
11	Necessity to use Merrill's principles in the online course	4,38
12	Necessity to use Gagné's levels of learning in the online course	4,38
13	Necessity to use Bloom's taxonomy in the online course	4,38
	On average	4,61

structure of management during online platform creation. As a result of implementing the model developed by the team, an online platform named "Higher School Mathematics Teacher" was created and posted on the Internet; this platform is functioning and developing [2].

While developing the online platform "Higher School Mathematics Teacher" a team of 8-10 participants was engaged, and among them, the roles of a coordinator, platform developer, course developer, and content manager were defined. One participant could perform up to two roles depending on their technical skills. For instance, the platform coordinator created their separate online course and was a course developer, and the platform developer assumed an additional role of a content manager.

One coordinator of all the team members was responsible for the organization of the whole process. Two people were engaged in software development, they took part in the process at the stages of requirements analysis, designing, development, and testing. Three content managers who posted and tested the material together with the developers were determined at the online course posting stage. After posting every online course a copyright specialist carried out an analysis of the conformity of the used materials to the intellectual property law.

Teamwork provided successful development and functioning of the online platform "Higher School Mathematics Teacher"

Table 4
The results of the survey among the participants of the online platform "Higher School Mathematics Teacher"

Question number	Questions	Average rating
1	Quality of online platform structure	4,82
2	Quality of online course structure that was or is learned	4,65
3	Convenience of carrying out knowledge assessment	4,53
4	Convenience of communication with the teacher during the course	4,76
5	Convenience of interactivity system during the course	4,41
6	Convenience of navigation system	4,65
7	Quality of visual design on the computer	4,71
8	Quality of visual design on mobile devices	4,41
9	Quality of presenting graphic, video, audio information	4,59
10	Quality of presenting text content	4,88
	On average	4,64

6. Conclusions

The research on the matter of development and support management of the online platform "Higher School Mathematics Teacher" was carried out in the article. The actuality of the matter to develop the online course management has been proven, which is conditioned by the fact that online education quality depends on the quality of its development and support management, as well as some issues that tutors of the online platform "Higher School Mathematics Teacher" face.

The analysis of scientific researches and resources allowed us to determine the research direction. The role of teamwork in online platform management was explained in the research; the processes of online course development, as well as online course creation and functioning of the platform, are described. The authors of the research recommended determining the leading role of the platform coordinator and formulating their main objectives for the high quality of the online platform management. It is necessary to choose an online platform developer to represent software tools for creation, management, and assessment of the course process, and also for the modernization of the software in the team. The researchers recommended having course developers (teachers or a group of teachers) among team members to design and develop the course content, as well as to manage the learning process. Considering the fact that teachers are not experts in educational design, the authors of the article consider it necessary to have content managers in the team for technical support of content management while creating and using the course. Due to the need to satisfy the clients' needs (educational platform participants), the authors of the course offered to involve a client manager in the process. The necessity to check the course content conformity to the intellectual property law required to introduce the role of a copyright specialist. The rules and models are determined by the researchers and in accordance with them, it is necessary to develop an online platform and create online courses on it. The process of developing the online platform “Higher School Mathematics Teacher” [2] should be carried out according to SDLC rules. Online course creation and functioning should take place in accordance with ADDIE pedagogical model. The management of the assessment system is better to be held following Bloom’s taxonomy. The selection of these models allowed us to represent an online course creation and use process by stages with the description of objectives for every stage and team members’ roles at these stages. As a result of the research, the components and represented model of the organizational structure of online platform management are determined.

The survey responses which were given by the team members of the online platform “Higher School Mathematics Teacher” and online course participants prove the positive results of the model implementation. The analysis of the participants’ responses confirmed the importance of the educational platform management and convenience of teamwork in its implementation. The participants’ high rating of the online platform convenience and quality proved the successful implementation of the model.

The authors of the article consider the direction of further researches in the development of a structural-functional model to design an online course for teachers’ professional development.

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The potential of Google Classroom web service for lecturers of higher educational establishments under pandemic conditions

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Abstract

Researches and publications on using Google Classroom web service for lecturers of higher educational establishments under pandemic conditions are analysed. The current state of higher education under pandemic conditions is characterised. Features of Google Classroom web service have been identified. The methodical development for lecturers of higher educational establishments "Potential of using Google Classroom web service" is described. Criteria and levels of using Google Classroom web service are defined. Initial diagnostic of the levels of using Google Classroom web service was conducted. During the diagnostic was revealed that most respondents have insufficient levels of theoretical knowledge and practical skills. In order to increase the level of using Google Classroom web service, the methodological development was implemented. As a result, positive dynamics in the levels of theoretical knowledge and practical skills of using Google Classroom web service was revealed. The effectiveness of the obtained results was confirmed by Fisher's criterion.

Keywords

Google Classroom web service, cloud technologies, educational process, distance education, higher educational establishment, pandemic, COVID-19, lecturers of higher educational establishments

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1. Introduction

The pandemic of 2020 is a global phenomenon of the 21st century caused by the COVID-19 viral spreading [1]. The pandemic of 2020 has affected absolutely all forms of human interaction and cooperation [2, 3, 4, 5, 6], including higher education [7, 8, 9, 10, 11]. On the one hand, higher education is facing new challenges, and on the other, new opportunities have emerged. Due to introduction of quarantine in Ukraine, the educational process in higher educational establishments is carried out remotely [12, 13]. Some higher educational establishments have successfully practiced distance learning before quarantine [14, 15, 16, 17]. However, most of the main activities were carried out in full-time and/or part-time study mode. Under such conditions of the extreme mode of the higher education system operation during the first months of the pandemic web services for education became especially relevant.

The relevance of using web services in higher education lies in the fact that information technologies not only serve as a tool used to solve specific pedagogical issues, but also add variety to the forms of organization of the educational process, promote the formation of skills of independent learning, stimulate the development of the educational process itself.

A free web service for distance learning Google Classroom combines the following services: Drive, Docs, Gmail, Calendar, etc. and is one of the effective means of solving educational issues [18, 19, 20, 21].

The purpose of the research is to substantiate theoretically and prove experimentally the effectiveness of the methodological development for lecturers of higher educational establishments "Potential of using Google Classroom web service".

According to the purpose of the research the following objectives are defined:

1. To analyse researches and publications on the defined issue.
2. To describe the current state of higher education under pandemic conditions.
3. To identify the features of Google Classroom web service.
4. To describe the methodological development for lecturers of higher educational establishments "Potential of using Google Classroom web service".
5. To define the criteria and levels of using Google Classroom web service.
6. To prove experimentally the effectiveness of the suggested methodological development.

Research methods:

- general scientific methods: analysis, synthesis, comparison, systematization and generalization for studying the works of foreign and domestic scientists, legislative support, etc.;
- specific scientific methods: interpretations to determine the basic concepts of the study, prognostic analysis to determine the prospects for further researches;
- empirical methods: a conversation was used to identify problems in work of lecturers of higher educational establishments related to using Google Classroom web service under pandemic conditions; a survey was used to identify levels of using Google Classroom web service; method of pedagogical experiment was used to study the effectiveness of the described and implemented methodological development for teachers of higher educational establishments "Potential of using Google Classroom web service";

- statistical methods: Fisher‘s criterion is used in order to prove the reliability of the obtained results.

2. Theoretical background

2.1. Analysis of researches and publications on the issue

In order to substantiate the relevance of the study, the authors studied scientific papers that reveal general aspects of using information environments in education, building a single public environment for providing electronic educational services, creating a system of electronic monitoring of the educational process, etc.

The conceptual principles of the cloud-oriented environment at different levels of education are reflected in the researches of Olga V. Bondarenko [22, 23, 24, 25, 26, 27, 28, 29], Valerii Yu. Bykov [30], Olena H. Kuzminska [31, 32, 33], Maiia V. Marienko [34, 35, 36], Oksana M. Markova [37, 38, 39, 40, 41, 42], Nataliia V. Morze [43, 44, 45, 46, 47, 48, 49], Yurii V. Tryus [50], Mariia P. Shyshkina [51, 52, 53], whose works are devoted to the theoretical foundations of designing and using cloud technologies in education. The authors pay considerable attention to the trends of web services and identify advantages and disadvantages of their use in education.

Thus, Mariia Shyshkina and Maiia Popel [54, 55] defined the concept of “cloud-oriented environment” of an educational establishment, identified the main stages of its formation, analysed the content of educational and scientific components of the cloud-oriented educational and scientific environment. Under cloud technologies, most scientists consider an available way to access external computing information resources in the form of services provided through the Internet. A network of interconnected remote servers is a so-called “cloud”.

Tetiana A. Vakaliuk [56] and Kateryna P. Osadcha [57] developed methods of teaching with the use of cloud technologies; prospects for introduction of cloud computing into educational establishments are reflected in the works of Lesya V. Bulatetska [58], Ihor V. Hevko [59], Nataliia V. Valko [60], Hanna B. Varina [61]; Nataliia V. Soroko [62, 63] researched a foreign experience in using cloud computing for teachers’ professional development; Nadiia P. Kozachenko [64], Iryna S. Mintii [65, 66, 67] and Pavlo P. Nechypurenko [68] consider the issues of creating training courses in the Moodle environment on the basis of cloud computing technology and the possibility of their implementation in the educational activities of pedagogical universities.

Creating a cloud-oriented learning environment of an educational institution is examined in the works of Svitlana H. Lytvynova [69, 70, 71, 72, 73, 74], who suggested the concept of “cloud-oriented learning environment”, identified its components, objects, technologies of interaction, distinguished levels of interaction within such environment, as well as stages, methodological approaches, development principles and developed a methodology for designing a cloud-oriented learning environment.

It is worth noting that most scientists define cloud computing as tools to support learning, i.e. interpret this notion according to the definition suggested by experts from the US National Institute of Standards and Technology, who noted that cloud computing is a model of providing convenient access according to the user’s need, regardless of its location and time of access to computing resources (networks, servers, storage systems, databases, services, etc.), which can be provided quickly and with minimal efforts of management and interaction with the IT services provider.

The expediency and necessity of ICT tools introduction on the basis of cloud technologies in Ukraine is declared at the state level and reflected in the national project “Open World” (2010–2014), in the Strategy of Information Society Development of Ukraine for 2013–2020, which provides the formation of modern information infrastructure based on cloud technologies.

Thus, the attention of both researchers all over the world researchers of web services is focused mainly on the issues of forming cloud-oriented informational and educational, learning, educational and scientific environment of higher educational establishments, creating information space, innovative educational IT environment of educational establishments based on Microsoft Office 365 cloud services as tools for organizing the educational process.

However, the potential of Google Classroom web service for lecturers of higher educational establishments under pandemic conditions has not been explored. Thus, the urgency of the chosen issue, its insufficient theoretical development and inconsistency of practical implementation in higher educational establishments under pandemic conditions determined the choice of the topic of the research.

2.2. Characteristics of the current state of higher education under pandemic conditions

Today education is becoming a continuous process that allows a person to navigate information flow, to feel comfortable in the information society, to adapt easy to continuous technical innovations.

According to Olena Hrashchuk, “education is a strategic resource of socio-economic, cultural and spiritual development of society, improvement of the welfare of population, ensuring national interests, strengthening international prestige, forming a positive image of the country, strengthening its competitiveness on the international stage, creating conditions for human self-realization” [75].

The study “Rethinking Education in the Digital Age”, conducted by the European Parliament in 2020, states that the rethinking of education in the digital age should become a central issue for modern politicians for two reasons:

- firstly, only education can form a skilled workforce, ready for future profession and changeable labour market. Therefore, rethinking education in the digital age is a prerequisite for future global competitiveness of Europe;
- secondly, only education can provide the preconditions for social integration and equality; participation of the European citizens in digital democracy [19].

Thus, rethinking education in the digital age is important for protection the European values such as equality, democracy and the rule of law.

In 2019, the staff of Ivan Zyazyun Institute of Pedagogical and Adult Education (Ukraine) conducted an online questionnaire of lecturers concerning the use of network technologies in professional activities. The results of the questionnaire showed that all respondents (185 people (100%)) use a personal computer (PC) and the Internet in their professional activities. However, 7.0% of respondents use mobile devices that do not have the ability to connect to the

Internet, which significantly limits the work with files located in cloud storage. The majority of respondents (85.9%) work on a PC with the Windows operating system, and 14.0% work on two or more PCs with different operating systems. Five applications of the seven listed are used by respondents in professional activities: Word (100%), PowerPoint (78.3%), Excel (71.3%), OneDrive (21.6%), OneNote (7.0%)). Respondents do not use Sway and Outlook applications. 14.3% of respondents use other applications. It should be noted that the questionnaire involved people from 21 and over 60 years. This means that using digital technologies is relevant in professional activities regardless of age.

Digital technologies have become especially relevant during the pandemic, as there were some difficulties with the introduction of distance learning.

The first problem is related to the technical support of both lecturers and students. Lack or improper state of computer equipment, the Internet (for example in rural areas) make it impossible to apply distance education. Another problem is software. Even with necessary technical equipment, software installation for distance education is difficult for users. These problems need to be addressed as a matter of priority. But, as it turned out, these are not the main problems of distance education. In our opinion, the problem of methodical training of lecturers for distance education under pandemic conditions is also important. Distance education requires special training of lecturers because teaching methods that are suitable for full-time education are not suitable for distance one. Therefore, often all classes are held in the form of a monologue by lecturer and independent work by a student. Resolving this issue is an urgent problem.

However, for teachers, distance education has a number of advantages and they are quite significant. This is an opportunity to improve skills online (saving time and money, especially when it comes to foreign internships, training, etc.), an opportunity to reach a larger audience during conferences, webinars, etc., an opportunity to hold joint meetings of departments, councils, etc. and quickly resolve organizational and other issues. In addition, the introduction of cloud technologies into educational process of university provides: efficient use of educational space, as there is no need to allocate separate and specially equipped premises for traditional computer classes; qualitatively different level of gaining modern knowledge, students have an opportunity to be involved in educational process at any time and in any place, where there is the Internet; an ability to create quickly, adapt and replicate educational services during the educational process; an opportunity for students to provide feedback to a lecturer by evaluating and commenting on the offered educational services.

As a result, digital technologies have become an integral part of the higher education system. The technical capabilities of digital technologies together with the creative and intellectual potential of lecturers allow to raise education to a new level that meets the demands of modern society.

2.3. Features of Google Classroom web service

Today, lecturers and students have access to many competing sources: digital educational resources, curricula, online courses and various online services, etc. In our study, we suggest analysing the potential of Google Classroom web service.

Google Classroom is a unique Google application designed specifically for educational purposes. Google Classroom web service performs functions of methodological, software, technical, informational and organizational environment.

The active use of Google Classroom, which has existed since 2014, began at the time, when educational establishments on a nation-wide and world-wide scale were forced to stop the process of face-to-face learning. The statistics on using Google Classroom during coronavirus are quite convincing. According to BBC News, as of March 30, 2020, the number of downloads was more than 50 million, but until March 2000 Google Classroom was not even in the top 100 educational applications.

The main goal of Google Classroom service, which has an interface in 38 languages, is to optimize and ensure the efficiency of the educational process. Google Classroom web service does not require special software. The attractiveness of this service is also its non-commercial basis and lack of advertising.

In Google Classroom, lecturers can easily create and check tasks, mark, comment and organize effective communication in real time or in distance learning mode. In addition, Google Classroom provides a user-friendly interface for creating and managing training courses, organizing project activities and has great educational potential.

We consider that the main advantages of the cloud technology are high speed data processing, availability from any personal device, data storage on the network, including Google Drive, great potential, educational process management, control and correction of results, data accumulation, etc. It is important to have access to our own materials from any place in the world, to keep information up-to-date, and to expand the opportunities for learning at home.

However, for objectivity of valuation of Google Classroom web service capabilities one should notes its disadvantages. The main disadvantage of the service is the constant need to be on the Internet to work as well as inconvenience of creation of test tasks; lack of ability to check oral assignments (in particular, in the process of learning a foreign language, where oral speech is one of the key skills); lack of real-time communication and lack of a webinar room; lack of possibility to join participants of educational process after the beginning of courses; lack of opportunity to create separate groups within one course; lack of electronic gradebook in the open version of Google Classroom (for corporate users this feature is provided); limited number of participants – 250 people.

In general, all available technical capabilities of the service provide the formal side of learning, while the creative and intellectual potential of a lecturer and a student often remains undiscovered.

2.4. Methodical development "Potential of using Google Classroom web service" for lecturers of higher educational establishments under pandemic conditions

The Google Classroom web service is a tool for organizing distance learning, project activities in higher educational establishments. All one needs to work with Google Classroom is to connect to the Internet or a browser. Lecturers and students of higher educational establishments, who have personal Google Accounts can use Classroom for free. The only condition is to register your own mailbox in Gmail and get an access key. Google Classroom supports new versions of major browsers depending on their updating. There are no problems with access from mobile devices based on Android and Apple iOS that is especially convenient for most students, who actively use smartphones. The service is secure because there is no advertising and students' materials and information are not used for advertising purposes.

With the help of Google Classroom, a lecturer can create training courses and add students, share educational and methodological materials, create tasks, check the level of students' knowledge, organize thematic discussions. After activating a function "create class", a lecturer must set up the basic settings: class name; course description; room, etc. At this stage, each class is given a unique code by which students can find it and gain an access.

The next step is to set the options that will be provided for students. Depending on the form of students' activity provided by a lecturer within the class, one can give them an opportunity to publish posts, make comments, etc. Everyone, who joins the class is displayed in the list of students. However, there is a certain disadvantage, which is that students use nicknames instead of real names in the registration form. That is why sometimes it is difficult to find a student on the list. This disadvantage can be easily corrected by creating a culture of business communication, in which using fictitious names is inappropriate. At the end of the semester, one can delete the list of students and create a new one, the content of the course remains.

When working with a web service, a lecturer should pay attention to the sections "Stream", "Classwork", "People", "Marks". The Stream tab in the Google Classroom app displays tasks and posts related to the course (discipline). To work with the task, a lecturer can give brief instructions on how to work with it, topic, deadline, attach a task template (add from Google Drive) and choose it for students. The algorithm of actions, when "creating a task" is the following one.

On the classroom desktop, we choose "Classwork" section. Users will see a list of tasks, which is marked as "+ Create": assignments, quiz assignments, questions, material, reuse post, topic. It is recommended to group objects in this feed by topic. Also, in the application there is a possibility of their arrangement in a convenient order for lecturers and students. For example, a lecturer plans to add educational content (lecture). He can easily download it. Students will receive a notification in the form of a message about updates and access to educational materials.

When creating a task – select the buttons "Create" "Assignments".

A window will open, in which you need to enter the title of the task, instructions for its performance, add material or create it.

When you click on the button "Add", there is a transition, which suggests a location of the folder for material attachment: from Google Drive, Links, File, YouTube.

The user can select the button "+ Create", which suggests several options for creating a task in the form of: Docs, Slides, Sheets, Drawings, Forms.

After receiving an assignment, a student processes it, selects the section "Perform", adds or creates a document and opens it. The name of the opened file will indicate name, surname of the student and the title of the assignment, which a lecturer has prepared in advance. The student answers the assignments, performs test tasks and clicks the button "Mark as done". If the whole algorithm is performed correctly – the status "Submitted" appears, after checking – "Checked" and "Marked", for example: 4/5, 90/100, 186/200.

At the same time, lecturers have an opportunity to mark, comment and organize effective communication in real time or in distance learning mode. Here is an example of using Google Classroom in classes on the subject "Pedagogical Innovation Studies", which is studied by higher education students on specialty 013 Primary Education of Vasyl Stefanyk Precarpathian National University. Since the educational course is aimed at forming a creative personality of the future teacher, who is professionally developing within the conditions of new Ukrainian education, it is necessary to teach future professionals to navigate in different systems, technologies, methods, adequately evaluate them, make optimal choices in the way of implementing author's innovative technologies in the educational process of the New Ukrainian School. For example, we suggest students to write argumentative essays on educational topics ("Morning Meetings at the New Ukrainian School: what is it and for what reason?", "Development of critical thinking of students in the context of interactive learning", "In Order to Think Critically, Students Must:...?"; essays ("Educational Establishment of My Dream", "Online Education: Pros and Cons"), prepare scientific reports ("Digital Literacy of Primary School Teachers", "Elements of STEM-Education in Primary School"), make a plan of integrated lessons. Students also receive links to videos (video lessons) posted on YouTube.

Example of assignment with link to videos:

Task: Watch the video. Answer the questions:

- Is the teacher‘s algorithm effective during explaining new material?
- What forms of work does the teacher use in class?
- Are the used forms of work effective during studying the topic?
- Has the goal of the lesson been achieved?

This allows to visualize a particular material, a student not only processes the content, as when working with the text, he can analyse an information context, an emotional presentation and perception of information.

The described experience of approbation of the suggested methodical development proves that Google Classroom web service allows to use in educational process actual video materials by placing assignments with a link to video. This contributes to the visualization and individualization of the educational process. Communication becomes more productive, because students can view topic materials, videos and photos before the lecture. The most important is the fact that implementation of the development promotes more effective communication between lecturer and students, does not require special conditions for studying (the use of multimedia classrooms, additional equipment), and exchange of comments and questions becomes possible before the meeting and motivates students to classroom activities.

Using Google Classroom web service during practical classes allows a lecturer to make interactive control over tasks performance. A combination of opportunities to comment on tasks and the service "Announcements" simplifies students' work with individual assignments. Google Classroom simplifies task verification. Google Classroom allows one to make student's gradebook as a separate Google Docs document. An additional convenience of using Google Classroom in the learning process is that a lecturer can specify deadline for task performance, providing higher scores for its timely completion and lower for late one.

It is advisable to pay attention to the fact that working in Google Classroom is an important requirement to place materials on topics, blocks, modules. Experience shows that insufficiently structured information only overloads students and does not produce the proper learning effect. The term of the task is indicated by the lecturer, but the service itself controls timely/untimely performance.

2.5. Criteria and levels of use of Google Classroom web service

The described above methodical development was suggested to lecturers of The National Pedagogical Dragomanov University (Ukraine), National Aviation University (Ukraine) and Vasyl Stefanyk Precarpathian National University (Ukraine) for use in professional activities under pandemic conditions. Since the quality of using Google Classroom web service is an important issue in the professional activities of lecturers, it was considered necessary to determine the criteria for effective using Google Classroom web service.

The criteria determining allows one to obtain qualitative and quantitative indicators of the studied process or phenomenon. A criterion is a feature on the basis of which evaluation, distinguishing or classification are carried out. Only in the presence of criteria it is possible to draw a conclusion about desirable, the best results of pedagogical influence.

Taking into account the features of Google Classroom web service, we have defined the following criteria for its effective use: the level of theoretical knowledge about Google Classroom web service and the level of practical skills of using Google Classroom web service.

Theoretical knowledge about Google Classroom web service. Studying the theoretical foundations of using Google Classroom web service will help to form a holistic view of the essence of this web service and determine necessary conceptual and categorical apparatus. Theoretical knowledge of Google Classroom web service is the basis for effective professional practice that can be properly directed, updated, and improved. Thus, in order to involve use of Google Classroom web service in professional activity of lecturers, it is necessary to comprehend it in theoretical categories.

The basic knowledge that a lecturer must gain in the process of mastering Google Classroom web service can be combined into two groups: knowledge of the essence of Google Classroom web service and knowledge of the specifics of the educational process using Google Classroom web service.

It is appropriate to determine the level of lecturers' mastering theoretical knowledge about Google Classroom web service using a control method. We consider method of written control, which consists in making a questionary, the most convenient one.

Practical skills of using Google Classroom web service. The effectiveness of lecturers' professional activities depends, among other things, on skills and abilities required for successful use of Google Classroom web service.

The level of use of Google Classroom web service depends on availability of the following skills: the ability to create a Gmail Account, create your own class/course, and invite students to the class; provide students with a class/course access code; publish information in the "stream", i.e. in the information line; download assignments (or create a test); check tasks and mark, etc.

The defined criteria of the effectiveness of using Google Classroom web service (theoretical knowledge of Google Classroom web service; practical skills of using Google Classroom web service) made it possible to distinguish their levels.

It should be noted that there are at least two main classifications to determine expressiveness of particular object in pedagogy: by number of features and level of development. The latter classification is characterized by differences not only in components but in their degrees of expression (degrees of formation).

This classification is based on matrix analysis (a method of studying relationships using matrix models, which is based on the mathematical theory of matrices). The essence of this analysis is that from a set of factors, parameters and other important characteristics of the system, the two most important are selected, and the characteristic of the system that should be determined, is considered as a function of these two variables. Using two variables, one can clearly present the result of the analysis in the form of a table (matrix) or in graphical form.

Thus, the effectiveness of using (EU) the Google Classroom, as we noted, is determined by two criteria: theoretical knowledge of the Google Classroom (TK); practical skills of using Google Classroom web service (PS). Thus, the efficiency of using Google Classroom web service corresponds to formula 1.

$$\text{EU Google Classroom} = \text{TK} + \text{PS} \tag{1}$$

Kindly note that each criterion has the indicators, which are described above. Therefore, these indicators are a priori included in the criteria. Further, for each of these two parameters, we introduce two degrees of expressiveness that are levels of use of the Google Classroom web service (insufficient and sufficient).

Thus, having two criteria for effectiveness of using Google Classroom web service (theoretical knowledge about Google Classroom web service and practical skills of using Google Classroom web service) and two degrees of their expression (insufficient and sufficient) one gets 2×2 matrix and, accordingly, 4 options of effectiveness of using Google Classroom web service:

1. Sufficient level of theoretical knowledge and sufficient level of practical skills.
2. Sufficient level of theoretical knowledge and insufficient level of practical skills.
3. Insufficient level of theoretical knowledge and sufficient level of practical skills.
4. Insufficient level of theoretical knowledge and insufficient level of practical skills.

The matrix simultaneously takes into account all possible options for using Google Classroom web service, which provide the presence of two criteria for possible two levels of each criterion.

This matrix allows one to see the prevailing criterion for using Google Classroom web service.

3. Experimental verifying the effectiveness of the methodological development for lecturers of higher educational establishments under pandemic conditions "Potential of using Google Classroom web service"

To prove the effectiveness of the described and implemented methodological development, we used a pedagogical experiment.

The study was conducted on the basis of the National Pedagogical Dragomanov University (Ukraine), National Aviation University (Ukraine) and Vasyl Stefanyk Precarpathian National University (Ukraine), where the methodological development was introduced, and provided three stages:

The first stage is the initial diagnostic of the levels of using Google Classroom web service.

The second stage is introduction of the methodological development for lecturers of higher educational establishments under pandemic conditions “Potential of using Google Classroom web service”.

The third stage is control diagnostic of the levels of using Google Classroom web service.

The experiment covered 87 teachers of higher educational establishments.

In order to determine the levels of using Google Classroom web service, the following have been developed:

- a questionnaire to determine the level of theoretical knowledge about web services (in particular Google Classroom);
- a questionnaire to determine the level of practical skills in using Google Classroom web service.

These uniquely designed questionnaires allowed us to analyse the levels of using Google Classroom web service, describe the state of the problem and describe the methodological development for lecturers of higher educational establishments under pandemic conditions “Potential of using Google Classroom web service”. For objectiveness during the questionnaire, a representative sample of respondents was formed, a formalized induction procedure was used, and the anonymity of the answers was ensured.

The author’s questionnaire for determining the level of theoretical knowledge about web services (in particular Google Classroom) consisted of 10 questions. All questions had multiple choice answers. Two or more correct answers had to be chosen for certain questions.

For each correct answer 1 point was awarded. Then, the total number of points was calculated (5–10 points made up sufficient level of theoretical knowledge; 0–4 points made up insufficient level of theoretical knowledge).

In order to determine the levels of practical skills of using Google Classroom web service, respondents were asked to perform uniquely developed 5 practical tasks. The level of practical skills was assessed as follows: correctly completed two tasks out of five indicated insufficient level of practical skills; three or more correctly completed tasks indicated sufficient level of practical skills.

At the first stage of pedagogical experiment in March 2020, lecturers of higher educational establishments under pandemic conditions were invited to take online entrance diagnostic of the levels of using Google Classroom web service.

Generalized results of determining levels of theoretical knowledge and practical skills of control and experimental groups are presented in table 1.

The analysis of the answers showed that some questions made difficulties for lecturers.

In particular, the majority of 56 lecturers (64.3%) did not know that Google Classroom service can be used for distance education. Almost all respondents – 81 people (93.1%) do not know about possibility of joint teaching with other lecturers in Google Classroom. 65 people (74.7%) cannot provide a complete list of actions that can be performed in Google Classroom. 69 people (79.3%) were confused in task evaluation system. 73 people (83.9%) do not have knowledge of the algorithm for creating tasks in Google Classroom. 58 people (66.6%) are not familiar with the rubrics.

Table 1
Levels of theoretical knowledge and practical skills at the stage of entrance diagnostic

Criterion	Level	Points	CG (46 people)	EG (41 people)	Total (87 people)
Theoretical knowledge	Sufficient	5-10	18 (39.1%)	16 (39.0%)	34 (39.0%)
Theoretical knowledge	Insufficient	0-4	28 (60.9%)	25 (61.0%)	53 (61.0%)
Practical skills	Sufficient	5-10	11 (23.9%)	8 (19.5%)	19 (21.8%)
Practical skills	Insufficient	0-4	35 (76.1%)	33 (80.5%)	68 (78.2%)

In terms of practical skills, the majority of respondents 82 people (94.2%) are able to create Gmail Account. However, 59 people (67.8%) could not create their own class/course. Accordingly, most respondents were unable to perform other tasks properly.

Thus, the majority of respondents, namely 53 people (61.0%) do not have enough theoretical knowledge to work with Google Classroom service. And only 34 people (39.0%) have sufficient level of theoretical knowledge. A similar situation is with practical skills because 68 people (78.2%) have insufficient level of practical skills and 19 people (21.8%) have sufficient one.

Based on the matrix and the obtained results, you can see minimum and maximum values (figure 1). Thus, we can conclude that only 19 people (minimum value) out of 87 effectively use Google Classroom service and 68 people (maximum value) do not have enough knowledge and skills to use the service effectively.

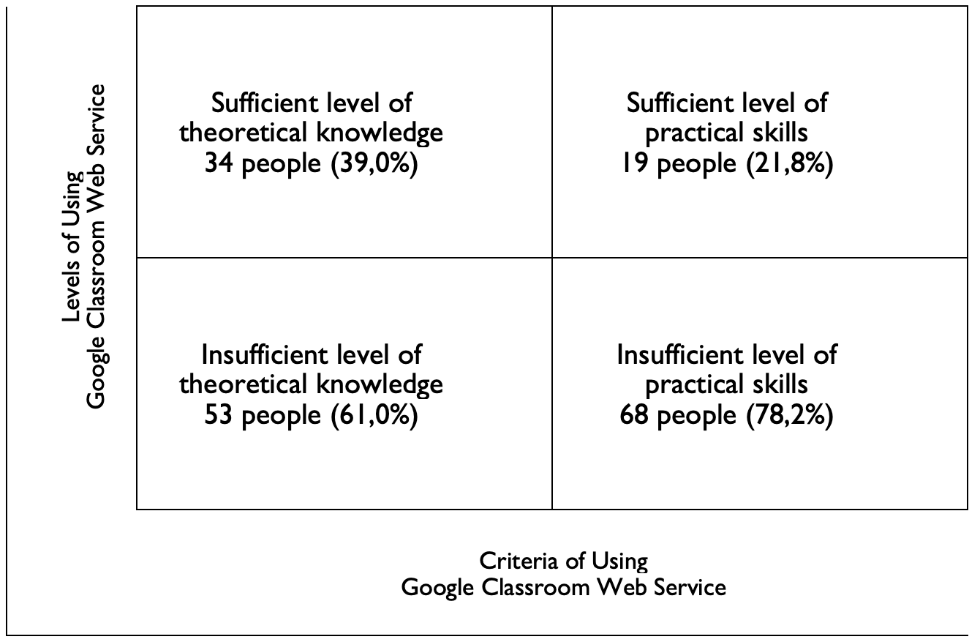

Figure 1: Matrix of effectiveness of using Google Classroom web service

The next stage of the experiment involved the introduction of the methodological development for lecturers of higher educational establishments under pandemic conditions "Potential of using Google Classroom web service". To this end, the authors of the publication conducted online webinars for lecturers, where the methodological development was presented. Each participant of the webinar (41 members of the experimental group) received a detailed description of the methodological development in PDF in order to be able to repeatedly return to it in the process of mastering the specified web service. The second stage lasted for several months (April – June 2020).

At the last stage of the experiment (in September 2020), the control diagnosis of the levels of using Google Classroom web service was performed. Diagnosis was carried out using the methodological tools used at the first stage. The questionnaire covered teachers of control and experimental groups.

The results of determining the levels of theoretical knowledge and practical skills of control and experimental groups at the stage of control diagnosis are presented in table 2.

Table 2
Levels of theoretical knowledge and practical skills at the stage of entrance diagnostic

Criterion	Level	Points	CG (46 people)	EG (41 people
Theoretical knowledge	Sufficient	5-10	21 (45.7%)	32 (78.0%)
Theoretical knowledge	Insufficient	0-4	25 (54.3%)	9 (22.0%)
Practical skills	Sufficient	5-10	16 (34.8%)	34 (82.9%)
Practical skills	Insufficient	0-4	30 (65.2%)	7 (17.1%)

The results of the questionnaire at the stage of control diagnosis in the experimental group revealed positive changes in levels of theoretical knowledge and practical skills of using Google Classroom web service. In particular, the number of people with sufficient level of theoretical knowledge increased from 16 to 32 people out of 41. The number of people with sufficient level of practical skills also increased significantly from 8 to 34 people.

However, the results did not change significantly in the control group. The number of people with sufficient level of theoretical knowledge increased from 18 to 21 people. The number of people with sufficient level of practical skills increased from 11 to 16 people. It is assumed that the respondents of the control group had chosen other web services to organize the educational process under pandemic conditions or communicated with students via e-mail.

The dynamics of changes in levels at different stages of diagnosis is summarized in figure 2.

To prove the effectiveness of the obtained results Fisher's criterion was used.

According to the indicators of entrance stage diagnosis, the number of respondents in the experimental group with sufficient level of theoretical knowledge and practical skills in average $(16 + 8) : 2 = 12$ people 29.26% of 41 people (100%). At the control stage of diagnosis, the number of respondents in the experimental group with sufficient level of theoretical knowledge and practical skills was $(32 + 34) : 2 = 33$ people (80.48%) out of 41 people (100%). This dynamics in the levels made it possible to formulate two hypotheses:

H_0 – The number of respondents in the experimental group with sufficient level of theoretical knowledge and practical skills at the entrance stage of diagnosis is less than at the control stage of diagnosis. This allows one to consider that the suggested and implemented methodological

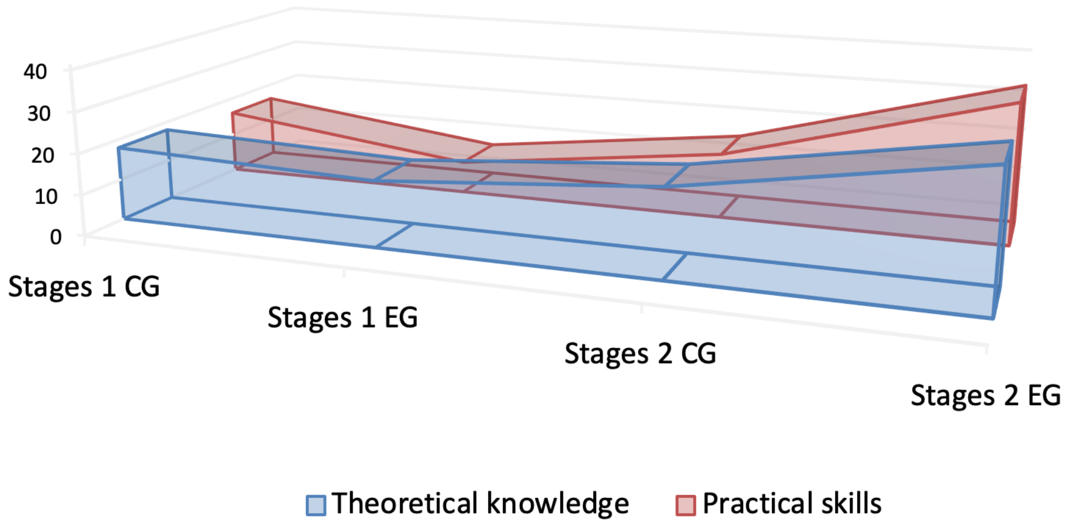

Figure 2: Dynamics of changes in the levels of theoretical knowledge and practical skills of using Google Classroom web service at different stages of diagnosis

development is effective.

H_1 – The number of respondents in the experimental group with sufficient level of theoretical knowledge and practical skills at the entrance stage of diagnosis is the same or more than at the stage of diagnosis. This allows one to consider that the suggested and implemented methodological development is not effective.

Using formula 2 calculate the empirical value φ^*_{emp}:

$$\varphi^*_{emp} = (\varphi_1 - \varphi_2)\sqrt{\frac{n_1 n_2}{n_1 + n_2}},$$

in which: φ_1 – the angle corresponds to the greater % of the part; φ_2 – the angle corresponding to the smaller % of the part; n_1 – quantity of observations in sample 1; n_2 – quantity of observations in sample 2.

Thus, get the empirical value: $\varphi^*_{emp} = 4.89$.

Determine the critical value of φ^*, which corresponds to the accepted in psychology levels of statistical significance:

$$\varphi^*_{cv} = \begin{cases} 1.64 \ (\rho \leq 0.05) \\ 2.31 \ (\rho \leq 0.01) \end{cases}$$

$$\varphi^*_{emp}(4.89) > \varphi^*_{cv}(2.31).$$

Since φ^*_{emp} is in the value range, we can conclude that hypothesis H_0 has been confirmed. The number of respondents in the experimental group with sufficient level of theoretical knowledge and practical skills at the entrance stage of diagnosis is smaller than at the control stage of diagnosis. This allows one to consider that the suggested and implemented methodological development is effective.

4. Conclusion

The COVID-19 pandemic, one way or another, has affected all areas of human life. Higher education is one of the areas that was significantly affected. In an extremely short period of time, higher education establishments were forced to switch to distance or blended learning. As a result of quarantine measures caused by the spread of the COVID-19 pandemic, there was a need for a radical change in forms and methods of learning, methods of interpersonal communication and system of organization of the educational process. Under the conditions of pandemic the following aspects of using cloud technologies in the educational process of the universities became of great importance: information and training portals, which include the joint work of lecturers and students on educational projects; personal account of a teacher and a student; creation of new platforms; webinars conducting.

One of the effective and high-quality means of solving educational issues in quite extreme conditions is Google Classroom web service.

Thus, Google Classroom web service, as any cloud technology used in the educational space, has its advantages and disadvantages. The methodical development "Potential of using Google Classroom web service" described by the authors and implemented in higher education establishments allows one to effectively use Google Classroom web service in the educational process. Google Classroom should be used in conjunction with other applications, for example, Google Meet. In particular, it is recommended to conduct online lectures and online workshops (seminars) in Google Meet and to check students' knowledge (tests, written practice, etc.), upload lectures, educational materials etc. in Google Classroom. Google Classroom web service under pandemic conditions is used as the main environment for education, whereas before the COVID-19 pandemic, Google Classroom web service was only a supplement (one of the teaching methods) to distance education.

Based on the defined criteria (the level of theoretical knowledge about Google Classroom web service and the level of practical skills of using Google Classroom web service) and their levels (insufficient and sufficient), a matrix of efficiency of using Google Classroom web service was built. The matrix allowed us to see the minimum indicators of the criteria, which were further developed with the help of the author's methodological development. The revealed positive dynamics in the levels of theoretical knowledge and practical skills of using Google Classroom web service confirmed the effectiveness of the obtained results.

The research does not cover all aspects of the problem. Further researches should be focused on the following issues: problem of the impact of Google Classroom web service on students' achievements; foreign experience in preparing lecturers to use Google Classroom web service; problem of improving and filling disciplines with the help of Google Classroom web service etc.

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Formation of informational and digital competence of secondary school students in laboratory work in physics

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Abstract
The article deals with the formation of informational and digital competence of high school students. First and foremost, the existing digitalization strategies for society already approved in the world and in Ukraine, including the implementation of STEM education and the Digital Agenda, are considered. On the other hand, attention is paid to the inconsistency of the level of ownership and frequency of use of digital technologies with the requirements of these initiatives. The concept of informational and digital competence is analyzed in detail. Existing publications identify key components, skills and competencies required to achieve this competence. A survey is conducted to better understand the current situation. One of the tasks is to determine the level of use of digital information in the classroom by teachers and in students' preparation at home. The second task was to show how developing students' informational and digital competence can be done by active introduction of existing software and hardware in the educational process in physics, in particular, a laboratory workshop. The example of laboratory work carried out in educational institutions shows how modern software can be used to analyze the movement of bodies and determine the physical characteristics of this movement. The concrete ways of performing laboratory work, analyzing its results and drawing conclusions are given. It is in the combination of existing teaching practices with modern gadgets, specialized and general programs that the basic way of forming informational and digital competence is seen. Further ways of modernization and improvement of described methods for increasing the level of information and digital competence are proposed.

Keywords
Informational and digital competence, training programs, laboratory practicum,

1. Introduction

The rapid introduction of digital media in every area of life and the daily need for their use have become a prerequisite for the successful development of society and a comfortable human life. Many professions require a certain level of digital skills [1]. The forum "Digitalization: business talk, open opportunities", dedicated to topical issues of implementation of digital transformations and development of the digital economy in Ukraine, emphasized that digitization of the country should be comprehensive, not local[2]. A "shallow" approach to the use of digital technologies

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will not help to gain significant benefits for the economy and citizens of Ukraine. Instead of selective digitization that improves the quality of certain systems or spheres of citizens' lives, Ukraine should move towards a full and inclusive transition to digital technologies. Ukraine takes an active role in implementing and initiating government programs that aim at building digital competencies, especially in the fields of education and science. The concept of development of the digital economy and society of Ukraine for 2018-2020 and the plan of measures for its implementation envisages the development of digital infrastructure and its large-scale implementation in the education system [3]. The Digital Agenda of Ukraine 2020 states: "Outdated teaching methods, lack of teaching standards and properly trained teachers, and the inaccessibility of digital technologies for the educational process have led to extremely low levels of digital literacy in all existing segments of the public education system (preschool, primary, secondary, higher). ... This approach does not meet current requirements, is not cross-platform and has very doubtful results" [4]. Therefore, the New Ukrainian School should form the informational and digital competence that the European Parliament and the Council of the European Union in 2006 called a key component of lifelong learning, which involves active daily use of digital technologies [5]. Moreover, more than 50 digital professions will appear in the public register, and the number of students of general secondary education institutions with STEM specialties will quadruple. Digital teaching and learning is being gradually introduced in Ukraine and considered under the Education and Training 2020 strategic program [6].

Ukraine has favorable conditions for the introduction of STEM education. The resolution of the Ministry of Education and Science of Ukraine "On the foresight of sociological and economic development of Ukraine in the medium-term (until 2020) and long-term (until 2030) time horizons (in the context of human capital training)" is confirmed [7]. Also a powerful state institution, the department of STEM education at the Institute of Modernization of the Content of Education of the Ministry of Education and Science of Ukraine, was created and operates. Ukraine adheres to the international educational standards of quality in the Natural Sciences. The use of STEM learning tools is conditioned by psychological, pedagogical, organizational-methodological, logistical and ergonomic factors [8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31]. That contributes to the development of students' research activity and forms their informational and digital competence. On May 22, 2018, the Ministry of Education and Science approved the "Regulations on the National Educational Electronic Platform", the main goals of which are: technological support for the secondary education reform "New Ukrainian School"; provision of educational process participants with up-to-date electronic educational resources and services; free provision of e-textbooks for the students; creation of favorable environment for development of national production of electronic educational resources, services and e-textbooks; development of e-learning and formation of digital competence of participants in the educational process in Ukraine [32].

In June 2019, at the invitation of Hi Tech Office Ukraine, a representative of the State Innovative Financial and Credit Institution participated in an expert working group on "Digitalization of Education", which discussed the main problems and prospects of implementing digitalization in real life. The discussed problems concerned providing the conditions for creating National Coalitions for Digital Skills; involvement in European digital skills development initiatives; implementation of the Digital Agenda and the development of a digital education and digital skills system based on EU experience [4]. On June 6, 2019, the presentation of the concept of a national digital education project, designed to promote school education in a globalized world, took place. “The concept behind the project is to create a state-of-the-art digital school for any child from anywhere in the world. The school issues a state certificate of complete secondary education. The Digital School is a multifunctional educational digital information service in which a student can be trained in remote access”. Such a form will help talented children who are ahead of the school curriculum and address the issue of access to educational resources for children living in remote areas, rural areas or outside Ukraine [33].

These and a number of other initiatives and projects are focused on building digital competences, being components of the reform of Ukrainian education and the basis of a sound national digitalization policy. However, there is some distance between the development of society and the level of ownership of digital technologies, and previous researchers do not study the problem of forming and assessing the level of information and digital competence of students of general secondary education in the context of digitalization of society.

Our studies have shown that the problem of digital and informational competence formation was engaged in Svitlana M. Amelina [34], Albert A. Azaryan [35], Zinaida P. Bakum [36], Nadiia R. Balyk [37], Olga V. Bondarenko [38], Valerii Yu. Bykov [39], Olean O. Gritsenchuk [27], Anna V. Iatsyshin [40], Alla A. Kharkivska [41], Hennadiy M. Kravtsov [42], Olena H. Kuzminska [43], Svitlana H. Lytvynova [44], Oleksandr S. Martyniuk [45], Mariia S. Mazorchuk [46], Yevhenii O. Modlo [47], Natalia V. Moiseienko [48], Yuliia H. Nosenko [49], Oksana V. Ovcharuk [50], Svitlana V. Shokaliuk [51], Nataliia V. Soroko [52], Andrii M. Striuk [53], Svitlana O. Sysoieva [54], Rostyslav O. Tarasenko [55], Iryna M. Trubavina [56], Kateryna V. Vlasenko [57], Vasyl V. Yahupov [58] and others.

3D mapping technology of digital competence in the education system of Ukraine has been proposed by Morze et al. [59]. The developed 3D mapping reflects the tendency of understanding by teachers and students of higher education institutions and teachers of secondary schools of basic current educational trends, the use of innovative pedagogical technologies and digital tools in the educational process.

Researchers mostly refer to the Digital Agenda of Ukraine 2020, DigComp Digital Competence Framework [60] and Development Concept of digital economy and society of Ukraine for 2018-2020. Problem of formation and assessment of the level of informational and digital competence of students in secondary education has not yet found a holistic solution.

The purpose of the article is to outline the main problems of forming the level of informational and digital competence of students of general secondary education; to analyze the student questionnaire results to determine the level of use of informational and communication technologies and modern electronic gadgets in Physics classes; development of methodology and technique of using cross-platform programs for improvement and modernization of educational experiment in Physics.

2. Theoretical backgrounds

In the period of intensive development of digital technologies, among the key competencies [61, 62, 63, 64], the informational and digital competence is a priority. Specialists in different industries must have informational and digital competence. The concept of competence approach, laid down in the National Qualifications Framework, provides for conditions that ensure that national education is in line with current market requirements. The definition of "informational and digital competence" is constantly in the discussion field for both foreign and domestic educators. In sources, concepts and terms used by the international pedagogical community defining informational and digital competence as knowledge, skills, personal abilities in the field of information and communication technologies. The adoption of the Digital Agenda by the European Commission in 2010 set out goals, one of which is to raise the level of ICT practitioner skills of European citizens, including digital and media literacy, e-skills. Common terms of it nowadays are digital literacy (digital fluency), ICT skills, ICT literacy, ICT competence, media literacy, information literacy, communication competence [65]. By informational and digital competence we mean the ability to use the available informational and digital tools to obtain, process, disseminate and store the necessary information. Until recently, the most common considered competencies are used for mastering informational and digital competence. Among them:

1) the ability to systematize and summarize information found on-line;
2) the ability to read and understand in a dynamic and inconsistent hyper-textual environment;
3) the ability to construct information bases from various sources, relying on the ability to gather and evaluate facts and statements without prejudice;
4) search skills;
5) the ability to manage "multimedia flow" using information filters and agents;
6) the ability to create a "personal information strategy" and implement a portfolio approach with the selection of sources and delivery mechanisms;
7) an awareness of collaboration with other participants in the process and the ability to find contacts with them to discuss issues and get help.

Informational and digital competence consists of two components: general and professional. They can be represented in the form of cognitive activity (level of knowledge formation about information and ways of its transformation, cybersecurity, digital resources and possibilities of their use), procedural and motivational (leading motives that determine ways of reaching informational and digital competence), organizational and constructive (the level of ability to organize educational activities using informational and digital resources and the ability to engage subjects of study in educational activities), emotional and communicative (degree of communication skills and emotional attitude to the learning process), information (ability to work with educational and scientific information), reflexive and diagnostic (willingness to assess their knowledge and skills at each stage) components of informational and digital competence (figure 1).

There are a number of approaches to the design and assessment of digital competencies in modern methods. For example, Balyk and Shmyher [66] are proposing to shape this process by developing new digital content and creating a digital educational environment for partnerships between participants in the educational process.

A DigComp digital competence framework has been created to support the development of digital competence for European citizens [60]. It outlines what competencies are needed today to use digital technology in a confident, critical, collaborative and creative way to achieve

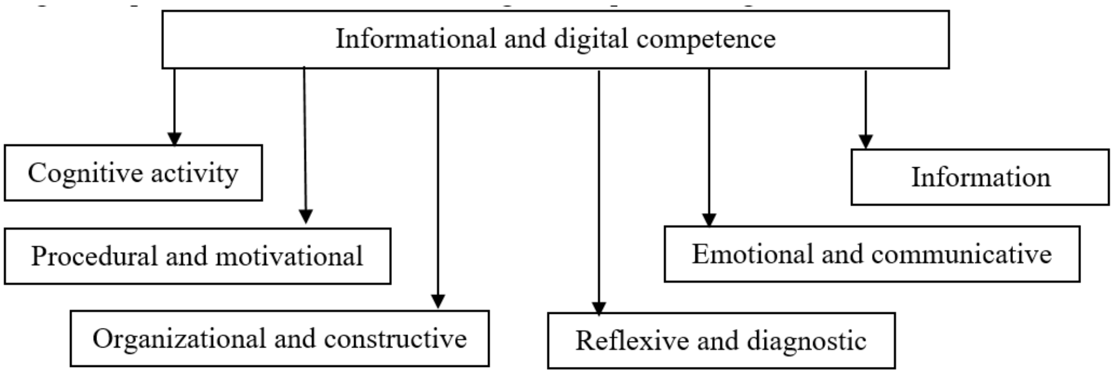

Figure 1: Components of information and digital competence.

work, learning, leisure and participation goals in the digital community. European experts in 2017 prepared the Digital Competence Framework for Citizens 2.1. The document contains descriptors (expected results by levels) of eight skill levels. They are defined by the formulation of the European Qualifications System (EQF). Each level description contains the knowledge, and skills described in one descriptor for each level of each competency: 168 descriptors were described in total. Each descriptor is an experimentally verified indicator that has been included in this document by generalizing the requirements in the education system and in the employment field of the European Union.

Europass is a tool for assessing digital competence. It can be used to create a competence unit dedicated to evaluating data, informational and digital content. Yes, a person must be able to analyze, compare and critically evaluate the reliability and reliability of data sources, informational and digital content; analyze, interpret, and critically evaluate data, information, and digital content. Many European initiatives are aimed at promoting innovative learning strategies. Individualized learning, self-regulated learning, and collaborative learning are all considered essential for the introduction of digital technologies in education. Maintaining the digital competence of pupils and teachers is an important task of European education policies.

Competences, including informational and digital, are categories that belongs to the sphere of relations between knowledge and practical activity of a person. It integrates knowledge, skills and assimilated modes of activity in relation to specific conditions, in a specific situation [3]. Therefore, the influence of the environment, conditions and lifestyle of the individual and society, have a significant impact on the directions of formation of informational and digital competence.

3. Findings

In order to analyze the level of informational and digital competence of students in the process of teaching physics, we suggested that they answer the questionnaire.

1. Are hardware (digital boards, laptops, projectors, specialized training programs, computer experiments) and digital gadgets used in physics lessons?

1) Yes.
2) No.

2. Do you use modern gadgets (tablets, laptops, smartphones) when preparing for physics lessons?
   1) Yes.
   2) No.
3. In your opinion, is it advisable to use modern technologies in the study of physics?
   1) Yes.
   2) No.
4. How freely do you think you use informational and digital technologies at the user level (use of Internet resources, use of applications, use of specialized software and hardware)?
   1) Freely.
   2) Sometimes need help.
   3) Need help frequently.
   4) Do not use (use it rarely).
5. What do you think is the concept of informational and digital competence (choose one)?
   1) Ability to use pre-configured firmware for a specific task.
   2) Theoretical knowledge regarding the work of a program or gadget.
   3) Ability to use existing software to perform daily tasks, as well as understanding the basic principles of their work.
   4) A thorough understanding of the operating principles of software and hardware gadgets used in daily business.
6. What is the importance of information security when using modern software and gadgets (on scale 5 - very important, 1 - absolutely not important)?|
   1) 5
   2) 4
   3) 3
   4) 2
   5) 1
7. What information security tools do you use when studying / preparing for training?
   1) No tools
   2) I try not to open the suspicious sites / run the suspicious programs.
   3) I use the basic tools of operating systems.
   4) Use antivirus.
8. Are there any information security tools on computers / gadgets used by the teacher when teaching physics? Which?
   1) Yes.
   2) No.
9. In your opinion, how can you improve students' competency when using software and gadgets in the physics training process?
   1) Constantly use them.
   2) The teacher should encourage students to use them more actively.
   3) The teacher should give practical advice on their use.

4) One lesson should be learned in the practice of using information and communication technologies when studying physics.
5) Teacher should not care about this.

The purpose of the survey was:

1) to determine the level of use of modern electronic gadgets by students in the study of physics in and outside the classroom;
2) to get an appreciation of their modern electronic gadgets;
3) to determine students' understanding of the concept of informational and digital competence;
4) to get from students an assessment of the ways to increase the level of informational and digital competence.

The survey was conducted among students of grades 9–11 who participated in the 26th All-Ukrainian tournament of young physicists, which took place in Lutsk in 2017, the 21st All-Ukrainian tournament of young inventors and innovators, which took place in 2018 in Kyiv, as well as students of Chervonograd secondary school No 12.

218 students participated in the survey, including:

- 74 students of 11th grade (34% of all respondents);
- 72 students in grade 10 (33% of all respondents);
- 72 students in grade 9 (also 33%).

In terms of age distribution, the largest number of participants were 15 years old, namely 83 (accounting for 38% of all respondents), and 16 years old for 78 persons (36% of all respondents). Interviewees aged 14 years were 40 (18%) and 17-year-old students were 17 (8%).

As shown in figure 2, in the course of the survey, the majority of students confirmed the use of modern digital media, namely 148 participants (68%). The rest (70 students) answered this question in the negative. Most also answered positively about using modern gadgets for home preparation. Answer "Yes" gave 165 respondents (76%), 55 students answered negatively (24%). The overwhelming majority consider the use of informational and digital means appropriate for the study of physics, namely 204 respondents (94% of all).

Figure 3 shows, that most students also confirmed that they were able to use modern digital media freely, with 148 participants, representing 68% of those polled. 62 participants (28%) indicated that they sometimes need help with their work and 6 students often need an outside help. Only 2 students responded that they could not use modern electronic gadgets.

In order to assess students' understanding of the concept of informational and digital competence, the respondents were offered different options for defining it, among which one had to be chosen. The answer "Ability to use already existing applications and devices, as well as understanding the basic principles of their work", selected 87 respondents, representing 37%. The other respondents chose the following options:

- A thorough understanding of the operating principles of software and hardware for devices used in daily activities – 71 students (30%);
- Ability to use pre-configured firmware – 46 students (19%)

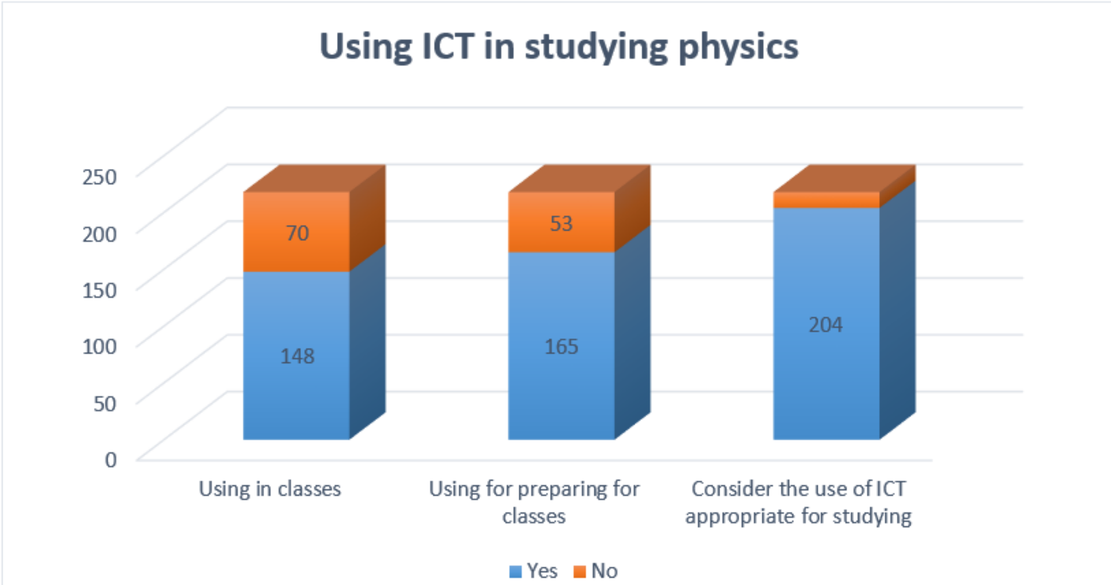

Figure 2: Using ICT in learning physics by students.

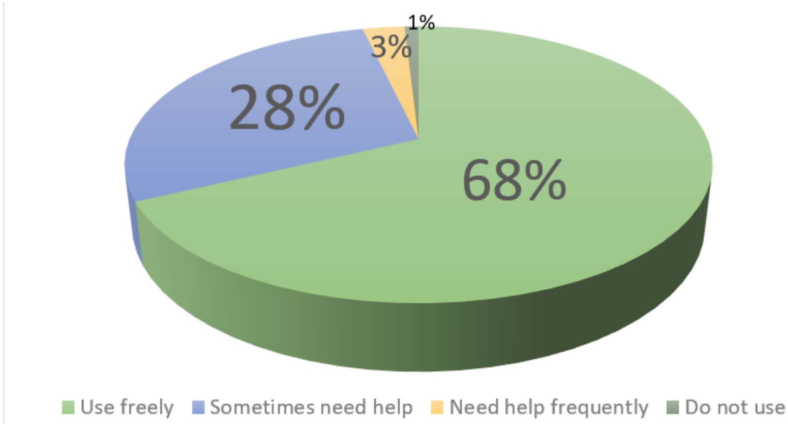

Figure 3: Students' ICT skills.

- Theoretical knowledge of the work of one or another information system – 32 students (14%).

To identify ways to increase the level of informational and digital competence that students see, several options have been proposed, among which respondents have chosen the right one. At the same time, one student could choose from several options. The frequency of occurrence of each of them is given below.

The conducted survey confirms that students use information and communication technologies on physic lessons and when doing homework. The vast majority of students see the prospect of using such technologies in and out of lessons. Moreover, for the most part, the

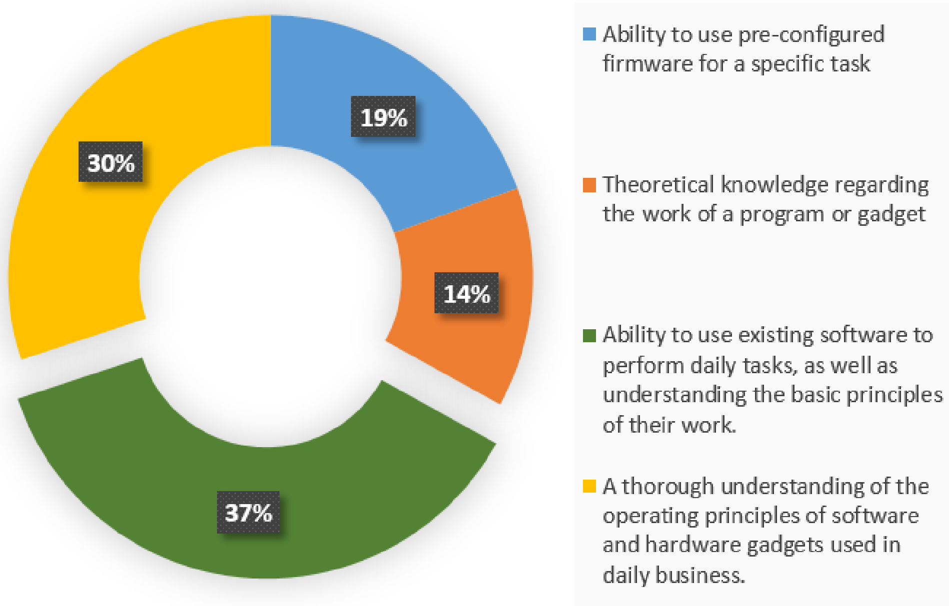

Figure 4: Understanding the concept of informational and digital competence.

respondents confirmed that they do not need any outside help in using modern information and digital tools. More attention should be paid to the formation of terminological base in students, since only one third correctly interprets this concept. This is probably due to the fact that it is not considered in the school course of physics or other disciplines of the modern school program. The options that prevailed when choosing ways to enhance the informational and digital competency should be considered when the teacher is preparing the lesson. As it turned out, the main requirement is the ability of the teacher to use these tools, give advice to students and introduce them into the educational process.

Finding useful tools for students, which could be implemented in the educational process is rather difficult task. Moreover, in most cases teacher is the one, who find useful and cheap software and hardware for lessons. Even after finding instruments teacher need to find methods to use them in classes. Some practical cases of using nowadays software for laboratory works are given below.

Laboratory work "Determination of body acceleration in the course of uniformly accelerated rectilinear motion" is part of the Physics course in the 10th grade [67]. During the laboratory work, students form an inclined plane, as shown in figure 6.

During the work student is is asked to measure the time of movement of the body (black ball) on the inclined bar from beginning to end three times. The student measures the path, that the body traverses with a ruler, the movement time – with a stopwatch. The experiment is repeated four times and the measurement results are recorded in a table. Then the average value of the acceleration of the body is determined.

However, such an approach results in significant measurement errors during the experiment. It also stipulates that the student is directly involved in the construction of the laboratory bench

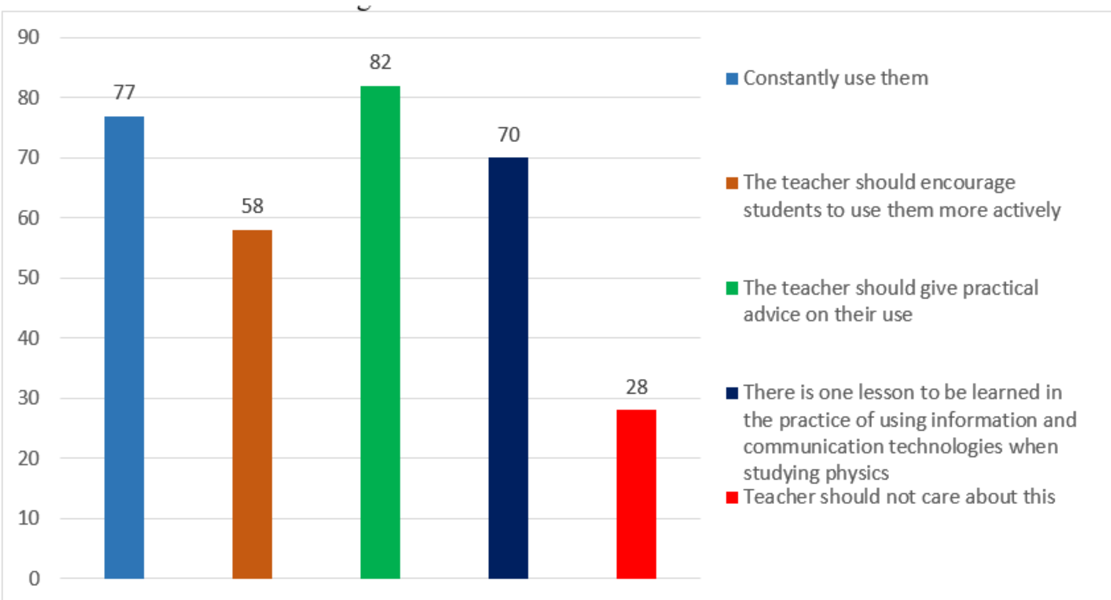

Figure 5: Ways to increase the level of informational and digital competence.

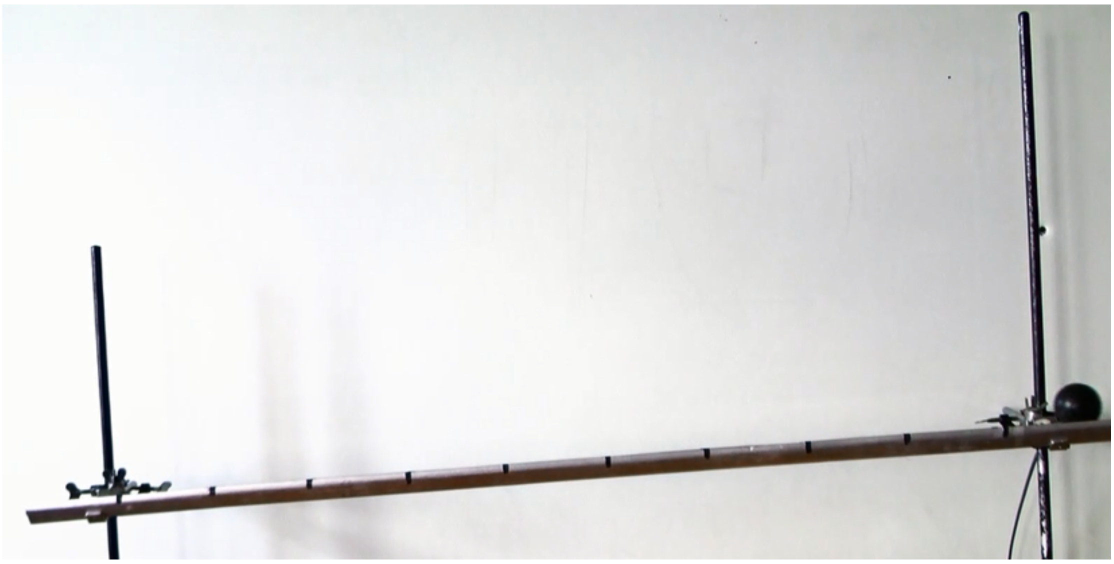

Figure 6: An incline plane for laboratory work.

and must make measurements in real time. This complicates the process of conducting the experiment at home or taking measurements outside the classroom.

At the present stage of information technology development, there are many software tools for video processing. They are used not only for physical research, but also in other fields, such as sports. However, such programs can be used by students in carrying out laboratory work, in particular in the study of mechanical movements.

The object tracking programs allow you to identify a particular object to which the market is programmatically assigned to a given template. Then frame by frame the program determines the position of the marker in the given coordinate system. Knowing the position of the object in different planes at each time makes it possible to determine the speed of the object, its acceleration, trajectory, and so on based on the data obtained. In more complex studies, an object is specified by its mass or other parameters, which allows it to calculate values of other physical quantities. This technology is actively used in the crash-test of cars, where markers mark points on a dummy and then programmatically calculate the parameters of their movement and interaction with other bodies. It is clear that within the physics lesson, it is necessary to use affordable and simple software.

As an example, let's consider the cross-platform software Tracker. It is based on the "Xuggle" software engine for video processing, which is also publicly available. In addition to exploring real-life videos, you can also download special models to emulate physical processes.

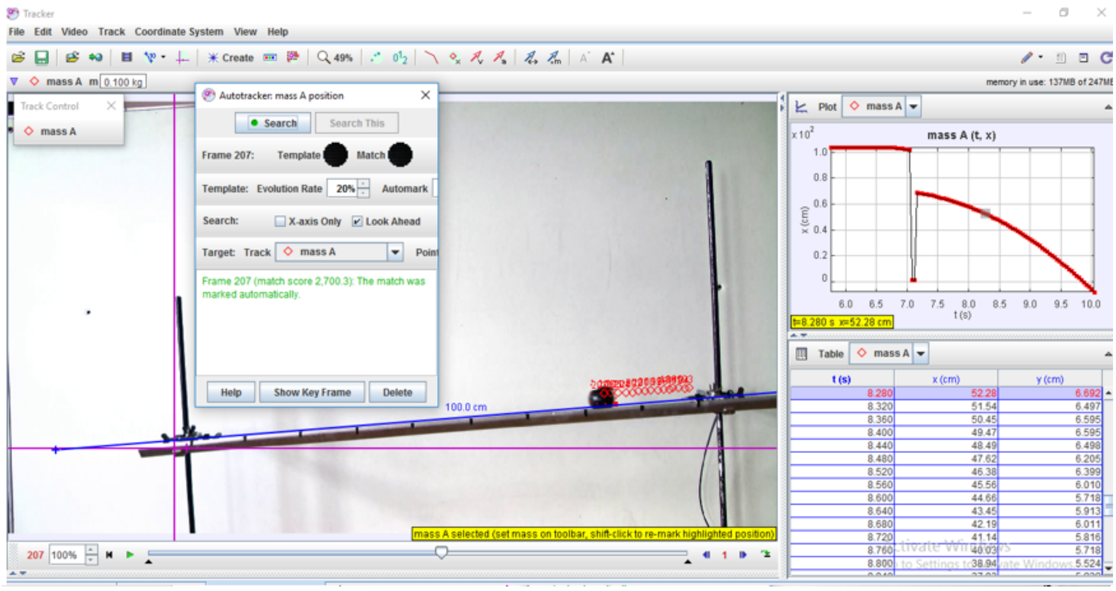

Figure 7: The main window of Tracker during measurement.

The main window shows a workspace with a video snippet. Above it is the control panel. It can perform functions like importing files to a program or saving data to a disc, changing the settings of a video or part of it, tracking, building a coordinate system, changing the display settings or call for help.

To perform the laboratory work described above, the student must complete the following steps:

1. Take one or more video clips of the ball moving along an inclined plane.
2. Upload the video file to a pre-downloaded application.
3. Determine the scale, that is, mark a special line on the video and specify its real size in the corresponding window of the program.

4. Mark the coordinate system.
5. Create a new Mass object that will be a body.
6. Use auto-tracking to bind this object to a real body and create a template for the program to follow.
7. Run tracking.
8. After receiving the results, analyze the chart to change the position of the body in space, determine the acceleration on the task of laboratory work, repeat the experiment, if necessary, to find the experimental error.

Also the VidAnalysis Free program was considered. This is a paid subscription program to exclude ads, but it can be used with a free version that is fully functional. The work of the program can be examined by the example of the above-mentioned laboratory work.

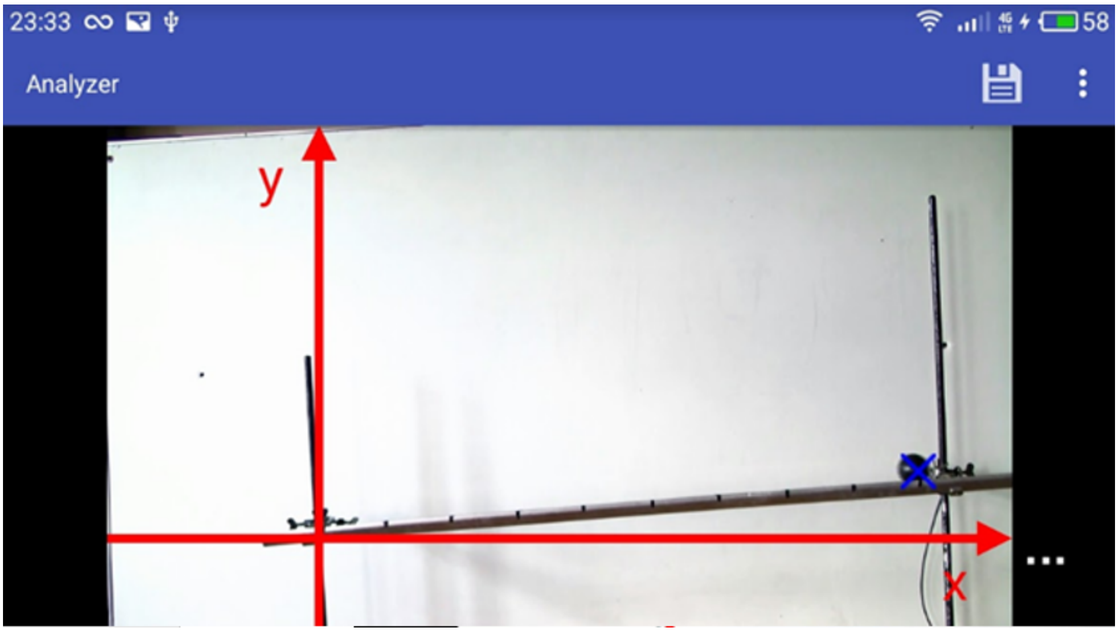

Figure 8: The main window of the VidAnalysis Free program.

To perform the task of laboratory work the student will perform the following procedure:

1. Download video footage to your phone.
2. Mark the coordinate system.
3. Specify the scale for which to mark two points on the video and write the real distance between them.
4. Next, in the frame of the video, the subject should be marked with a special marker.
5. Open the results of the study in tables.
6. Based on the obtained data, make calculations according to the task of the laboratory work.

In addition to using basic software, the student can also deploy cloud environments in the work scenario. This allows to upload the results in tabular form and to carry out a more detailed and in-depth analysis. An example of this is Google Drive. After collecting the data, the program will prompt you to save it. With an Internet connection and a Google Drive mobile application, it is possible to download the spreadsheet there. With the help of Google Sheets, students are able to independently build graphical dependencies of speed, acceleration, coordinates on time, to find the value of acceleration, according to the task of laboratory work.

In addition, the teacher may provide a laboratory work using the Atwood machine. With it, the student will be able to check the laws of the path and speed. The Atwood machine consists of a vertical riser on top of which a light block is mounted through which a light thread with weights at both ends is thrown. The weight of the weights is known and even. There are also additional weights to give the weights acceleration. On a riser there are centimeter divisions to determine the length of the path that the tractor travels. In order to conduct the experiment, the student must minimize the movement of the weights at different masses of additional weights and track one of the weights with a special program, such as Tracker. Figure 9 shows a view of the main window of the program during laboratory work.

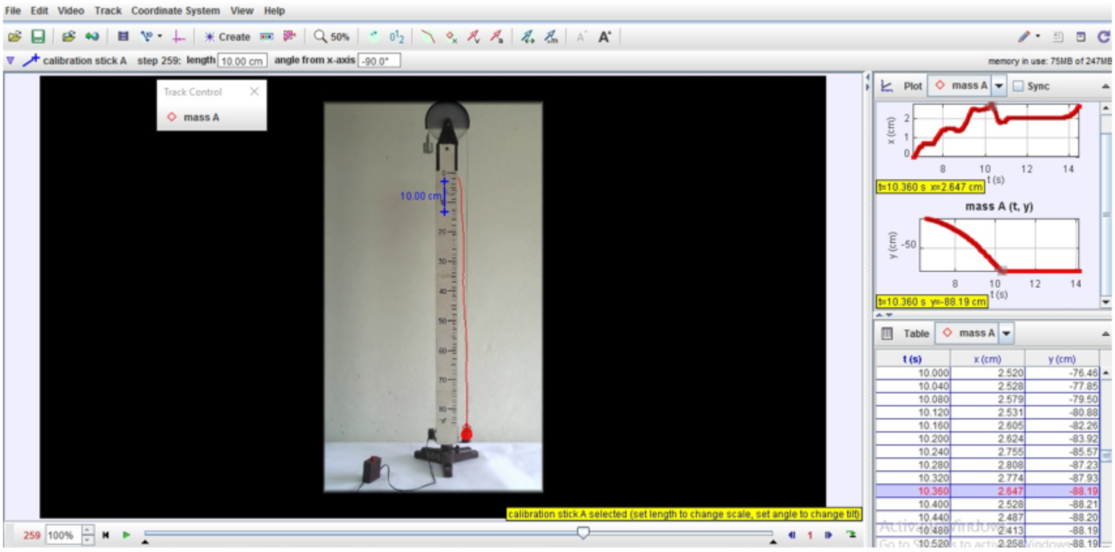

Figure 9: Tracker application window when performing laboratory work with the Atwood machine.

Thus, to verify the law of the path, the student must complete the following steps:

1. Put on the right load an additional tractor of mass (m).
2. Position the lower base of the right load a certain distance from the lower position (S).
3. Record the motion of the system on video.
4. Upload the file to the application.
5. Mark the scale line (blue line in figure 4).
6. Start auto-tracking. In this case, determine the object template.
7. Determine the acceleration of the body by the results obtained.
8. Repeat the experiment for another distance S.

4. Conclusions

Competence approach to learning changes some principles of learning and poses new challenges for teachers and students. Now, instead of simply accumulating knowledge, it is necessary to accumulate experience and develop skills. This expands the possibilities of using modern tools and devices during training. Today, students use digital technology in preparation for lessons. However, in physics lessons, the use of modern gadgets and software is not common practice. At the same time, physics lessons provide many opportunities for the application of information technology. This allows to form the information and digital competence of students in the learning process. The combination of specialized programs, mobile devices and cloud technologies, especially in the laboratory workshop, will have a positive impact on the formation of information and digital competence of students. It will also improve the skills of using these tools, will positively affect the measurement results (reduce measurement error) and will expand the range of tabular data, to form graphs of the dependence of different physical quantities. Prospects for further research are aimed at developing methods and techniques for the modernization of physical equipment based on modern software and hardware to ensure the development of information and digital competence of students.

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The selection of cloud services for ER-diagrams construction in IT specialists databases teaching

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Abstract

One of the main aspects of studying databases in higher education institutions by future IT specialists is database design and software product development. This, in turn, is the most important problem of the developer's interaction with the customer. To facilitate the process of database design, ER-diagrams are used, which are based on the concepts of "Entity" and "Relationship". An ER diagram allows you to present a database in the form of visual graphical objects that define a specific subject area. The article considers the available cloud services for the construction of ER-diagrams for learning databases of future IT specialists and their selection the method expert evaluation. For this purpose, the criteria and indicators for the selection of cloud services for the construction of ER-diagrams of databases by future information technology specialists have been determined. As a result, it was found that the cloud services Dbdesigner.net and Lucidchart are the most convenient to learn. It is determined that for a teacher of a higher education institution the use of cloud services is an opportunity to use licensed software in education without additional costs.

Keywords

selection, cloud services, ER-diagrams, databases, future specialists in information technology, future IT specialists

1. Introduction

One of the main aspects of studying the discipline "Databases" in higher education institutions by future information technology specialists is database design and soft-ware product development, which in turn is the most important problem of interaction between the developer and the customer. While studying it, students should realize that the task of the developer is to reproduce the wishes of the customer as accurately as possible by developing a database management

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software product. Therefore, the main problem that future IT professionals need to learn to solve is the correct construction of a database diagram. To do this, future developers must study in detail the subject area of the database and make the requirements of the customer. The result of this work should be a database that is clear and that most accurately reflects the problem to be solved and does not contain redundant data.

To facilitate the database design process, ER charts are used, which are based on the concepts of “Entity” and “Relationship”. ER diagram allows you to present a data-base in the form of visual graphical objects that define a specific subject area.

1.1. Analysis of recent research and publications

Many scientific papers are devoted to database theory (DB), database normalization processes, database design methodology, database architecture, consideration and description of modern DBMS, SQL query language, etc.

Dowming Yeh and Yuwen Li and William Chu investigated the possibilities of extracting the diagram of the relationship of the entity from the table of an outdated database [1].The author’s proposed new approach uses the display forms, table schema, and instances as a database reverse engineering input [1].

Paul Schmieder, Beryl Plimmer, Gillian Dobbie consider the possibilities of computer tools for building sketches for informal sketching and automatic conversion into official submissions [2]. At the same time, the authors consider the InkKit charting tool with domain semantics for successful recognition and automatic conversion of entity-relationship diagrams [2].

Another group of authors (P. S. Dhabe, M. S. Patwardhan, Asavari A. Deshpande, M. L. Dhore, B.V. Barbadekar and H. K. Abhyankar) considered the Articulated Entity-Relationship, which was considered an extension of the Entity-Relationship diagram. The researchers considered these types of diagrams as an integral part to fully automate normalization in the case of placing information about functional dependence [3].

A group of authors (Xiong Jing, Liu Yong-ge, Gao Feng, Wang Ji-peng) analyzed the similarities between the model of entity relationships and the model RDF (model for representing named properties and property values), also, proposed ideas and processes of transformation. The researchers also implemented the Oracle Bone Inscriptions ontology using a transformation method that requires manual intervention during the transformation process [4].

Other scientists (Alexander L. Hayes, Mayukh Das, Phillip Odom and Sriraam Natarajan) have proposed a convenient automatic construction of background knowledge by constructing a mode from ER diagrams. The authors have developed a graphical user interface that allows a domain expert to interact with the system using entity relationship diagrams used to build modes for the learning system [5].

Cloud technology has been studied by many scientists [6, 7, 8, 9, 10, 11, 12]. In particular, Albert A. Azaryan, Kateryna P. Osadcha, Viacheslav V. Osadchyi, Svitlana V. Symonenko, Svitlana O. Sysoieva, investigated cloud technologies for enhancing communication of IT professionals [13]. Nataliya O. Kushnir, Viacheslav V. Osadchyi, Nataliia V. Valko considered cloud technologies for STEM education [14], Svitlana L. Proskura and Svitlana H. Lytvynova considered the approaches to Web-based education of computer science bachelors in higher education institutions [15]. Oksana M. Markova, Serhiy O. Semerikov, Andrii M. Striuk, Hanna

M. Shalatska, Pavlo P. Nechypurenko and Vitaliy V. Tron investigated the implementation of cloud service models in training of future information technology specialists [9].

However, the question of appropriate selection of cloud services for the construction of ER-diagrams for training databases of future information technology professionals has not been explored, so this will be the purpose of this article.

2. Methods of the study

Methods of analysis and generalization were used to determine the criteria and indicators for the selection of cloud services.

To determine the most important cloud services for the construction of ER-diagrams of databases that can be used in the educational process of future specialists in information technology, the method of expert evaluation was used [16, 17].

Experts were involved in this method twice. The first stage of involving experts was to determine the most effective cloud services for building ER-diagrams of databases. At this stage, experts and teachers of higher education institutions were involved as experts, which in one way or another are related to the database learning of IT specialists (17 people).

For consideration by ranking experts, 12 different cloud services were proposed to build ER-diagrams of databases that can be used in the training of databases of future information technology professionals.

Experts were offered a scoring system [16, 17], according to which for N services the value of N is given to the most important in use, 1 – to the least important.

The main parameter for assessing significance is its total rank S, which is calculated by the formula [16, 17]:

$$S_j = \sum_{i=1}^{m} R_{i,j}, \tag{1}$$

where S_j is the total rank of the j-th indicator; $j = 1, 2, 3, \dots, n$; n is the number of indicators; m – number of experts; $R_{i,j}$ – the rank of the j-th indicator, determined by the i-th expert.

Besides, to determine the level of agreement between experts, it is necessary to calculate the Kendell concordance coefficient W [16, 17], which determines whether such total ranks are objective, and it is calculated by the formula:

$$W = \frac{S(d^2)}{S_{max}(d^2)} = \frac{12 \cdot S(d^2)}{m^2(n^3 - n)} \tag{2}$$

where:

$$d_j = S_j - 0.5 \cdot m(n+1), \tag{3}$$

$$S(d^2) = \sum_{j=1}^{n} d_j^2, \tag{4}$$

After the calculations, if the value obtained differs significantly from zero, it indicates that there is an objective agreement between the experts and therefore the total rankings are quite objective.

The second stage of involving experts was to select the most important cloud services for building ER-diagrams of databases according to certain criteria and indicators. At this stage, 15 respondents were involved to test the manifestation of each of these criteria for each of the selected cloud services to build ER-diagrams of databases.

At this stage, respondents were asked to evaluate all indicators for each criterion. Evaluation of indicators was proposed to be carried out on a well-known scale [16, 17] from 0 to 3. As a result, the indicator was considered positive if the value of the arithmetic mean of its parameters was not less than 1.5.

The degree of manifestation of the criterion was determined by the following scale: if 76% – 100% of its indicators are positive, the criterion is characterized by the high expression, 56% – 75% – sufficient manifestation, 50% – 55% – critical manifestation, if less than 50% of its indicators were positive – the criterion is considered insufficiently manifested.

3. Results

To build an ER-diagram of the database at the logical and conceptual levels, we propose to use cloud services. Such tools help to design a database to better form the ideal data structure according to customer needs.

We share the opinion of Mariia P. Shishkina and Maiia V. Marienko, who note that cloud services are used to provide the user with electronic educational resources, as well as to ensure the processes of creation and supply of educational services [18].

The use of cloud services in the training of future specialists in information technology opens the way to individualization of learning, interactive interaction, and active cooperation between participants in the educational process.

Consider in detail the available cloud services for building ER-diagrams of databases. Note that we will consider completely free services or those that have a free tariff plan, but with some limitations of functionality.

Erwin Data Modeler [19] is a cloud service that allows you to create a logical data model. This service can be used free of charge in the educational process to train specialists in information technology. The main characteristics of this service include: providing centralized management of data models; cooperation with other users; simple graphical interface; automatically compares models and databases; effective synchronization of direct and reverse code design, etc.

Cloud service **SQL DBM** [20] (figure 1) in the free plan allows you to create only 1 project. This service has a clear interface for building ER-diagrams of databases, which allows you to easily manage both large and small databases; import an existing database schema; add tables, keys, indexes, constraints, links, etc to an existing ER chart; copy or move columns between tables; share the project with other users, and in the settings, there is a function to increase or decrease the chart, change the screen theme (dark, light), etc.

Toad Data Modeler [21] – this cloud service can be used for free for 30 days. It is designed for

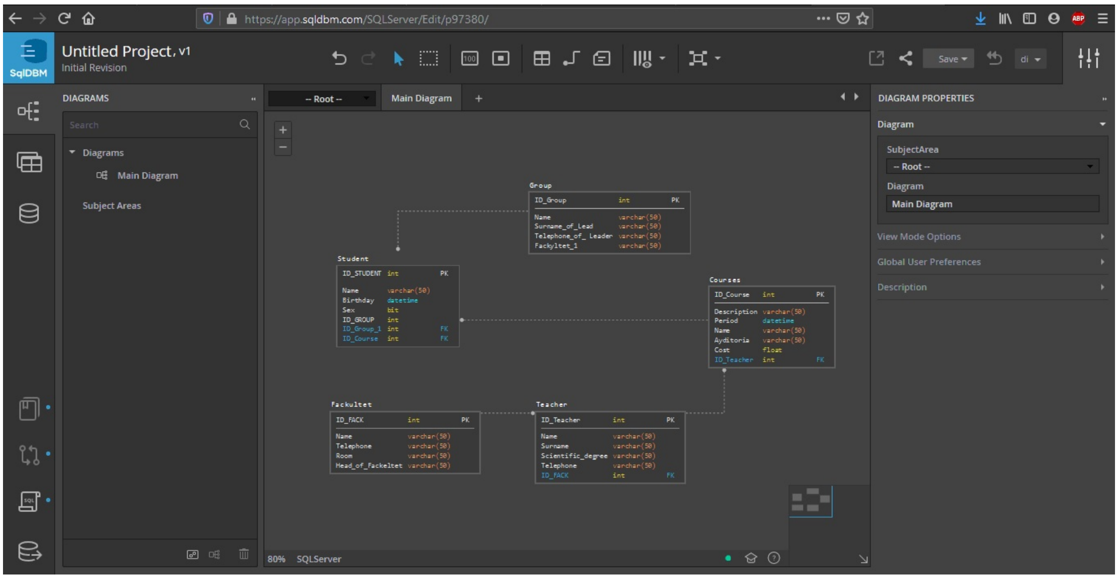

Figure 1: SQL DBM cloud service.

data modeling, which maximizes performance through high automation, transparent workflows, and built-in functionality. This service is characterized by:

- speed of access to key data,
- the ability to export the chart to an Excel file,
- ease of finding differences, comparing and synchronizing data and diagrams,
- saving the rollback of transactions directly from the transaction log without the need to restore from a backup,
- powerful query customization capabilities,
- ensuring the execution of scripts and fragments of T-SQL for multiple instances and servers,
- automatic rewriting and optimization of queries, etc.

Gen My Model [22] – cloud service for building ER-diagrams of databases, supports Archi Mate (architecture modeling language) and BPMN (business process model and notation system), has a centralized storage model that allows you to simultaneously simulate collaboration. It allows you to manage versions and access rights; import or export PDF documents, etc.

Valentina [23] is a cloud service for creating, administering MySQL, PostgreSQL, SQLite, and MariaDB databases, which allows you to add or remove users, manage rights, view live logs, and run diagnostics. Its main characteristics can be considered:

- editing ER-diagrams of databases,
- providing special forms of Valentine to work with data,
- view and print Valentine's reports,
- SQL query management,

- diagnostics, defragmentation, re-indexing, data storage, and compression, etc.

Lucidchart [24] – this cloud service combines the construction of diagrams, data visualization, and collaboration, simplifies the process of drawing diagrams and charts (figure 2). This service contains samples and examples of block diagrams, UML models, ER models, and business process models, frameworks/layouts, system diagrams, organizational charts, connection diagrams, and sites.

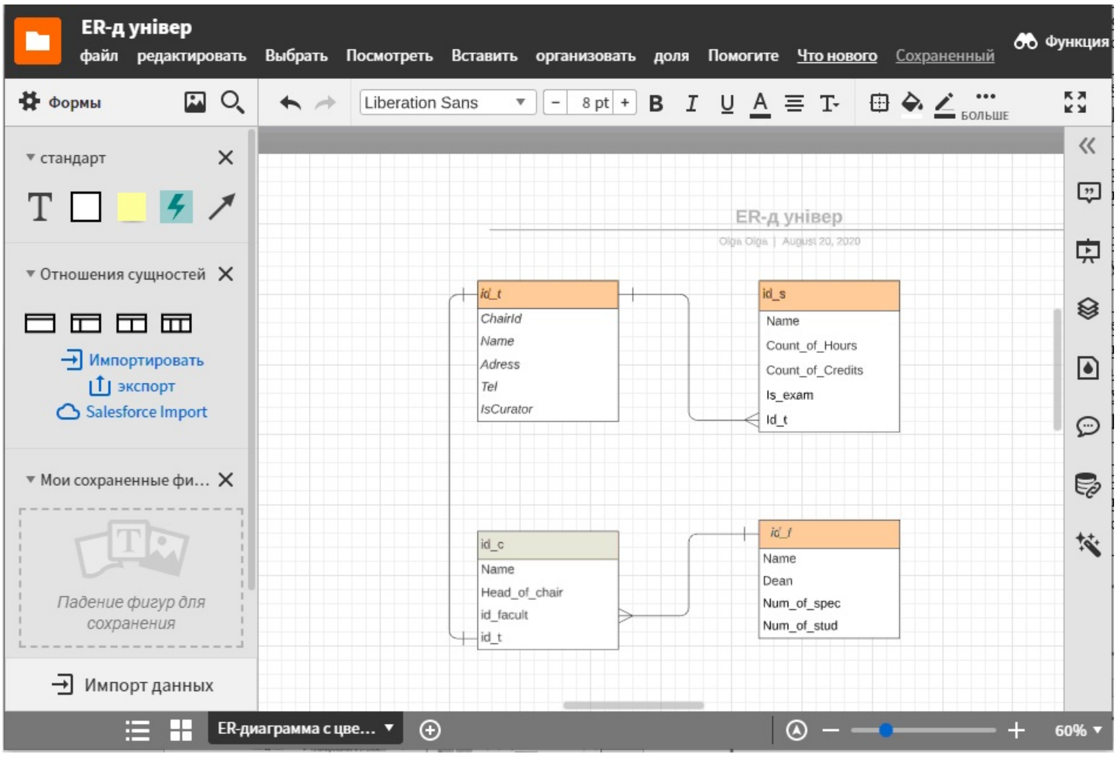

Figure 2: Lucidchart cloud service.

This service is characterized by:

- export the edited database schema to SQL and transfer it from Lucidchart to the database at the user's choice,
- support for the most common DBMS platforms, including MySQL, Oracle, PostgreSQL, and SQL Server,
- intuitive interface,
- import and export of Microsoft Visio documents,
- conversion of results into PDF, JPG, PNG,
- ready-made templates and forms,
- quick addition or merging of objects,
- adding images;
- adding schemes to blog or wiki pages,

- version control with preservation of previous developments,
- group chat,
- post-it comments;
- distribution of images and samples, etc.

The free version includes the creation of 3 documents (up to 60 objects per document), access to a limited set of ready-made templates, as well as available integration with the disk, documents, spreadsheets, presentations, and e-mail from Google and Microsoft.

In the free plan of the cloud service, **Creately** [25] can create 5 documents, 1 folder, and collaborate with 3 users. It features a variety of schematic tools, a powerful context interface, smart objects, and special tools that help you draw charts fairly quickly compared to other services. This service allows you to build charts, site maps, organizational charts, UML charts, network charts, SWOT analysis charts, connection maps, business process models, and more.

The functionality includes: establishing joint work between users, creating joint projects, adding comments when working in a team, the ability to share charts with other users, monitoring of project changes.

Each change is saved, but the user can easily revert to previous versions of documents. The service has a large library of forms and templates, offers unlimited possibilities and different types of charts and visual effects, export charts to PDF, JPG or PNG, image import, Drag & Drop support, offers work with JIRA, Confluence, GoogleApps, and more.

Dbdesigner.net [26] is a cloud service that allows the user to create 2 database models with 10 tables in each for free. Its main characteristics include: user-friendly interface for designing the database structure; joint work on projects and their exchange; function of importing an existing database or creating it from scratch; export of the created diagram of a DB in PNG and PDF formats; generation of SQL-scripts for any of the following databases: MySQL, MSSql, PostgreSQL, Oracle, SQLite, etc.

The **QuickDBD** [27] cloud service can be used free of charge to create 1 model from 10 tables. The service allows users to share their charts on the Internet using a URL, creating it in the form of images, PDF, and SQL; build a database chart.

Vertabelo [28] is a cloud service for the visual design of basic data, supports the following basic data: PostgreSQL, MySQL, Microsoft SQL Server, SQLite, Oracle, IBM DB2, and HSQLDB. It allows you to create a model of basic data simply by graphically drawing tables. The features of this service include checking the model that is created at each stage and providing tips on how to improve it.

At any time, you can see the SQL preview that will be generated for the selected item. It is also possible to share your baseline models at three different levels of access: Owner, Editor, and Viewer. In this service, when working together, it is possible only one user to edit the model, for others it is read-only, everyone can see the changes in the model immediately after an autosave.

If the user wants to share the model with other users, but they do not want to create Vertabelo accounts, it is possible to create a public link to the model or send it via e-mail. Thus, there is a visualization of the database data structure and joint work on it.

Vertabelo cloud service is fully accessible to students, teachers, and non-profit organizations, provided that it is used only for educational or non-profit purposes.

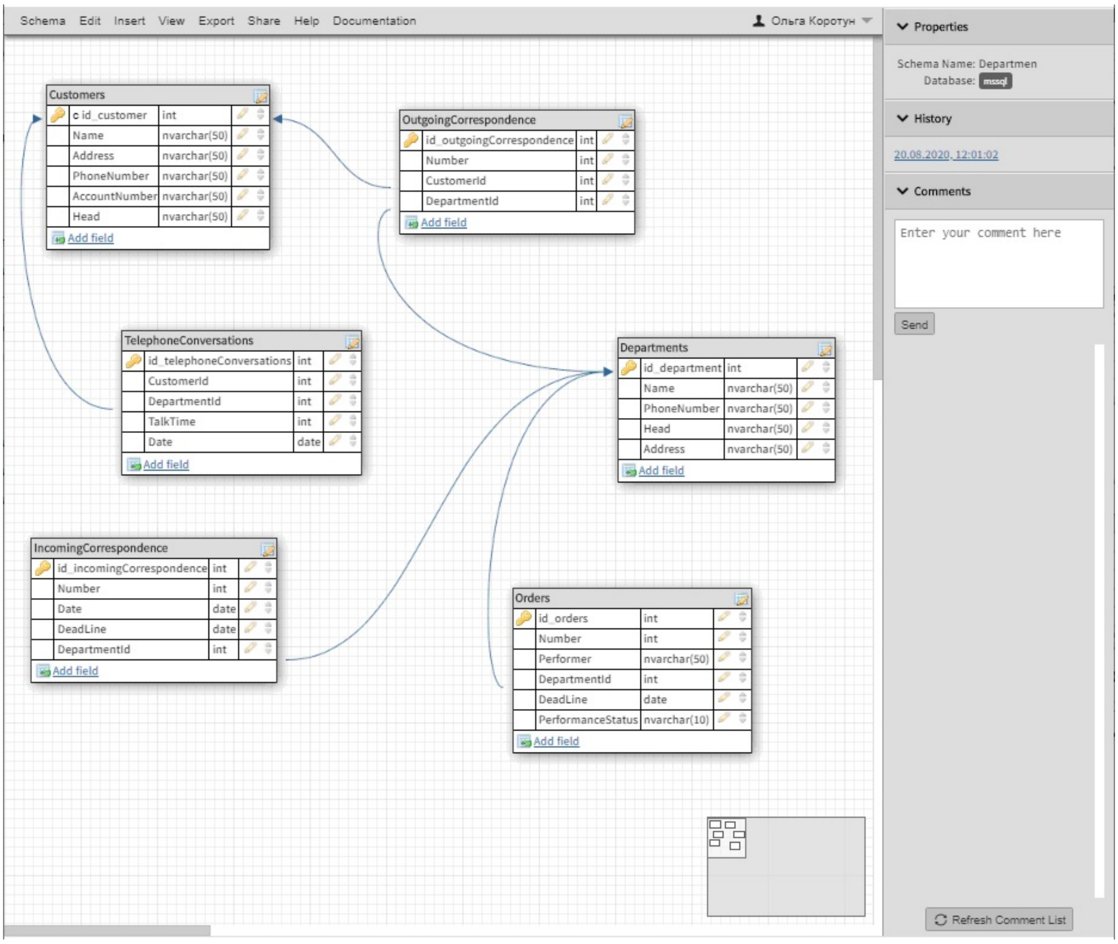

Figure 3: Dbdesigner.net cloud service.

DModelAid [29] – this cloud service allows you to build 1 model for free, consisting of less than 11 tables, designed to document the design of the basic data in the form of an interactive diagram.

Characteristic features of this service are:

- allows you to visualize tables with keys, indexes, and links,
- supports keyboard shortcuts for easy access,
- automatically documents the created database project,
- perform physical design using the following databases: Microsoft SQL Server, Oracle, MySQL, SQLite, MS Access,
- supports SQL queries,
- allows you to export a script from a project to create physical databases,
- change the database at any time, and it will be correlated with the data type and so on.

Draw.io cloud service [30] is free to develop charts, allows you to easily create and manage them. Its main characteristics include:

- storage of the built model in various formats,
- creation of a wide range of database diagrams, including UML diagrams, ER diagrams, etc.,
- availability of templates for database design,
- joint work,
- display relationships between tables using different shapes and arrows,
- export of database diagrams in the form of images, PDF, HTML, XML, etc.

At the first stage of the expert evaluation method, the experts were offered a survey, which proposed to rank the following cloud services to build ER-diagrams of databases: 1) Creately; 2) Dbdesigner.net; 3) DModelAid; 4) Draw.io; 5) ErwinDataModeler; 6) GenMyModel; 7) Lucidchart; 8) QuickDBD; 9) SQL DBM; 10) ToadDataModeler; 11) Valentina; 12) Vertabelo.

According to the results of the survey, the relevant data on the ranking of the proposed cloud services for the construction of ER-diagrams of databases were obtained (see table 1).

Table 1
Ranking of cloud services for building database ER-diagrams

expert|service	1	2	3	4	5	6	7	8	9	10	11	12
1	3	12	7	6	11	1	10	2	9	5	4	8
2	4	11	6	3	12	8	9	5	10	1	2	7
3	1	9	6	7	10	4	11	8	12	3	2	5
4	8	10	5	6	9	7	12	3	11	1	2	4
5	6	11	2	1	10	4	12	5	9	8	7	3
6	3	12	7	6	11	1	10	2	9	5	4	8
7	4	7	6	3	8	12	9	5	10	1	2	11
8	1	9	6	7	10	4	11	8	12	3	2	5
9	8	10	5	6	9	7	12	3	11	1	2	4
10	6	11	2	1	10	4	12	5	9	8	7	3
11	3	8	7	6	11	1	10	2	9	5	4	12
12	4	11	6	3	12	8	9	5	10	1	2	7
13	1	9	6	7	10	4	8	11	12	3	2	5
14	8	10	5	6	9	7	12	3	11	1	2	4
15	6	11	2	1	10	4	12	5	8	9	7	3
16	3	12	7	6	11	1	10	2	9	5	4	8
17	4	11	6	3	12	8	9	5	10	1	2	7
S	73	174	91	78	175	85	178	79	171	61	57	104
d	-37.5	63.5	-19.5	-32.5	64.5	-25.5	67.5	-31.5	60.5	-49.5	-53.5	-6.5

According to the results of the survey, the following cloud services were selected: Dbdesigner.net, ErwinDataModeler, Lucidchart, SQL DBM.

Based on experimental data (see table 1), we calculate the Kendell concordance coefficient according to formulas (1) – (4). As a result, we have $W = 0.64$. Since W differs significantly from 0, there is an objective agreement between the experts and the total ranks are fairly objective.

The analysis of the available cloud services for the construction of database charts allowed to identify the following criteria and relevant indicators for the selection of cloud services for the construction of ER-charts of databases:

1) `design-didactic`: integration of different technologies for creating databases (1.1); model for a DB (1.2); setting up SQL queries (1.3); collaboration (1.4); key fields and links (1.5); the final view of the database schema (1.6);
2) `technological`: access rights (2.1); availability of templates (2.2); communication capability (2.3); cloud data storage (2.4); free of charge (2.5);
3) `functional`: import of existing database diagrams (3.1); project settings (3.2); version control (3.3); export to various formats (3.4).

The **design-didactic criterion** characterizes the service for designing ER-diagrams of databases and its didactic component:

- The indicator "integration of different technologies for creating databases" provides for the creation of charts for the following databases: MSSQL, MySQL, PostgreSQL, SQLite, NoSQL, etc.
- The indicator "model for a DB" provides the ability to automatically create a chart based on an existing database.
- The indicator "setting up SQL queries" characterizes the ability to generate an SQL script.
- The indicator "collaboration" provides an opportunity to work together on the project, which is the basis of project work for future professionals in information technology.
- The indicator "key fields and links" characterizes the ability to identify key fields and establish relationships between tables.
- The indicator "the final view of the database schema" characterizes the appearance of the final diagram of the database, its readability, and intelligibility.

The resulting data on the indicators of design-didactic criteria for each of the selected cloud services for the construction of ER-diagrams of databases contains table 2.

Table 2
The design-didactic criterion of cloud services for the construction of ER-diagrams of databases and its indicators

Service | Indicators	1.1	1.2	1.3	1.4	1.5	1.6	Manifestation of the criterion
Dbdesigner.net	2,13	1,13	1,87	2,73	2,60	2,40	high
ErwinData Modeler	1,47	2,53	1,47	2,53	2,87	1,87	sufficient
Lucidchart	1,80	2,73	0,53	2,40	2,40	2,60	sufficient
SQL DBM	2,53	2,13	2,07	0,93	2,47	2,67	high

The **technological criterion** characterizes the technical capabilities of cloud services for the construction of database diagrams, and includes the following indicators:

- "Access rights", which provides access to the created database diagram at different levels.
- "Availability of templates", which characterizes whether this service has ready-made templates for quick creation of a database diagram.

- “Communication capability” means the ability to chat with other users who have accessed this chart.
- “Cloud data storage” characterizes the ability to store the created charts in the data warehouse.
- “Free of charge” means free access to the cloud service or its specific functionality.

The resulting data on the indicators of the technological criterion for each of the selected cloud services for the construction of ER-diagrams of databases are contained in table 3.

Table 3
The technological criterion of cloud services for the construction of ER-diagrams of databases and its indicators

Service | Indicators	2.1	2.2	2.3	2.4	2.5	Manifestation of the criterion
Dbdesigner.net	1,73	2,07	0,73	2,40	2,53	high
ErwinData Modeler	1,33	1,27	1,93	1,27	1,87	Insufficient
Lucidchart	1,73	2,47	2,87	2,47	2,67	high
SQL DBM	1,00	0,53	0,53	1,60	1,67	Insufficient

The **functional criterion** characterizes the available functionality of the cloud service for building ER-diagrams of databases. Consider in detail all the indicators of this criterion.

- The indicator “import of existing database diagrams” provides the ability to import an existing database diagram and the ability to refine it.
- The “project settings” indicator provides the ability to change project settings, such as copying or moving columns between tables, viewing only table names or only keys, and more.
- The “version control” indicator provides an opportunity to compare different versions of the constructed diagrams to one DB.
- The indicator “export to various formats” provides the ability to present the results of work in the cloud service in various formats, including pdf, jpg, png, etc.

The resulting data on the indicators of the functional criterion for each of the selected cloud services for the construction of ER-diagrams of databases are contained in table 4.

Table 4
The functional criterion of cloud services for the construction of ER-diagrams of databases and its indicators

Service | Indicators	3.1	3.2	3.3	3.4	Manifestation of the criterion
Dbdesigner.net	2,00	1,67	2,13	2,47	high
ErwinData Modeler	1,53	2,47	1,87	1,07	sufficient
Lucidchart	2,73	2,60	0,53	1,73	high
SQL DBM	2,40	1,53	0,60	0,60	Insufficient

The generalized results are presented in table 5.

Table 5
Generalized results of the selection of cloud services for the construction of ER-diagrams of databases on a display of all criteria

Service | Criterion	Design-didactic	technological	functional
Dbdesigner.net	high	high	high
ErwinData Modeler	sufficient	Insufficient	sufficient
Lucidchart	sufficient	high	high
SQL DBM	high	Insufficient	Insufficient

Thus, as research shows, the most convenient and high-quality tools among cloud services for building ER-diagrams of databases on the manifestation of all criteria were Dbdesigner.net and under certain conditions Lucidchart.

These services allow you to quickly and efficiently design a database based on the built ER-diagrams, which in turn are used for research and development of software and information systems for business.

4. Conclusions

Therefore, the construction of ER-diagrams of databases by future IT professionals is convenient to do using cloud services for the purpose, which significantly speeds up the process, as it saves time (does not require installation, configuration, and upgrade), allow students to work in pairs and small groups, in free versions there is enough functionality for training.

Criteria and indicators for the selection of cloud services for building ER-diagrams of databases by future information technology specialists have been determined, according to which it has been established that the services Dbdesigner.net and Lucidchart are the most convenient to learn. For a teacher of higher education, the use of cloud services is an opportunity to use licensed software in education at no additional cost.

Thus, the importance and timeliness of the introduction of such services in the training of databases of future information technology professionals will help improve the educational process of the discipline “Databases”.

Prospects for further research see the study of the use of selected cloud services in the educational process and their impact on the formation of professional competencies of students.

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Approaches to the choice of tools for adaptive learning based on highlighted selection criteria

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Abstract

The article substantiates the relevance of adaptive learning of students in the modern information society, reveals the essence of such concepts as "adaptability" and "adaptive learning system". It is determined that a necessary condition for adaptive education is the criterion of an adaptive learning environment that provides opportunities for advanced education, development of key competencies, formation of a flexible personality that is able to respond to different changes, effectively solve different problems and achieve results. The authors focus on the technical aspect of adaptive learning. Different classifications of adaptability are analyzed. The approach to the choice of adaptive learning tools based on the characteristics of the product quality model stated by the standard ISO / IEC 25010 is described. The following criteria for the selecting adaptive learning tools are functional compliance, compatibility, practicality, and support. By means of expert assessment method there were identified and selected the most important tools of adaptive learning, namely: Acrobatiq, Fishtree, Knewton (now Wiliy), Lumen, Realize it, Smart Sparrow (now Pearson). Comparative tables for each of the selected tools of adaptive learning according to the indicators of certain criteria are given.

Keywords

adaptability, adaptive learning, adaptive learning tools, selection criteria

1. Introduction

The main trends in global online education are related to the development of computer technology and increase of diversity and accessibility of education. Information and communication technologies, in particular learning management systems (LMS), serve as a means of improving the effectiveness of learning, its individualization and differentiation. LMS provides access to data and tools to support the learning process, accumulates information about the courses taken by students and the results of final tests [1, 2, 3, 4, 5, 6, 7, 8]. However, the effectiveness of such systems usually depends on the adaptive capabilities of the educational process with consideration of psychological characteristics of students and subject area. However, sometimes educational content is quite simple for more prepared students, and for less prepared it can be

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almost inaccessible. On the other hand, most LMSs provide ample configurable capabilities, but adaptability has not been a priority in the architecture of such systems.

The main approach to solving this problem is the use of adaptive learning tools as one of the promising areas in modern education.

Philosophers, educators and psychologists have paid attention to the problem of adaptive learning. In particular, the experience of Ukrainian researchers is relevant in the context of consideration of adaptive learning systems based on programming, algorithmization and use of web technologies [9, 10].

Pavlo I. Fedoruk considers the problems of theory, methodology and techniques and construction of intelligent adaptive systems of individual distance learning on the basis of the latest Web-technologies [11]. Igor V. Gritsuk devoted his work to adaptive testing in educational electronic environment of maritime higher education institutions [12]. Functioning peculiarities of intellectual adaptive educational systems were investigated by Andrii M. Striuk [13, 14]. Adaptive learning on the basis of modern information technologies is considered by Viacheslav V. Osadchyi [15]. Approaches to the introduction of cloud adaptive technologies in teacher training are explored by Yuliia H. Nosenko [16, 17].

Noteworthy are the studies [18, 19, 20], which present the results of scientific publications for 2010–2020, on the problems of personalized and adaptive learning and analyzed the ergonomic indicators of training courses and their compliance with the principles of educational design in adaptive learning systems. A number of researchers [17, 21] conducted a comparative analysis of adaptive learning systems according to the scope, type of adaptive learning, functional purpose, integration with existing learning management systems, application of modern technologies for generation and recognition of natural language and curriculum characteristics.

The scheme of designing an adaptive learning system can be found in the work of Chang Ming Liu, Yan Jun Sun and Hai Yu Li [22], which describe computer learning platforms.

E-learning systems that provide personalized content to users with the gradual adaptation of educational material based on the results of student progress are considered by Ana-Maria Mirea and Mircea Cezar Preda. They provide different types of adaptation that take into account the content and navigation in the course, explore the student's profile and model learning activities [23]. In [24] it is proposed to use intelligent methods for automatic adaptation to dynamic changes in student behavior in real time during learning.

The effectiveness of the use of adapted online training courses depends on the feedback, on the current learning outcomes of the proposed content [25, 26, 14]. Andrew Thomas Bimba, Norisma Idris, Ahmed Al-Hunaiyyan, Rohana Binti Mahmud and Nor Liyana Bt Mohd Shuib considers different feedback options in an adapted educational environment based on dialogue, intelligent e-learning systems and adaptive hypermedia systems [27].

Thus, nowadays the development of technologies for adaptive learning occurs in different forms and contexts. The share of adaptive learning technologies in higher education in Ukraine is small. In our opinion, technical solutions in the field of adaptive learning that would allow to implement it are not fully studied.

The purpose of the article is to highlight the approaches to the choice of adaptive learning tools based on the selected criteria and indicators of its selection.

2. Theoretical fundamentals

Adaptability is interpreted as the possibility of adaptation, coordination of the learning process, taking into account the choice of learning pace, diagnosis of the achieved level of mastering the material, providing the widest range of different learning tools that would make it suitable for a wider range of users [28]. Adaptive learning system able to adapt to human, age and psychological characteristics, in addition, adaptive training should consider and agree with the general stage changes which experience the knowledge and ways of cognitive actions of students during their studies. Given this, adaptive learning is a dialectical unity of two processes: a child's adaptation to learning and adaption of learning to the individual characteristics of the child and provides for adaptation to modern time requirements of all the elements of pedagogical systems: objectives; content; methods, ways, means of learning; forms of organization of cognitive activity of students, diagnostics of results.

According to [29], adaptive learning system is a new model of learning organization, which is characterized mainly active independent activity of students, which is controlled by curricula and control programs, network plans and self-accounting schedules.

Adaptive learning is that an individualized learning method will help the student learn faster, more effectively and with greater understanding. Typically, components of adaptive learning include: monitoring activity, interpretation of results, understanding of the requirements and benefits of learning new topics to facilitate the learning process. The main purpose of adaptive learning is to make the learning process most effective by transferring the educational process to the electronic environment [30].

In modern information educational systems, the problem of adaptive learning is considered in two aspects: methodological and technical. The methodological aspects of adaptive learning in information training systems include planning and organization of the educational process, determination of the types of tasks, their levels of complexity, the sequence of submission of material, conduction of various types of control, definition of evaluation criteria for each type of task. The technical aspects include: an algorithm that offers to move to a new level with the correct execution of most of the tasks or return to the previous level, taking into account errors made during the tasks; algorithm for assessing student achievement, etc. [31].

Let's dwell in more detail on the technical aspect.

The origins of adaptive learning are the first software algorithms of B. F. Skinner, Norman A. Crowder and Gordon Pask, which were used in 1950-1960.

Skinner's algorithm assumed that the training material should be divided into small fragments, the answers should be taken in an open form and all participants in the learning process take the same course regardless of individual characteristics [32]. This approach has been called a linear algorithm. Another approach was suggested by Norman A. Crowder, according to which the teaching material should be presented in the form of more complex tasks, which are broken down into smaller ones in case one of the students cannot complete the initial one. Unlike Skinner's concept, Crowder suggested a closed form for receiving answers (choose the correct option out of the offered), feedback appears (after answering the question, the program explains why the answer was correct or where a mistake was made). But the most significant is the emergence of individual learning trajectories [33]. This approach is called branched. The concept of adaptive learning, laid down by Gordon Pask, has become widespread.

According to the concept, curriculum must be constantly adapted to a person who interacts with it, adjust course, maintaining the optimal level of complexity [34]. In modern interpretations of adaptability, one can find examples of linear, branched and adaptive algorithms. The latter was the most widely used in computer training systems.

Currently, the e-learning market has enough systems that use the term “adaptive learning” in the description of their product. In order to individualize learning, they actively develop adaptive learning tools – technologies that interact with the student in real time. They automatically provide individual support to each student.

To study the existing adaptive learning systems, consider the existing classifications given in studies [35, 36, 37, 38], and describe how adaptability is implemented in such systems.

Depending on the complexity of the curriculum , there are three levels of adaptive learning systems: systems that provide “passive”, “active” and “intellectual” adaptability [35].

Systems that provide “passive adaptability”: the active role is delegated to the student: based on the recommended set of parameters, the student, based on their own interests, plans the trajectory of their progress in the material, the timing of the study of content. Such systems use passive schemes ‘if ..., $\rightarrow$ then ...”, simple hypertext systems.

Systems that provide “active adaptability”: the system itself determines the trajectory of his further study on the basis of already completed educational material and on the basis of the student’s answers to test questions. In such systems active schemes “if ..., $\rightarrow$ then ...” are used, programming is applied.

Systems that provide “intellectual adaptability”: a student profile is formed on the basis of both psychological characteristics and personal preferences, which is constantly expanding. Based on it, a trajectory of progress in the assimilation of content is created. Such systems use programming methods based on the use of big data analytics in the field of learning – Learning Analytics [39].

Lou Pugliese [36] divided adaptive systems into four types: machine learning systems, advanced algorithm systems, rule-based systems, and decision tree systems. Others classify systems based on a basic adaptive algorithm [37]. However, one particular adaptive algorithm is rarely identified with a single system.

EdSurge [38] determined that adaptivity can occur in one or more elements: content, assessment, sequence.

Tools with adaptive content allow you to identify material that the student does not understand or misunderstands and get tips, corrections and links to useful resources.

Content is “adapted” to the student within one skill, which, at the same time, is divided into components. That is, the student learns one component, then moves on to another – as a result, acquires a full-fledged skill. In this case, the teacher in real time can receive information about how fast the student is moving, at what stage he is and where he needs help.

Adaptation of assessment assumes that each subsequent question depends on what answer the student gave to the previous one. The better it is, the more difficult the tasks, and vice versa – if it is difficult for the student to complete, the questions will be easier until he learns the material.

Traditionally, assessments are made in two ways: fixed form or adaptive. Fixed form assessment is one in which the elements are pre-selected, and each student is tested on the same set of questions (for example, the final exam). In adaptive assessment, elements change based on how individual students answer each question. This change is often the result of the level of complexity of the element. For example, if a student answers a simple question correctly, the next received option is a little harder, etc.

Adaptive assessment tools are usually used for periodic monitoring every few months. Students receive a relatively voluminous test task, the purpose of which is to check how well they have mastered the material in 2–4 months. After monitoring, data analysis is performed, and the results are used to further adjust the program and individual learning trajectory of each student. Therefore, one of the advantages of adaptive tests is detailed statistics.

Continuous data collection and analysis are inherent in sequence adaptation. That is, while the student completes the task, the adaptive program analyzes his answers and automatically selects the relevant content, level of complexity and order of learning the material. Adaptive sequence tools are the most complex, as they both analyze data and compose and adjust the student's individual trajectory in real time.

To make an individual learning trajectory, adaptive programs take into account many different indicators: the correctness of the answer; number of attempts; use of additional tools or resources; student interests.

Sometimes these tools take into account the social reaction to the student (comments and likes) and even his mood.

The adaptive sequence is implemented in three stages: to collect data, analyze it and adapt the sequence of presentation of material to the needs of a particular student.

The main advantage of a learning tool with an adaptive sequence is to fill gaps in knowledge. If a student misses a lesson or has not mastered the topic before, and now it interferes with the study of new material, the sequence of tasks and topics changes. Thus, student fills the gap in knowledge first, and then moves on to the current topic.

The adaptive sequence is used by Knewton, Fishtree, BrightspaceLeap.

Some developers of adaptive learning tools use several strategies at once. For example, the tools Aleks, ScootPad, SmartBook combine adaptive evaluation and consistency. Adaptation of both content and evaluation is carried out by I-Ready, Fulcrum labs, Mastering CogBooks, Mathspace, Smart Sparrow combine adaptive content and consistency.

It is worth noting the study of the evolution of the market of adaptive learning "Learning to adapt 2.0" [40], which analyzes the adaptive learning technologies for the following opportunities (features):

- content source (OER, developer content, customer-generated content),
- technical support services,
- opportunities for communication and cooperation between participants in the learning process,
- adjustment functions (for example, teachers can set a scale for evaluating technology or indicators).

These classifications will be useful for understanding how technology can collect data and adjust adaptability. These technologies will be most effective if they are combined in one tool.

3. Results

In order to determine the most important tools of adaptive learning, the method of expert evaluation was used. The examination involved 20 people among teachers, teachers of educational institutions who have experience and research the implementation of elements of personalization of e-learning and understand the prospects for its use in the educational process. To select the tool of adaptive learning, a questionnaire was developed in which teachers distributed the selected tools by assigning a rank number. The tool that can, according to the expert, implement adaptive learning technologies as fully as possible (regardless of the discipline), was assigned the rank N = 14, the least – 1.

The concordance coefficient (W) or coefficient of agreement is used to assess the objectivity of the opinions of experts [41]:

$$W = \frac{12S}{m^2 \cdot (n^3 - n)}, \tag{1}$$

where S is the sum of the squares of the deviations of the sums of ranks from the average value of the sum of ranks for a given object of study ($\bar{R}$).

Then

$$\sum \bar{R} = \frac{1}{2} \cdot m \cdot (n - 1), \tag{2}$$

$$S = \sum (\sum R_i - \bar{R})^2. \tag{3}$$

where R_i – ranks assigned to each tool by i-expert; m – number of experts; n – the number of indicators.

After performing the calculation using formulas based on experimental data, we obtain certain value W. The coefficient of concordance varies in the range $0 < W < 1$, and at $W = 0$ agreement of experts is absent, and at $W = 1$ agreement is complete. If the value of concordance coefficient exceeds 0.40–0.50, the quality of the assessment is considered satisfactory, if $W > 0.70 - 0.80$ – high.

The significance of the concordance coefficient is checked using the statistical criteria χ^2. It is significant and differences in expert assessments are not significant if the inequality holds $m \cdot (n - 1) \cdot W \geq \chi^2_{critical\ value}$ ($\alpha = 0.05$).

The results of expert surveys are listed in table 1.

The value of the coefficient $W = 0.79$. It indicates a strong consensus of experts. Let's check its significance by the criterion $\chi^2 : 210.6 \geq 36.2 = \chi^2_{0.05}$. Therefore, at a significance level of 0.05%, the calculated concordance coefficient is taken as significant.

As a result, 6 adaptive learning tools were chosen: Acrobatiq, Fishtree, Knewton (now Wiliy), Lumen, Realize it, Smart Sparrow (now Pearson).

Taking into account the possibilities of adaptive learning technologies, we will formulate the criteria for selecting an adaptive learning tool.

Under the criteria for selecting tools for adaptive learning we will understand the features and properties of adaptive learning tools necessary for the holistic use of the learning process and its successful operation.

Table 1
Ranking of adaptive learning tools

Experts	Acrobatiq	Aleks	Brightspace by D2L	Cerego	CogBooks	Drillster	Fishtree	Fulcrum Labs	Knewton (now Wiliy)	LearnSmart	Lumen	Open learning invitiative	Realize it	Smart Sparrow (now Pearson)
1.	11	10	2	3	4	1	5	9	13	6	8	7	12	14
2.	9	8	4	5	3	2	6	10	14	1	11	7	13	12
3.	12	9	3	6	2	5	4	8	11	1	14	7	10	13
4.	10	8	1	7	2	5	6	9	14	3	13	4	11	12
5.	12	11	4	8	1	3	9	10	14	2	6	5	7	13
6.	11	8	2	4	5	1	14	7	13	3	10	6	9	12
7.	9	8	1	3	5	2	12	7	10	4	11	6	13	14
8.	8	10	5	2	1	4	13	6	14	3	9	7	11	12
9.	10	6	1	2	3	5	13	8	12	4	9	7	11	14
10.	9	7	2	4	5	1	12	8	10	3	11	6	13	14
11.	12	4	1	6	5	3	14	9	11	2	8	7	10	13
12.	12	8	2	6	5	4	13	3	14	1	10	7	11	9
13.	10	8	1	5	4	2	11	6	7	3	13	9	12	14
14.	9	10	3	6	1	4	12	5	11	2	8	7	14	13
15.	11	7	4	12	2	1	8	5	9	3	10	6	14	13
16.	10	8	1	5	4	2	12	6	11	3	9	7	13	14
17.	10	8	4	7	1	3	13	5	12	2	9	6	11	14
18.	9	7	2	3	4	1	11	6	12	5	10	8	15	14
19.	9	7	1	4	5	2	12	6	14	3	10	8	11	13
20.	10	9	2	6	1	3	8	5	11	4	12	7	13	14
$\bar{R}$	203	161	46	104	63	54	208	138	237	58	201	134	233	260
$R_i - \bar{R}$	53	11	-104	-46	-87	-96	58	-12	87	-92	51	-16	83	110

It should be noted that nowadays there are no complete and fairly detailed structured descriptions of the characteristics of adaptive learning tools in Ukraine. There are also no scientifically sound methodological approaches to the selection of such tools and evaluation of their quality. One way to validate software properties is through certification. It is carried out on the basis of current standards.

The most common is the international standard ISO/IEC 25010 [42], which defines two quality models:

1) a quality model in use, consisting of five characteristics that relate to the results of product interaction when used in a given context,

2) product quality model consisting of eight characteristics relating to the static properties of the software and the dynamic properties of the computer system.

The analysis of the characteristics of the product quality model described by the ISO/IEC 25010 standard and the specific features inherent in the tools of adaptive learning, allowed to identify the following selection criteria:

(i) functional compliance – the degree to which the system provides functions of adaptive learning, which are implemented using this tool;
(ii) compatibility – the degree of ability of the adaptive learning tool to share information with other products or systems;
(iii) practicality – the degree of applicability of the tool of adaptive learning by users to achieve the goals with efficiency, effectiveness and satisfaction in a given context of use;
(iv) support – determines the quality of support for the tool of adaptive learning by developers.

Each of the criteria is disclosed (deepened) in the following indicators:

(i)
- The "content adaptability" indicator suggests that content can be adjusted to student knowledge.
- The indicator of "opportunities for joint work" involves the ability of students and / or teachers to interact with each other in the learning process.
- "Socio-emotional state" indicator describes the use of the feedback and intervention based on student's socio-emotional state.
- The indicator "organization of knowledge assessment" characterizes the completeness of the presented tools for the development of various certification units.

(ii)
- The "LMS compatibility" indicator provides integration with known learning management systems (LMS).
- The "standard compliance" indicator determines the types of standards for exporting the courses.
- The "cost" indicator is responsible for the availability of a free tariff plan (even with limited functions).

(iii)
- The "learning autonomy" indicator assumes that students can influence or expand (deepen) learning based on their own choice.
- The "accessibility" indicator takes into account the needs of all potential users, including those with disabilities.
- The indicator "support for different forms of learning" provides the opportunity to organize learning with the tool of adaptive learning in various forms.

(iv)
- The "setting" indicator suggests that teachers and course developers can change the content of training or assessment.
- The "content source" indicator characterizes the full range of opportunities for management and use of educational material.
- The "documentation" indicator characterizes the completeness and quality of documentation for the tool of adaptive learning.

Table 2
Criterion "functional compliance" and its indicators

Indexes **Adaptive learning tools**	Content adaptability	Opportunities for joint work	Socio-emotional state	Socio-emotional state	Manifestation of the criterion
Acrobatiq	2.00	1.42	1.33	2.42	60%
Fishtree	1.50	1.33	1.08	2.08	50%
Knewton	2.25	2.58	1.58	2.33	73%
Lumen	2.17	2.75	2.25	2.67	82%
Realize it	2.33	1.92	1.67	2.58	71%
Smart Sparrow	2.83	2.17	2.67	2.58	85%

Table 3
Criterion "compatibility" and its indicators

Indexes **Adaptive learning tools**	Compatibility with LMS	Standards compliance	Cost	Manifestation of the criterion
Acrobatiq	2.42	2.67	1.17	69%
Fishtree	2.67	2.58	1.67	77%
Knewton	2.33	1.92	1.58	65%
Lumen	2.67	2.00	1.17	65%
Realize it	2.25	2.42	1.83	72%
Smart Sparrow	2.42	2.50	2.17	79%

Table 4
Criterion "practicality" and its indicators

Indexes **Adaptive learning tools**	Learning autonomy	Accessibility	Support of various learning forms	Manifestation of the criterion
Acrobatiq	1.58	2.50	2.58	74%
Fishtree	1.67	1.75	1.92	59%
Knewton	2.00	2.50	2.75	81%
Lumen	2.42	2.67	2.58	85%
Realize it	2.42	2.58	2.67	85%
Smart Sparrow	2.75	2.67	2.33	86%

Another group of experts (12 people) was involved in the selection of the most important tools for adaptive learning. Manifestation of each criterion was determined by the assessment of its indicators: 0 points – the indicator was not met; 1 point – the indicator is no longer observed than it is observed; 2 points – the indicator is more adhered to than not adhered to; 3 points – the indicator is fully complied with. In addition, the indicator was considered positive if the value of the corresponding coefficient – the arithmetic value of its parameters – was not less than 1.5.

Table 5
Criterion "support" and its indicators

Indexes Adaptive learning tools	Settings	Content source	Documentation	Manifestation of the criterion
Acrobatiq	2.25	2.50	1.42	69%
Fishtree	1.58	2.42	1.50	61%
Knewton	2.42	2.50	2.00	77%
Lumen	2.50	2.58	1.75	76%
Realize it	1.75	2.58	2.25	73%
Smart Sparrow	2.67	2.50	2.33	83%

The criterion was considered insufficiently manifested if less than 50% of its indicators were positive; critical manifestation of the criterion – 50–55%; sufficient manifestation – 56–75%; high manifestation – 76–100%.

Consider in more detail the results of each of the tools of adaptive learning. Tables 2–5 show the indicators of the defined criteria for each of the selected tools of adaptive learning.

Thus, according to the research, among the suggested tools of adaptive learning Smart Sparrow (now Pearson) and Lumen meet the most relevant criteria.

4. Conclusions and prospects of further research

The results of the study showed the importance of adaptive learning in the organization of the educational process, as it ensures the coordination of the learning process, taking into account the pace of learning, diagnosing the achieved level of mastery, providing the widest range of different learning tools, which would make it suitable for a wider audience.

The use of adaptive learning in higher education is a new area for learning. An important aspect is the choice of adaptive learning tool.Analysis of the characteristics of the product quality model described by ISO/IEC 25010, and specific features inherent in adaptive learning tools, allowed to identify and describe the criteria and indicators that should be followed when selecting adaptive learning tools: functional compliance; compatibility; practicality and support. According to the results of the study of adaptive learning tools according to these criteria, we can conclude that Smart Sparrow (now Pearson) and Lumen are best implemented the ability to show adaptability.

Prospects for further research are in-depth analysis and research of methodological aspects of adaptive learning, as well as the development of guidelines for the use of certain criteria for the selection of tools for adaptive learning.

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Computerized adaptive testing in educational electronic environment of maritime higher education institutions

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Abstract
The article is devoted to the organization of modern learning process, namely the use of innovative technologies – computerized adaptive testing in educational electronic environment of maritime higher education institutions. The example of educational electronic environment is presented in the article on LMS Moodle. The provided new technological and methodological opportunities are a priority in the developed methods of control and testing of knowledge, skills and abilities of students. Comparative characteristic of using computerized adaptive testing in educational electronic environment is given in the article according to different criteria: the role of tests in the learning process; methods of training; equipment; presence of the problems in educational process; level of its control and learning outcomes. The paper also presents examples of activities to form communicative competency of future maritime professionals. Types of adaptive tests are listed in the paper. The research activities were done by second year cadets of ship engineering department of Maritime College of Kherson State Maritime Academy. The experiment was devoted to the formation of communicative competence with the help of electronic environment of maritime higher education institution. The results of experiment proved positive impact of computerized adaptive testing on communicative competence of future ship engineers. Further investigation of adaptive testing can also be done for learning system of maritime education establishments using simulation technologies of virtual, augmented and mixed realities.

Keywords
distance learning, educational electronic environment, maritime higher education, LMS Moodle, computerized adaptive testing, English for specific purposes

1. Introduction

An important role in the organization of the educational process is played by the use of the modern information technologies in the process of selection, accumulation, systematization and transfer of knowledge. The provided new technological and methodological opportunities are a priority in the developed methods of control and testing of knowledge, skills and abilities of students [1].

One of the tools for managing the learning process is test control [2, 3]. That is why one of

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the problems that require priority attention is to improve the testing process, to increase its efficiency.

Computer testing can be used in three ways: computer testing as an alternative form of test presentation (options, and, consequently, the order of presentation of tasks are fixed); computer testing with automatic generation of different test options (options are formed automatically from the existing set of tasks according to the rules set by the developer); computer adaptive testing (for each subject in the testing process an individual set of tasks is formed) [4].

Adaptive testing is generally adequate to modern trends in distance education and opens up new opportunities for improving the efficiency of educational processes [5].

Our common educational model of adaptive school is based, in fact, on the general ideas of adaptive learning and adaptive knowledge control [6, 7]. The origins of this approach can be traced back to the pedagogical works of Comenius [8], Pestalozzi et al. [9] and Diesterweg [10]. At the center of their pedagogical systems was the Student. In their works, they called for starting teaching with what the student stopped to study, because without the "knowledge base" it is impossible to learn new material further. Insufficient awareness of the real level of knowledge of students and their ability to assimilate the proposed knowledge, have become the main reason for the emergence of adaptive systems based on the principle of individualization of learning, so this principle cannot be implemented in traditional, classroom form [11].

Analyzing recent research, we can see many scientists who have dealt with the problem of implementing adaptive tests in the educational process. Modern researchers related to the problem of adaptive testing include Albano et al. [12], Austin et al. [13], Cetin-Berber et al. [14], Collares and Cecilio-Fernandes [15], Istiyono et al. [16], Kang et al. [17], Kozmina et al. [18], Lin and Chang [19], Paap et al. [20], Samsudin et al. [21], van der Linden and Choi [22], van der Linden and Ren [23], Wang et al. [24], Yasuda et al. [25].

Bradác and Klimes [26] created a model of adaptive e-learning system for significant optimisation of language learning with the primary focus on the English language, which is based on using Learning management systems (LMS). Created by them adaptive system for decision-making support enables automated creation of study variants which are suited to each individual student's needs, which current LMSs do not enable.

Souki et al. [27] have placed an emphasis on preferred ways of studying. Scientists provided evidence about the potential of the framework in increasing specific aspects of self-regulated learning and students' performance.

The use of adaptive testing is usually possible in personalized learning. Thus, Balogh et al. [28] dealing with the way of personalizing the teaching of IT subjects from the point of view of a constructivist approach towards the learner proposed their e-course creation methodology that fulfils the assumptions to personalize the education.

The study of Susanti et al. [29] experimentally proved computerised adaptive tests' advantages comparing with the baseline, a linear test.

However, the study of computerized adaptive testing in the training of maritime professionals (teaching English for professional purposes) has not been fully implemented [30].

Therefore, the purpose of this work is to analyze the content of tests and results of computer testing of students to assess the effectiveness of this type of teaching and improve testing methods in teaching English for professional purposes.

The tasks of our work include the following: description of types of adaptive testing, examples of adaptive testing, analysis of its advantages and disadvantages, evaluation of testing.

2. Methods

The participants of this research are a total of 90 cadets (male) aged 17–18 from Ukrainian maritime education establishment (Maritime College of Kherson State Maritime Academy). They are cadets of three departments: navigation, ship engineering and electrical engineering one.

The participants of the research were asked to study in an educational electronic environment including study on Learning Management System (LMS) Moodle and its activities (Forum, Chat, Lesson, Assignment). The materials to be used on LMS Moodle e-course are from "Welcome Aboard: course book" created by English teachers of Kherson State Maritime Academy [31].

A range of interrelated methods was used to solve the formulated tasks for achieving the goal and verification the hypothesis:

- theoretical: terminological analysis – to define the basic concepts of the investigation "communicative competence", "gamification approach"; analysis and generalization of these concepts from the standpoint of different scientific approaches; synthesis, comparison and generalization of theoretical provisions, normative documents, and experience of teaching English in a professional direction by future ship engineers to determine the most appropriate approaches for solving the problem; generalization of scientific-theoretical and practical data for scientific substantiation of structural training of future ship engineers; modeling for the development of a structural model for the formation of foreign language communicative competence of future ship engineers based on a gamification approach;
- empirical: pedagogical monitoring of the state of preparation of future ship engineers for professional activity in order to identify the levels of the specified training, experimental verification of effectiveness developed methods of forming foreign language communicative competence of future ship engineers on the basis of a gamification approach and pedagogical conditions of its implementation; interviewing; questionnaires; analysis results of sea practices;
- statistical: methods of mathematical statistics in order to analyze experimental research data and their interpretation.

3. Results

Computer adaptive tests, which are a fast and quite effective way to measure the level of learning, are becoming more and more widely used for input diagnostic, intermediate and final testing [32].

To determine the level of knowledge of the student, you can conduct initial testing, and then conduct a control test with questions of this level. This type of adaptive tests is more appropriate to conduct at the initial stage of studying the topic, in order to diagnose the initial level of knowledge of the student, and further correction by presenting tasks of optimal complexity.

Currently, there are three options for forming an adaptive test. The first one is pyramidal, when without a preliminary assessment, each student is given a task of medium difficulty and then, depending on the answer, the next task is formed, the scale of which is lower or higher by 2 times [33].

When creating computerized adaptive testing of this type, we use LMS Moodle [34], which supports the “Lesson” activity. This activity allows to create a single task (add a page with data), and after the answer to move to the next page with a question that will depend on the answer provided by the student.

The example of a test of this kind in the author’s electronic course LMS Moodle is illustrated below. The first page of the test consists of a task (Read the case and choose the correct answer to the question below), quasi-professional situations, the authentic text of which was taken from the Internet newspaper, the question (What has crewmembers of Pacific Express done while pirates attack? Where their actions correct or not?), Four possible answers and the scale of progress that is element of gamification and reflects the percentage of correctly completed tasks [35].

Depending on the chosen answer, the next page, if the answer is correct, will have the text of the next question and four possible answers to it. The example of the second page can be seen in figure 2.

If the answer to the question is incorrect, then the next page contains a repetition of the text, a simpler question (What type of ship was attacked by pirates?) and fewer options for answering it [36]. Figure 3 shows the page with incorrect answer.

The second method (flexy level) initially uses any level of difficulty, gradually selecting the appropriate one for the student [37]. Using the “Lesson” activity of LMS Moodle when creating the first page of the test and the question to it, the average level of difficulty is selected. Teacher manages settings of “Lesson” activities: progress bar – to see student’s progress while completion; ongoing score – to know the grade to pass; menu – to choose previous page any minute. He also provides the option to try a question again, chooses maximum number of attempts, restricts the access, links this activity with previous one.

The linked media chosen by teacher is instructions on how to use “Lesson” activities. The maximum number of answers is four. The time limit is 60 minutes. The activity is attempted offline using the mobile application. Students are allowed to review. There is a special setting called Competencies which allows teacher to connect the activity with course competencies from Competency framework. Competency framework allows teacher to add the list of competencies added by an administrator from Standards of training, certification and watchkeeping international convention and IMO Model course 3.17 Maritime English [38]. Competency framework also has progress bar where students see the list of activities needed to achieve competencies of the course.

When a student answers the questions created by teacher correctly all the time, the questions become more difficult.

If a student makes a mistake at least once, the questions become easier. In the third stratified method (stratified adaptive) tasks are taken from the bank of tasks, divided by levels of difficulty. If the answer is correct, the next task is taken from the upper level, if it is incorrect, it is taken

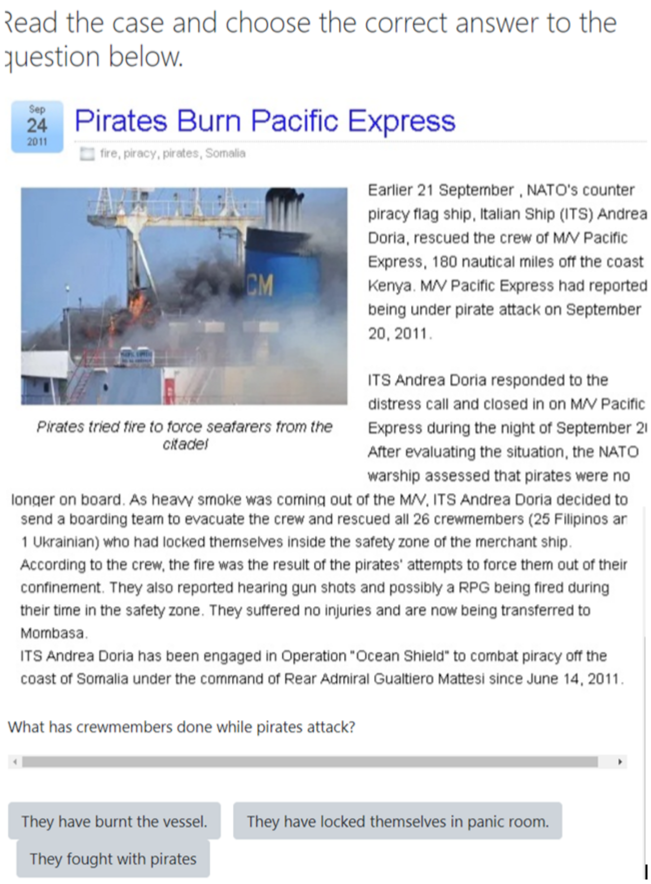

Figure 1: The first page of the electronic adaptive test "Security case".

from the lower level [39].

Distinctive features of adaptive testing in comparison with other forms of testing are the following: each subject receives his own set of tasks, so the content and length of the test may differ for different subjects; each subject is evaluated individually (at his level) with a minimum measurement error [40].

The example of a stratification testing method on LMS Moodle "Lesson" activity where a student can choose his level of knowledge about burns by himself can be seen in figure 4.

Such tests have advantages and disadvantages. The advantages of adaptive tests include a reduction in testing time, as the student may be presented with far fewer tasks. At the same time diagnostic possibilities are not reduced. High measurement accuracy is also achieved. The reliability of test results in this case is the highest. Also, these tests allow flexible and accurate measurement of students' knowledge, identify topics that are poorly known and allow you to ask them a number of additional questions [41].

Disadvantages include the fact that it is not known in advance how many questions need to be asked to determine the level of knowledge of the student; if the student did not answer all

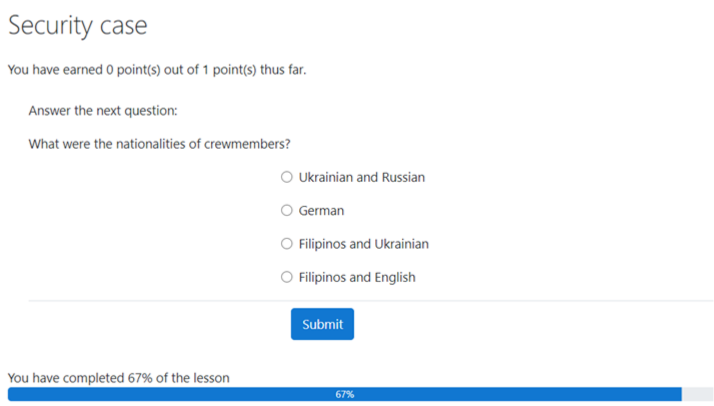

Figure 2: Security case's page in case of correct first answer.

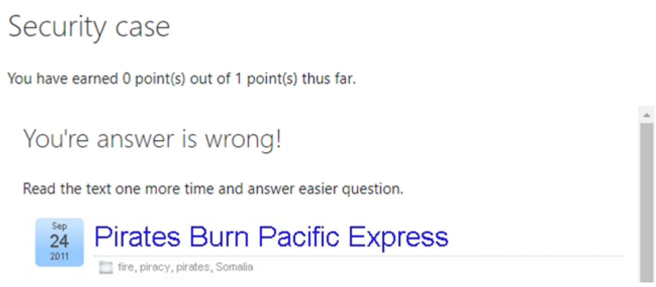

Figure 3: Incorrect answer page example.

the questions, then you can evaluate the result by the number of questions answered. can be used only on a computer [42]. Another important question that arises when using monitoring programs is the question of how to evaluate the results. There are different assessment methods for adaptive testing [43].

The first method is when the assessment is based on the number of correctly performed tasks, without taking into account their complexity. For example, if a student performed correctly from 0–40% of tasks – "unsatisfactory", from 40–70% of tasks – "satisfactory", from 70–90% of tasks – "good", and more than 90% – "excellent".

The second method is when first all the questions are broken down by levels of difficulty and the correct implementation of the next level (in the presence of previous ones) leads to an increase of 1 point (if we talk about the traditional five-point grading system). This method takes into account the quality of the test and makes it possible to somehow differentiate students, even with insufficient adequacy of the test material.

When grading by the third method, the best result among the test participants is taken into account, which is evaluated as "excellent", and all other marks are already set taking into account this result [44].

The fourth method, as well as the second, is based on the initial distribution of all questions

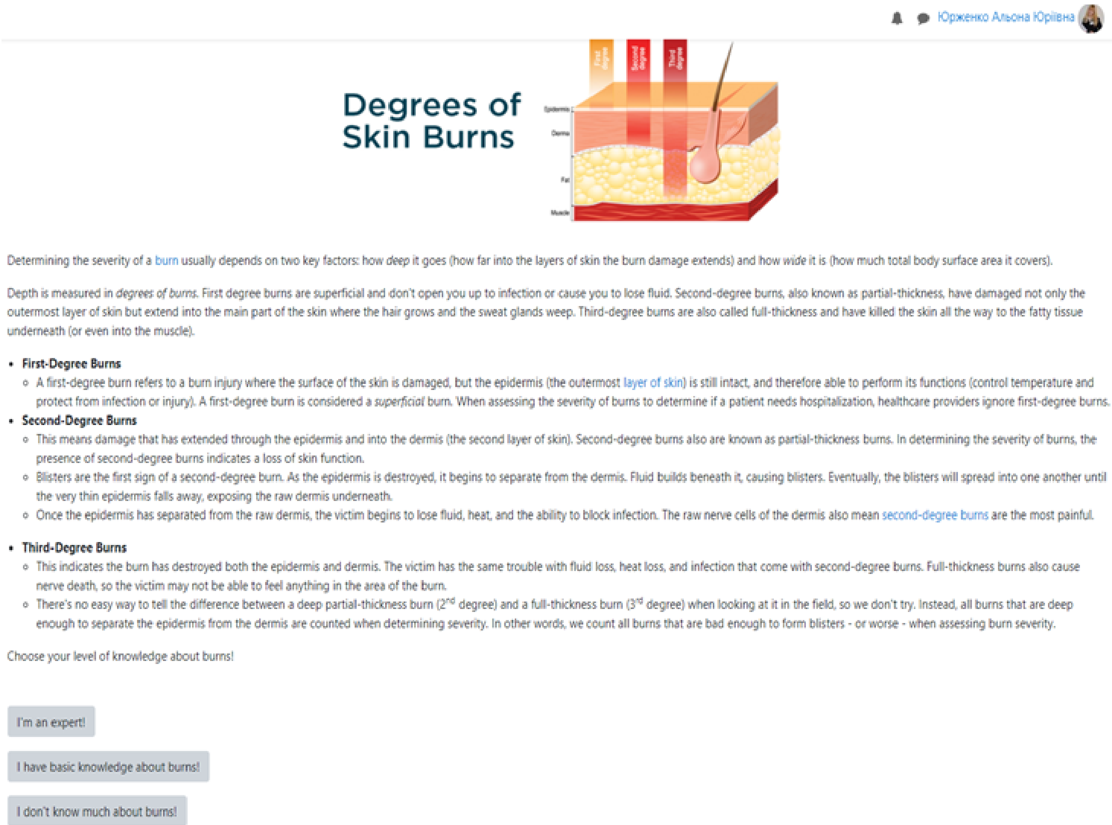

Figure 4: The example of a stratification testing method on LMS Moodle.

by levels of complexity, each of which has its own assessment. And in contrast to the second method, which is taught immediately determined by the level of complexity that he can and works within this level. At correct performance of all tasks the corresponding estimation is exposed. If the number of incorrect answers exceeds 30%, the level of complexity is reduced [45].

When testing, three criteria of test quality are taken into account: reliability, validity, objectivity. The reliability index is characterized by the accuracy and stability of the measurement results using the test with its repeated use. In order for the test to really perform its functions, it is also necessary that its compliance with the requirement of "validity", e.g. the reflection of the scientific content of the discipline and its suitability to serve as a means of measurement. The most common reasons for the invalidity of control: there is a write-off, hint, "teaching" tutors, indulgence, excessive demands, the use of any method in the absence of appropriate conditions [46].

In order to increase the validity of pedagogical control, expert assessments of control material are usually used. Objectivity – a criterion that combines reliability, validity and a number of aspects of psychological, pedagogical, ethical, value nature. When developing this test, all these requirements must be taken into account, but the final conclusions can be made only after its repeated practical application [47].

4. Discussion

The analysis of scientific knowledge and pedagogical practice demonstrates that the student's tests can be effective. By analyzing the data of success after using the tests in the electronic course, one can observe that the current state of formation of the communicative competence of future ship engineers of the 2nd year 2019–2020 Maritime College of KSMA is better compared with 2018–2019 academic year.

According to the results, we see an increase in the success (by 17%) and knowledge quality (by 9%). Qualitative indicator of success was taken as the number of students by "good" and "very good" multiplied by 100% and divided by the total number of students. An absolute success indicator was taken as number of students by "good", "very good" and "sufficient" multiplied by 100% and divided by the total number of students.

The data was taken from the processing of control testing results on LMS Moodle of Kherson State Maritime Academy (Stop and checks activities and Progress tests). Stop and check is testing conducted by the end of every module. Progress tests are conducted twice a semester.

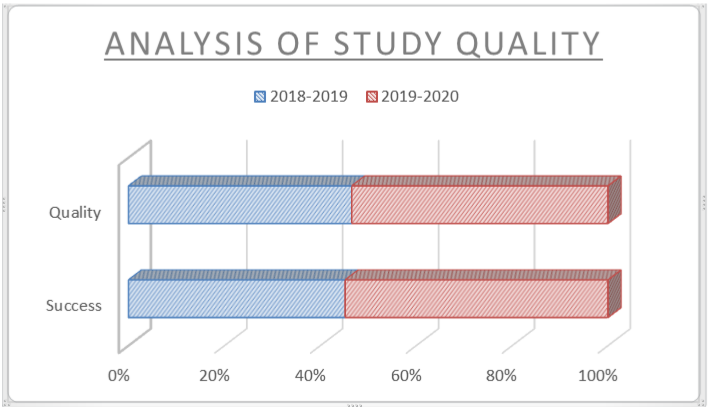

Figure 5: Comparison of statistics for 2018-2019 academic year and 2019-2020 one.

The surveys conducted by cadets of Kherson State Maritime Academy were created by English teachers in Google forms. Links to the surveys were located in LMS Moodle English for professional purpose courses. The results of survey have showed the following data graphically represented in figure 6.

The cadets were asked to answer few questions on the usefulness of new system of computerized adaptive testing on e-course of English for specific purpose. The course contained adaptive tests of the following topics: First aid on board; Emergency situations onboard a vessel; Lifesaving appliances and their use; Marine Environment and its protection; Maritime security. The computerized adaptive tests were located on LMS Moodle with the help of Lesson activity which enables a teacher to deliver content and/or practice activities in interesting and flexible way. Teacher can also create 'branching' exercises where students are presented with content

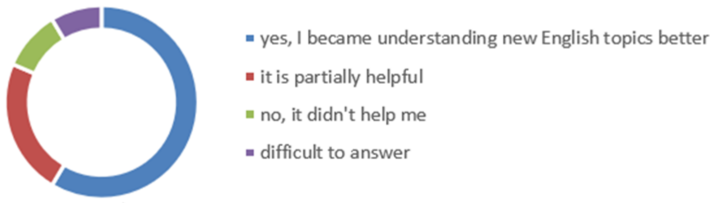

Figure 6: The results of survey conducted among students of ship engineering department on computerized adaptive testing in English for specific purpose.

and then, depending on their responses, are directed to specific pages. The content may be text or multimedia [48].

According to survey results the biggest part of students find adaptive testing useful and comfortable for English for specific purpose studying.

5. Conclusions

Today, learning through the use of computer technology has a number of features that significantly distinguish it from the traditional. Studies have shown that the use of adaptive computer testing technologies can reduce testing time by 50–60%, helps to individualize each test and get a more accurate assessment of knowledge and skills. The tasks offered to the student become more complex gradually and ideally suit his knowledge and skills, increasing his motivation to pass the test.

The expediency of adaptive control follows from the need to streamline traditional testing. Every teacher understands that a well-prepared student does not need to be given easy tasks, as they do not have significant developmental potential. Similarly, due to the high probability of the wrong decision, it makes no sense to give difficult tasks to a weak student. It is known that difficult and very difficult tasks reduce the learning motivation of many students.

The use of tasks that correspond to the level of preparedness significantly increases the accuracy of measurements and minimizes the time of individual testing to about 5–10 minutes. Adaptive testing allows to provide computer delivery of tasks at the optimal, approximately 50% level of probability of the correct answer.

We see the prospects for our further research in this direction in the study of adaptive testing in the system of in-depth learning.

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Adaptive toolkit of branch-oriented workshop environment for enlargement the cloud-based e-learning media platform

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Abstract

The ways of providing comprehensive efficiency increase in communication facilities of the academic space are given with regard to stipulated methods of managing distributed network resources. Selected the user interfaces types are distinguished according to user actions in the studied subject area, which made it possible to justify and hierarchically organize the categories of adaptive toolkit of the branch-oriented workshop environment by the classes of components declared in the project, which are closely related to the scheme of learning experiment and are basic means for simulating transients. The analytical models of classes of components of the virtual laboratory stand are compiled, the elements of which represent the properties and methods for visualization and further processing of interacting instances of the basic locations of the subject area, while ensuring system stability and controllability by clear distribution of functionality. Finally, the unification of component set template properties of the subject area is implemented, which greatly extending the targeted destination of virtual platform and increasing number of educational disciplines of academic course covered by the designed media resource. The results of the pedagogical verification showed an increase in the students' performance in mastering the subject area by means of presented branch-oriented workshop environment.

Keywords

academic information space, workshop media platform, profiled content, structured data flows, subject area

1. Introduction

The deepening of the boundaries of information educational technologies use to poses a strong need for permanent increase in the efficiency of virtual environments at the academic space and improvement of the services quality provided by scientific and pedagogical communication networks [1]. The flexibility of such provision cognitive activity for subjects of educational

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process is possible only with the extension of criteria of analysis of the level of competence of future specialists of engineering and technical direction.

1.1. The importance of the experimental research environment for the training of highly qualified specialists

In order to ensure effective acquisition of skills and practical experience, the laboratory form of organization of cognitive activity is especially important involving computer graphics [2], augmented reality [3], and interactive animation [4], including software, resources for electronic methodological documentation adopted by higher education institutions and provided for industry standards and curriculum on training of specialists; as well, an indispensable factor is an modern production methods, efficient analytical apparatus and instrumentation in accordance with requirements of industry branch. Implementation of advanced educational practices in objectification of computerized training experiment environment using traditional and neoteric laboratory tools determines the topicality of designing computing tools for distributed processing of educational data flows, as well as mechanisms for delimiting end-user personalized areas of unified academic space to meet research needs of hearers of technical and natural courses, and to deployment of remote teamwork over creative collective tasks.

From the described formulation of topicality it follows the timeliness to look for measures to building adequate structural models according to the relevant object classes, which will be key components of the subject area and an interactive metrology toolkit for the infocommunicative experimental research environment as an adaptive learning means.

1.2. Analysis of modern views of authoritative scientists on problem the implementation of computerized means of training experiment

Nowadays methods of academic activity digitalization are widely covered by scientists [5, 6]. This is especially interesting here use of multimedia data mining, stratification and data management, which circulate in a virtual platform of experimental research.

Psychological and social peculiarities of virtual and augmented reality implementation and their potential for enriching students' learning experience investigate in particular Makransky and Petersen [7], while highlighting the affective and cognitive paths that obviously contribute to increasing quantitative learning outcomes. Using of some common ones gamification function to promote a student-centered learning environment for personal and professional development dedicated the works of Buzko et al. [8], Champion [9], Haranin and Moiseienko [10], Katsko and Moiseienko [11], Pokulyta and Kolotylo [12], Shepiliev et al. [13], Symonenko et al. [14], Tokarieva et al. [15], Tsay et al. [16], Vakaliuk et al. [17, 18], Voloshynov et al. [19], Yildirim [20], Zinovieva et al. [21] etc. The conditions of application of telecommunication solutions in remote subject-information environments for acquiring competencies in the mastering of technical specialties are analyzed in detail by Barker et al. [22], Calvo et al. [23], Lovianova et al. [24], Milani and Navimipour [25], Modlo and Semerikov [26], Modlo et al. [27, 28], Rashevska and Soloviev [29], Vlasenko et al. [30, 31]. The current state of virtualization of the educational laboratory in the field of science, technology and technology is summarized with recommendations and outlining the prospects for further development in the works of

Bondarenko et al. [32, 33], de Hei et al. [34], Kiv et al. [35], Lavrentieva et al. [36], Nechypurenko and Soloviev [37], Nechypurenko et al. [38, 39, 40], Pererva et al. [41], Potkonjak et al. [42], Syvyi et al. [43], Tarasenko et al. [44], Zinonos et al. [45]. Directions of extension of functional of subject area of experimental researches to full-fledged workshop format in the appearance of diagram models with introduction of mechanism of prototyping of components see into by Karagiannis and Buchmann [46], also algorithms for the identification and arrangement of such components are being developed by Goyal and Ferrara [47], Jia et al. [48], Murphy [49].

However, in considered researches, as well as in existing platforms of world and domestic practice, the question of accumulated information interactive introduction of sectoral enterprises production process directly into educational environment of experimental researches is almost not covered, and unification directions of subject area composition tools for provision of interdisciplinary pedagogical services are very superficially determined. It should also be noted that mechanisms for integrating virtual laboratory computing resources into academic information space together with provision of profiled content for authenticated recipients of multi-user creative training ground to initiation and support of educational and scientific projects are practically never disclosed; as well as completely ignores the problem of providing adequate access to interested representatives from other academic departments and independent cultural-educational and research institutions of profile industry.

Therefore, it is timely to find conceptual solutions in data flows management the subject area of interactive media resources of laboratory workshops as an organic constituent the computerized learning system in the preparation of highly qualified specialists in technical direction and developing competencies as future engineer, which will in handy in the fulfillment of his professional duties.

2. Infocommunicative media platform of remote experimental research

Hearers of modern engineering specialties master the practical component of the profile industry in the laboratory lesson when using equipment adapted to the conditions of the educational process, laboratory models, installations and the like. For holding laboratory work standardized instructions are prepared corresponding requirements of profile industry branch. Instructions for laboratory and practical lessons are a variety of workshops – educational publications of tasks and exercises that contribute to the assimilation of acquired knowledge, skills and abilities. The official confirmation of the expediency of their use in the pedagogical process of higher education institutions is realized through the procedure of approval by the subject committee of the Scientific and Methodological Council for Education.

Appropriate recommendations also accompany laboratory studies implemented on neoteric systems based on computing platforms for monitoring physical devices and material laboratory stands and with only indirect involvement of the end-terminal of the academic space.

2.1. Stipulation the object-oriented concept of virtual laboratory

Unlike classical laboratory stands to increase the effectiveness of the self-study component for today it is advisable to use a computerized learning experiment platform providing full simulation of laboratory work from combining the experimental scheme directly from the virtual toolkit to further study the imitation models obtained and to automatically generate a report of the selected research results according to the requirements made in the higher education institution. Thus, the student as the subject of the educational process operates descendants of classes of object model, which are presented at the end-terminal as graphical images of real equipment of the subject area [50].

When performing laboratory tasks such graphical images form structured objects; object-oriented programming methods and events allow them to be moved / copied, grouped, rotated, and more. Having superficial skills in handling the environments of computer-aided design, students of inceptive courses will be able to independently make a imitation model of the subject area, and based on a virtual experiment scheme to carry through the analysis of transient process. Given the known difficulties, when designing an interactive virtual media laboratory resource with its subsequent integration into academic information space, first of all it is necessary to spend stratification of all possible categories of data flows and determining the end software modules where they will be applied.

Therefore, to placement research objects and visualization of the subject area itself to necessary define the types of *user interfaces*. The main user actions go within the If_A application workspace through specialized toolkit T_A. Regardless of the purpose of the virtual laboratory and her place in the academic curriculum to group the commands of this pictographically toolkit of the application object-oriented interface there is a need to distinguish generalized categories of data structures in the designed learning experiment environment.

The basic locations of the experiment scheme are given by virtual models of the *main components* of class $\boldsymbol{D}$, which developed and introduced for the implementation of physical devices (stages) of the investigating technological process by their transient function. To integrate virtual models of class $\boldsymbol{D}$ components from T_A toolkit physical device category of laboratory research application into continuous scheme of educational experiment, in created educational media resource is separated category of *connecting components* implemented in class $\boldsymbol{L}$. For informational support of the learning experiment scheme, it is necessary to provide a separate tag that will store the *independent text components* $\boldsymbol{E}$. Also, in a separate data structure, it is advisable to keep information about certain *contours* of $\boldsymbol{R}$ from a generalized scheme of learning experiment.

2.2. Categorization of data flows in computerized learning experiment environment

According to the conditioned object-oriented model of experimental research environment some current component D_i as an instance of class $\boldsymbol{D}$ first of all, will be determined by identifier of individual component class *IdClass*, which is unique to the research subject area, and identifier of specific instance $IdCom_i$, which exceptional in the modeled scheme of the experiment. Also, the data structure pointer of the current component captures its *attributes* in the computerized learning experiment environment and placement features on the canvas of the subject area, which are determined by nested pairs.

So, the set of attributes of an instance of the *Exp* component represented by the optional parameter in, which stores the component index in its reference designation, provided by the identifier *IdClass*; in general, this index is generated and rendered automatically by the serial number of an instance of a specific object class of major components in the current subject area, but in the project presented it was advisable to provide a means of correcting it. In addition to the index in the layout of the learning experiment scheme, the end user of the educational information space also indicates the nominal of component *nom*. If the instance nominal is not adjusted by the student, the *Exp* property will retain the default value initiated by the class identification. It should be noted here, that another optional parameter – the mathematical model *mod*, which describes the functioning of the component and is required for further research of transient processes in the system under investigation, is determined by the class identifier, and as well the *minimum* and *maximum* value of the component.

The location *Pl* of graphical designation current instance of the component on canvas of subject area of the virtual laboratory stand is visualized by the coordinates xy_i of its reference point in the relative coordinate system of the screen environment, the *ori* property identifying the rotation angle and the mirror option, and the instance identifiers of adjacent components *IdCom* in scheme of the learning experiment. Thus, the tuple of instances of the main components of object-oriented class ***D*** in the data flow of subject area includes a predefined list of typical properties and methods as reactions to user and system events (1):

$$\begin{aligned} D_i = \{IdClass_D, IdCom_i, Exp\{in, nom, mod\}, \\ Pl\{xy_i, ori, Adj\{IdCom_{i-1}, IdCom_{i+1}\}\}\}. \end{aligned} \tag{1}$$

Further, the basic properties of some current link L_j as an instance of class of *connecting components* ***L*** will also be determined by the native class identifier *IdClass* and the identifier the *j*-th instance of the link *IdCom*$_j$. The formatting attributes of the connection component are stored in nested *Exp* pair and show the start and end types of the link. Structure of pointer location of the *Pl* connector is consistent with the corresponding tag of the main components and provides an abscissa and ordinate for the onset of rendering, the link orientation and a list of the main components connected to it. So the structure of data flows fragment with the properties of the current connection component (2) will be simpler, more compact and faster processed by computing resources of graphics device interface at the end-user terminal of the learning system:

$$\begin{aligned} L_j = \{IdClass_L, IdCom_j, Exp\{bl_j, el_j\}, \\ Pl\{xy_i, ori, Adj\{IdCom_{L(bl)}, IdCom_{L(el)}\}\}\}. \end{aligned} \tag{2}$$

It is even simpler to implement a fragment of a data structure in the project that covers the *independent text components* ***E*** necessary for informational support of the scheme of the learning experiment. As this component does not carry any technical load, it is inappropriate to allocate a separate class of the internal component library to it. Therefore, it was decided to use the standard character field of the edit class provided via the terminal graphics device interface and to keep in the specification some of its important parameters that are available for adjustment by the end user. Consequently, the projection E_k of some independent text object (3) contains a set of simpler font attributes *Ft*, such as a font type, size, design of type face, etc., already described *Pl* location pointer options and actually context:

$$E_k = \{Ft, Pl\{xy_k, ori\}, context_k\}. \tag{3}$$

It should be noted that such a traditional connecting component as *node*, acting as part of the communication network, in the presented project implemented by a class of principal components ***D*** with corresponding properties (1) with a somewhat simplified description, a blank orientation record, and an advanced array of adjacent components list. The contain of this array is dynamically changed during the experimental research, interactively adjusting the number of gateways of the corresponding *node*. It is this component that allows us to detail in the experiment scheme a particular region of R_p, to that is given particular attention as a separate step according to map of the technological process.

For highlight regions ***R*** within an outline of virtual laboratory stand the T_A toolkit provides a separate cursor by which the user captures key components. In turn, the set of such selected regions with corresponding properties (4) are saved in the final fragment of pithiness part of subject area data flow, encompassing the *Pt* array of the sequence of components in the direction of the signal in the research region with his inherent cumulative mathematical model mod_p for further automized modeling of transient process:

$$R_p = \{Pt\{IdCom_{[p]}\}, mod_p\}. \tag{4}$$

The built models (1) – (4) as an organic part of our analytical apparatus of the transient modeling application, they provide flexible processing the data structures of subject area in the learning experiment environment. However, for designing the full-fledged unified educational platform of virtual laboratory as an organic component the academic information space these conditioned descriptors is obviously not enough.

2.3. Tagging of the basic templates structure a learning experiment environment

The correctness and completeness of the conceptual description of the collection of basic templates of multiple components of the subject area defines the limits of application of the projected environment. To expand a target appointment the virtual platform of experimental research and involvement in it maximum number of educational disciplines from an academic course to prepare qualified professionals, it is advisable to implement such templates in the form of distributed software libraries *iLib* that will dynamically connect to the application environment of the learning experiment.

An object-oriented class of template components as T_A toolkit categories is formed in a service environment with a separate type of the user interface If_K with a slightly different T_K toolkit. Generated as a result original data packet will store the unified properties of the component and will later transfer them on the descendant instances. The pithy part of the component description is located in the descriptor of the class identification block (5):

$$IdBlock = \{IdClass, Name\_C, Cond\_M, Units, Nom, Mod\}, \tag{5}$$

where *IdClass* is identifier of component prototype object class;
Name_C is character array of component name;
Cond_M is reference component designation;
Units is the units of component transient measurement;
Nom is default value of component nominal;
Mod is the mathematical model of component transient measurement.

As noted, specified by default mathematical model *Mod* is not a required parameter and can be adjusted in a step of building the scheme of experiment (1). Representation features of component instance in the application window workspace, him appearance and features of behavior are defined by description of graphic block (6):

$$GrBlock = \{Gr\_C, Size\_C, Gate\_C, Icn\_C\}, \tag{6}$$

where *Gr_C* is graphics image of the component in scheme of experiment;
Size_C is two-elements array of dimensions of graphic image on canvas;
Gate_C is eight-elements array of connector gateways of graphic image;
Icn_C is bitmap array of component's thumbnail in toolkit T_A.

By default, a bitmap array of thumbnail is formed by scaling the graphic image of the component. The graphic image itself is attached to a dynamic library from an external file or created by the user in the If_K interface in component designer with using the T_K toolkit, what operates with primitives from system graphics device interface.

Application environment design virtual laboratory as a distributed means of providing remote educational services provides for the mandatory introduction of the accompanying block for contextual information and methodological support for experimental research, in particular indicating the sequence of implementation of the current studies exercise (7):

$$AccBlock = \{Val\_C, Help\_C, KnB\_C\}, \tag{7}$$

where *Val_C* is the numerical array of component transient process values;
Help_C is context of the target indexing of the help subsystem;
KnB_C is context of targeted indexing of the academic knowledge base.

Numeric array of benchmarks the transient process measured in *Units* (5), gives the nominal value, which is stored by default in the instance of the corresponding component of experiment scheme (1), as well as the minimum and maximum possible values to account of boundary conditions for further modeling the subject area.

3. Directions for expanding resources of virtual laboratory

Indexed sections of the help subsystem promptly provide the context for drop-down tooltip of T_A toolkit and a sampling of hyperlinks in the expandable zone of the application window

If_A. For a complete organization of scientific and educational conditions a similar sampling of profiled methodological materials [51], indexed from the repositories of the academic knowledge base *ADB*, arrive at the end-terminal of the computerized learning system.

3.1. Integration of the virtual laboratory environment into the academic information space

The tuple (7) provides flexible integration of virtual laboratory environment into educational space (figure 1, *a*) in service of authenticated recipient *U*. First of all, it is provided here the classic content of theoretical piece and methodological guidance, which is approved by the relevant department in its static form as information support for the preparation of specialists in a specific educational program *E_Pr*. In addition to the above information support for the end-user the adaptive *F*1 content is delivered, which is dynamically generated by analytical apparatus of education space from resource funds of the academic scientific and technical library on individual profile requests or according to the results of introductory testing on the relevant topic of laboratory lesson [52]. The result of this individually oriented solution is to improve the perception and memorizing of practice information.

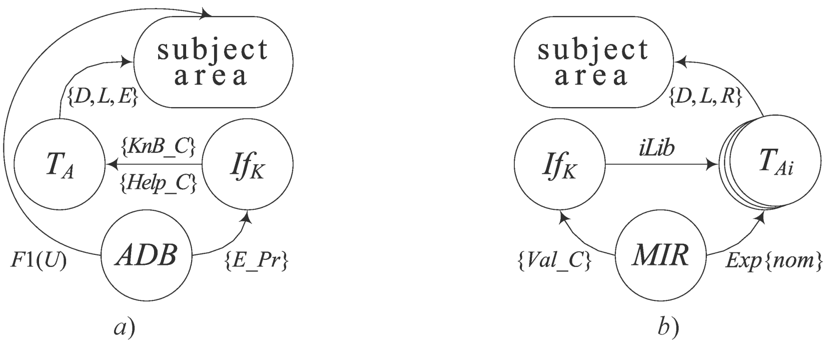

Figure 1: Structurization of data flows when expanding resources of virtual laboratory.

Management of such data flows inclusive with their content happens this way, to the interdisciplinary content of adaptive profiled content was in direct proportion the amount of competencies missing from the recipient. Such adaptability is ensured by the automatic structuring of the academic knowledge base resources through carefully marking by the authors of key concepts as it is refreshed and indicating interrelations with other topics of the discipline or with topics of other disciplines of the educational program.

Specific means of target indexing of help subsystem and academic knowledge base provide reflection in informational accompaniment of fragments of an intermediate version of editions, which are being prepared for printing, but which are located by author on department's network. Such excerpts is initiated in accordance with the keywords of the studied subject area, which are specified in the search query; thus resolves the problem of bringing of unpublished faculties funds to the end user.

These closed sources supposed an opportunity for online discussion, commenting, highlighting of eventuality errors or omissions in feedback to the author, which is very useful when verifying the unfinished tasks of learning experiment. Integration of the environment of virtual laboratory into the academic information space also expands opportunities to organize student teamwork, turning to a multi-user media platform to support educational and scientific research and the development of collective projects.

3.2. Updating of scientific and methodological content of laboratory workshops

An important means in supporting scientific research and activation of students cognitive activity through teamwork, conducted in the designed environment of experimental research it is possible to get real manufacturing telemetry reading (figure 1, *b*). Descriptor of a numeric array of transient process values of component *Val_C* from the tuple (7) as attributes of the location components scheme of experiment *Exp* {*nom*} (1) allows connect to one of the specialized distributed dynamic libraries *iLib* of some relevant channel of data exchange with manufacturing information resources *MIR* for prompt broadcast of relevant pieces from the profile industry.

As a source of such manufacturing resources in the project applied through protocol description of industry processes [50, 53], which specifically stores transactions direct data exchange with automated data systems and equipment. This protocol, as well as the logistic information of the enterprise, which are organized as separate dynamic libraries of conditioned structure (5) – (7) will be an toolkit array T_A={T_{Ai}} and gives the flexibility to specialize the learning experiment environment If_A to the subject area of the respective academic discipline, and a list of tutorials and component options of transient process, being tested in laboratory work, bring closer to real production circumstances. The implementation of the described similarity with the production conditions of the future profession for young engineers is very important and also enhances the effectiveness of the projected virtual computerized platform of practical workshops supply, which is closely integrated into the academic scientific and educational information space.

4. Approbation and results of pedagogical exploring

The presented infocommunicative media platform of the virtual laboratory was introduced into the educational process in the discipline “Electrical engineering and electromechanics” according to the educational and professional program of higher education bachelor’s degree in “Automation and computer-integrated technologies”. Measurements were performed to compare the competencies of students who completed the first year of study.

Participants in the pedagogical exploring were 60 students: 30 – control group (CG) and 30 – experimental (EG). Group homogeneity was determined using Pearson’s chi-squared test. Under the terms of the exploring, only the experimental group was allowed to work in the virtual laboratory. Instead, the control group traditionally worked with highly specialized computer applications for digital modeling of electronic circuits Micro-Cap 11. It should be noted that this electronic design automation software does not comply with the requirements of domestic standards in the graphical designation of subject area components and also there are the complexity and specificity of the English-language interface, especially for initial years students.

To evaluate the effectiveness of the proposed method of work with a virtual laboratory in conditions of comparing the empirical distribution with the theoretical for the two available small samples, the quantity of which is given by pedagogical practice (5 ÷ 20 < *n* < 30), the difference (or agreement) of the academic performance level of the experimental and control groups was researched using the criterion of agreement χ^2 (Pearson):

$$\chi^2 = \{n_E G, n_C G, k\}, \tag{8}$$

where $n_E G$ is the frequency of progress points in the experimental group;
$n_C G$ is the frequency of progress points in the control group;
k is the number of compared frequencies ($k = 6$ for points from 0 to 7, which provided by the curriculum).

Figure 2 presents a histogram of the academic performance distribution of the groups that participated in the experiment (control group marked with cones, experimental – parallelepipeds) at the end of the year. In the experimental group, compared with the control group, there is an increase in the number of students at intermediate and advanced levels. This indicates that the students of the experimental group study the subject area faster and more deeply in a virtual laboratory.

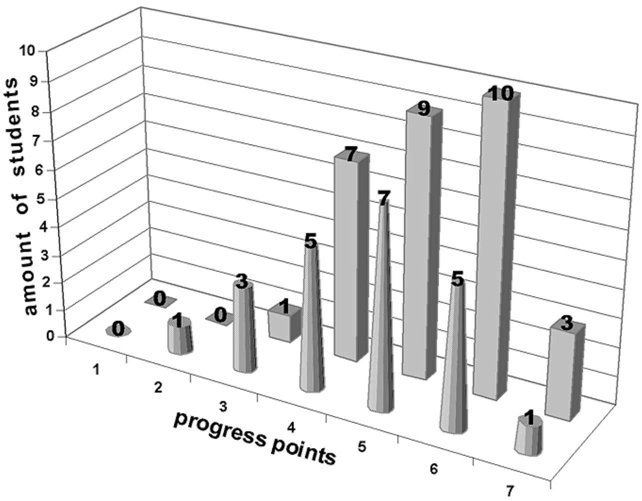

Figure 2: Histogram of the academic performance distribution in the control (cones) and experimental (parallelepipeds) groups.

To test the hypothesis about the effectiveness of teaching methods using a virtual laboratory, Pearson's chi-squared test was used (8): H_0 – assume that the empirical distribution of EG agrees with the theoretical distribution of CG (no differences between group performance), or H_1 – there is a difference between distributions. For the selected significance level $\alpha = 0.05$ and the number of freedom degrees $s = k - 1 = 5$ we find by the upper-tail critical values of chi-square distribution critical value $\chi^2_{cr}(\alpha, s) = \chi^2_{cr}(0.05; 5) = 12.705$.

Comparison of tabular and calculated value of the criterion $\chi^2_{cr} < \chi^2_{cr}(\alpha, s)$, namely 11.07 < 12.705, gives grounds to reject the hypothesis H_0 about the identity of the distributions of estimates in the groups EG and CG and to accept the opposite H_i about the difference between the distributions. Also, we can conclude with a probability of 0.95 that there are differences between teaching methods.

Thus, the results of the pedagogical exploring show that the interdisciplinary environment of laboratory research introduced into the educational process with sufficient tools helps to increase the advancement of future specialists in mastering the subject area. This progress is obviously due to the lack of redundant features that distract students from the content of the laboratory task, and a positive User Experience when interacting with a practical and friendly media platform.

5. Conclusions

Conditioned structural relations between component attributes, that make up a formalized description of the properties, characteristics and functionality of subject area as descriptors are formed the basis of the original specification of the virtual laboratory in general and the internal libraries for it. Using the specifications of the agreement, proposed structure provides optimal control of data flows of interactive media resources of laboratory workshops, which simplifies the methods of modeling and visualization of the subject area of the learning experiment at terminal of end-user of the academic information space with the operative attachment of target control elements and provision of profiled dynamically generated content from different sources of corporate knowledge base.

For all descriptors of the specification of the interactive media resource, the preservation of the optimal list of parameters is implemented, which provides simplification of the methods of its modeling when pulling up the structured content from different sources of the knowledge base, reducing the load on the hardware of the end-terminals of the scientific-pedagogical space and offsetting possible incompatibilities with the future reorganization of the single-pages applications web-interface to provide prompt and comfortable end-user access to actively sought after educational services. The proposed solutions for technological content will improve the future professionals training quality, training them on the current means of modern production, while enhancing cognitive activity and accumulation of knowledge capital with leadership skills through effective teamwork, and in the future to deploy interactive supervisory systems of the profile industry based on academic environment computing resources of the experimental researches for the subject area of professional disciplines where the contour routes of the experimental scheme are provided.

Further development of the project is planned to focus on the implementation of distributed access by authenticated users for independent processing of the separate stages of a single scheme of the learning experiment. Specification and extension of mechanisms for simultaneous exchange of resources for all parts of the virtual lab stand in real time will allow to formalize and narrow down a set of QoS methods to managing of Display Network packet resources, will ensure the elimination of conflicts especially at the stages of profile identification, which are sensitive to data incompleteness and delay, and as a result promote of competitive media-oriented product, which will be required by the target consumer of educational services.

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Cloud enabling educational platforms with corc

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Abstract
In this paper, it is shown how teaching platforms at educational institutions can utilize cloud platforms to scale a particular service, or gain access to compute instances with accelerator capability such as GPUs. Specifically at the University of Copenhagen (UCPH), it is demonstrated how the internal JupyterHub service, named Data Analysis Gateway (DAG), could utilize compute resources in the Oracle Cloud Infrastructure (OCI). This is achieved by utilizing the introduced Cloud Orchestrator (corc) framework, in conjunction with the novel JupyterHub spawner named MultipleSpawner. Through this combination, we are able to dynamically orchestrate, authenticate, configure, and access interactive Jupyter Notebooks in the OCI with user defined hardware capabilities. These capabilities include settings such as the minimum amount of CPU cores, memory and GPUs the particular orchestrated resources must have. This enables teachers and students at educational institutions such as UCPH to gain easy access to the required capabilities for a particular course. In addition, we lay out how this groundwork, will enable us to establish a Grid of Clouds between multiple trusted institutions. This enables the exchange of surplus computational resources that could be employed across their organisational boundaries.

Keywords
teaching, cloud computing, grid of clouds, Jupyter Notebook

1. Introduction

The availability of required computational resources in organisations, such as scientific or educational institutions, is a crucial aspect of delivering the best scientific research and teaching. When teaching courses involving data analysis techniques it can be beneficial to have access to specialized platforms, such as GPU accelerated architectures.

At higher educational institutions, such as the University of Copenhagen (UCPH) or Lund University (LU), these centers are substantial investments, that are continuously maintained and upgraded. However, the usage of these resources often varies wildly between being fully utilized to sitting idly by.

We therefore propose, that these institutional resources be made available (with varying priority) across trusted educational and scientific organisations. Foremost, this is to enable the

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voluntary sharing of underused resources to other institutions, thereby potential establishing greater scalability than can be found within each individual institution.

1.1. Basic IT

Within institutions such as UCPH, there is a mixture of services that each provides. At the very basic level, there are infrastructure services such as networking, account management, email, video conferencing, payroll management, license management, as well OS and software provisioning. In this paper, we define these as Basic IT services. At educational institutions, additional services can be added to this list, these include services for handling student enrollment, submissions, grading, course management, and forum discussions. As with the initial Basic IT services, these are typically off the shelf products that needs to be procured, installed, configured and maintained on a continuous basis.

A distinguishing trait of Basic IT services, in an education context, is that they are very predictable in terms of the load they will exhibit, both in times of high and low demand. For instance, there will be busy junctions, such as assignment hand in days, release of grades, student enrollment, and so on. In contrast, holiday and inter-semester periods will likely experience minor to no usage. Given this, these services are classic examples of what cloud computing was developed to provide. Efficient utilization of on-demand resources, with high availability and scalability to handle fluctuating usage in a cost effective manner.

1.2. Science IT

Science IT services, in contrast, revolve around the institutions scientific activities whether by researchers or students. They include services such as management, sharing, transferring, archiving, publishing, and processing of data, in order to facilitate the scientific process. In addition, these facilities also enable lecturers to utilize their research material in courses, giving students access to the same platform and resources.

What distinguishes these services, is that they impose different constraints compared to Basic IT services. These typically involve areas such as, computational load, security, budgetary, scientific, and legal requirements, among others. For example, it is often too inefficient, or costly to utilize public cloud resources for the storing and processing of large scientific datasets at the petabyte scale. In this case, a more traditional approach such as institutional compute resources is required [1].

Research fields such as climate science [2], oceanography [3], and astronomy [4], often employ experimental simulations as a common scientific tool. These simulations produce output up to petabytes in size, that still need to be stored for subsequent postprocessing and analysis. Upon a scientific discovery from this process, the resulting datasets needs to be archived in accordance with regulatory requirements, which in the case of UCPH is 5 years [5] (only available in Danish).

1.3. Institutional resources

High Performance Computing (HPC) and regular compute centers are often established at higher educational institutions to provide Science IT services. The UCPH [6], University of

Antwerp [7], and LU [8] compute centers are examples of this. In addition, institutions can also gain access to similar resources through joint facilities like the Vienna Scientific Cluster [9], which supports 19 institutions, 10 of which are higher educational institutions. Finally there are national and pan-national resources such as ARCHER2 (UK) [10] or the EuroHPC [11] that review applications before access is granted.

These established centers are very expensive to build and have a limited lifespan before they need to be replaced. Even smaller educational compute platforms follow a similar life-cycle. For instance, at the UCPH a typical machine has a lifetime of 5 years before it needs to be replaced. This is whether the machine has been heavily utilized or not. Therefore, it is important that these systems across institutions are utilized, not only efficiently, but at maximum capacity throughout their lifetime.

For organising the sharing of resources across trusted educational and scientific organisations, inspiration is drawn from the way traditional computational Grids have been established [12]. The difference is, that instead of establishing a Grid where individual resources are attached, this model will instead be based on each institution establishing a Cloud of resources that are shared via a Grid. This means that the Grid is responsible for interconnecting disjointed clouds, whether they be institutional or public cloud platforms. The result being an established model for sharing cloud resources across educational institutions in support of cloud services for bachelor and master courses, general workshops, seminars and scientific research.

In this paper, we present how an existing teaching and research service at UCPH could be enabled with access to a cloud framework, which is the first step towards a Grid of Clouds resources. We accomplish this by using the Cloud Orchestrator (corc) framework [13]. Through this, we are able to empower the DAG service with previously inaccessible compute resources across every course at UCPH. This was previously not feasible with internal resources alone. Since we do not have access to other institutional resources at this point in time, we utilized a public cloud provider to scale the service with external resources.

2. Background

At the Niels Bohr Institute (NBI), part of UCPH, we host a number of Science IT services that are part of providing a holistic educational platform for researchers, teachers, students, and general staff. A subset of these Science IT services have been especially beneficial across all levels of teaching. Namely, services such as the University Learning Management System (LMS), called Absalon, which is based on Canvas [14] for submissions and grading. The Electronic Research Data Archive (ERDA) [15] for data management and sharing tasks. In addition to the Data Analysis Gateway (DAG) [16], which is a JupyterHub powered platform for interactive programming and data processing in preconfigured environments.

2.1. Teaching platforms

The combination of these subset services, in particular the combination of ERDA and DAG, has been especially successful. Teachers have used these to distribute course material through ERDA, which made the materials available for students to work on at the outset of the course. This ensures that students can get on with the actual learning outcomes from the get go, and not spend time on tedious tasks such as installing prerequisite software for a particular course. Due to budgetary limitations, we have only been able to host the DAG service with standard servers, that don't give access to any accelerated architectures.

Across education institutions, courses in general have varying requirements in terms of computing resources, environments, and data management, as defined by the learning outcomes of the course. The requirements from computer science, data analysis, and physics oriented courses are many, and often involve specialized compute platforms. For example, novel data analysis techniques, such as Machine Learning or Deep Learning have been employed across a wide range of scientific fields. What is distinct about these techniques is the importance of the underlying compute platform on which it is being executed. Parallel architectures such as GPUs in particular are beneficial in this regard, specifically since the amount of independent linear systems that typically needs to be calculated to give adequate and reliably answers are immense. The inherent independence of these calculations, makes them suitable for being performed in parallel, making it hugely beneficial to utilize GPUs [17].

Given that the DAG service was an established service at UCPH for data analysing and programming in teaching bachelor and master students, it seemed the ideal candidate to enable with access to cloud resources with accelerator technology. For instance, courses such as Introduction to Computing for Physicists (abbreviated to DATF in Danish) [18], Applied Statistics: From Data to Results (APPSTAT) [19], and High Performance Parallel Computing (HPPC) [20], all would benefit from having access to GPU accelerators to solve several of the practical exercises and hand-in assignments.

2.2. ERDA

ERDA provides a web based data management platform across UCPH with a primary focus on the Faculty of Science. Its primary role is to be a data repository for all employees and students across UCPH. Through a simple web UI powered by a combination of an Apache webserver and a Python based backend, users are able to either interact with the different services through its navigation menu, or a user's individual files and folders via its file manager. An example of the interface can be seen in figure 1. The platform itself is a UCPH-specific version of the open source Minimum Intrusion Grid (MiG) [21], that provides multiple data management functionalities. These functionalities includes easy and secure upload of datasets, simple access mechanisms through a web file manager, and the ability to establish collaboration and data sharing between users through Workgroups.

2.3. Jupyter

Project Jupyter [22] develops a variety of open source tools. These tools aim at supporting interactive data science, and scientific computing in general. The foundation of these is the IPython Notebook (.ipynb) format (evolved out of the IPython Project [23]). This format is based on interpreting special segments of a JSON document as source code, which can be executed by a custom programming language runtime environment, also known as a kernel. The JupyterLab [24] interface (as shown in figure 2) is the standard web interface for interacting with the underlying notebooks. JupyterHub [25] is the de-facto standard to enable multiple

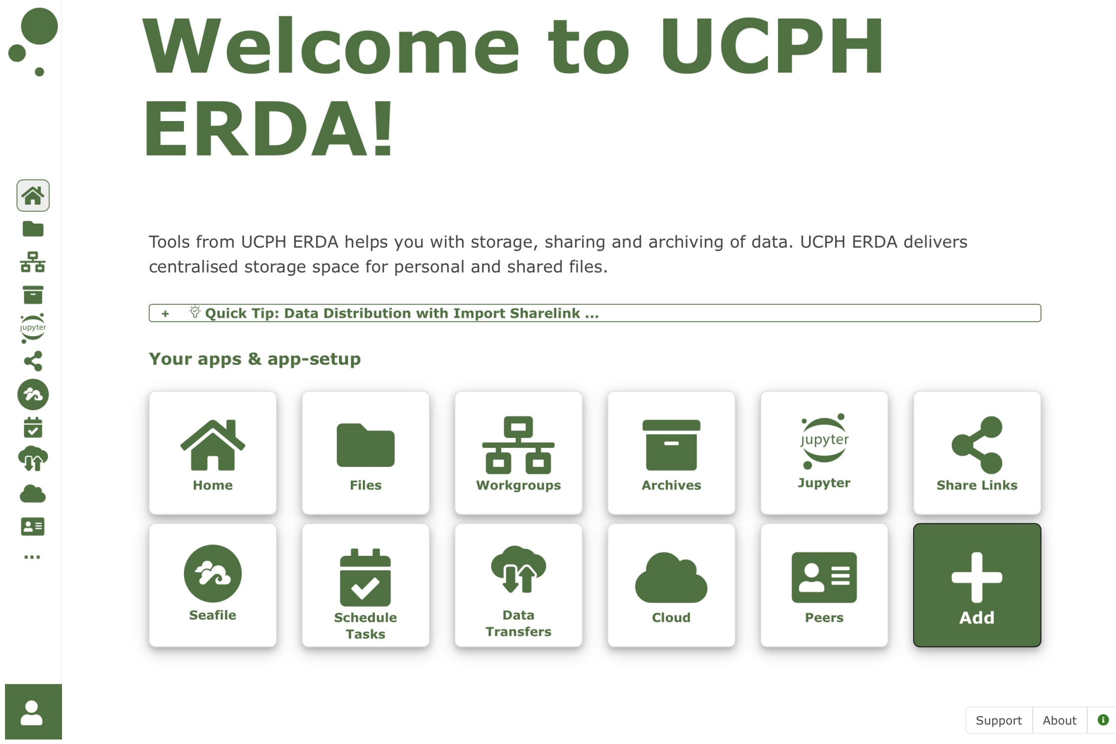

Figure 1: ERDA Interface

users to utilize the same compute resources for individual Jupyter Notebook/Lab sessions. It does this through its own web interface gateway and backend database, to segment and register individual users before allowing them to start a Jupyter session.

In addition, JupyterHub allows for the extension of both custom Spawners and Authenticators, enabling 3rd party implementations. The Authenticator is in charge of validating that a particular request is from an authentic user. The responsibility of the Spawner is how a Jupyter session is to be scheduled on a resource. Currently there exist only static Spawners that utilize either preconfigured resources that have been deployed via Batch, or Container Spawners, or at selective cloud providers such as AWS [26]. As an exception to this, the WrapSpawner [27] allows for dynamic user selections through predefined provides. However, these profiles cannot be changed after the JupyterHub service is launched, making it impossible to dynamically change the set of supported resources and providers. Therefore it would be of benefit if a Spawner extended the WrapSpawner's existing capabilities with the ability to dynamically add or remove providers and resources.

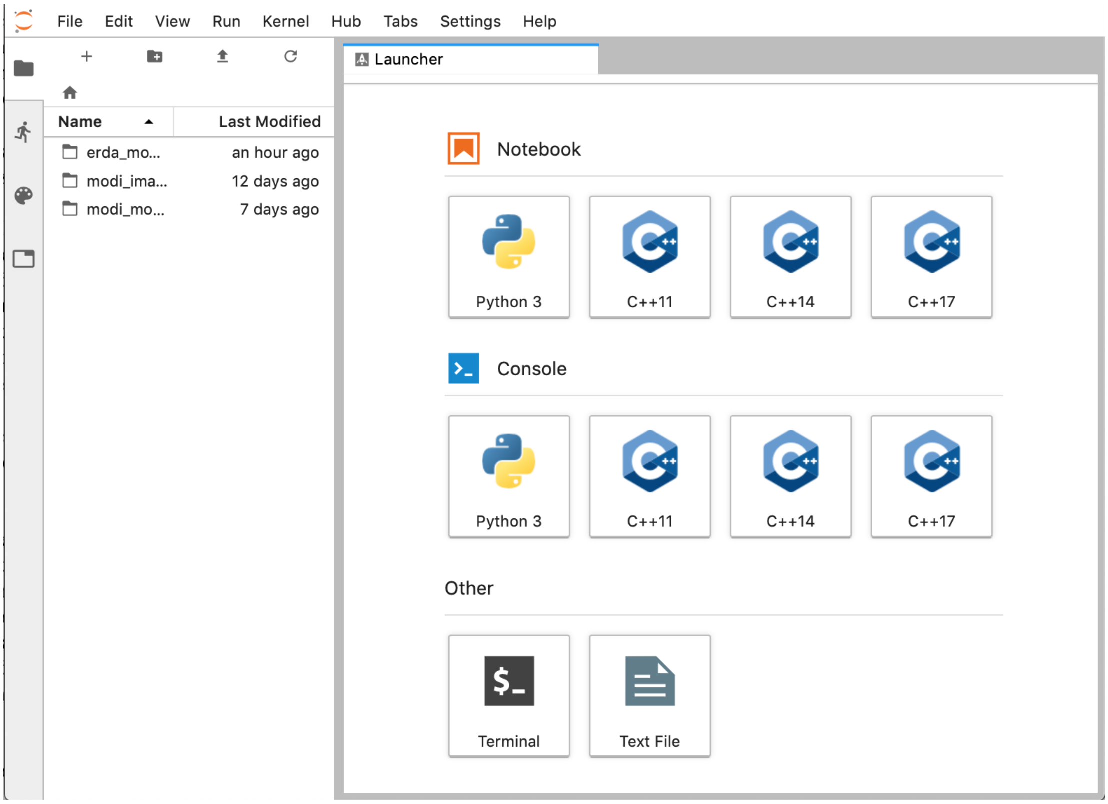

Figure 2: JupyterLab Interface

3. Related work

As presented in [28], Web-based learning by utilizing cloud services and platforms as part of the curriculum is not only feasible, but advisable. In particular, when it comes to courses with programming activities for students, educational institutions should enable access to innovative Web-based technologies that supports their learning. These include interactive programming, version control and automated programming assessments to ensure instant feedback.

3.1. Interactive programming portals

Research in cloud computing for education typically revolves around using Web-enabled Software as a Service (SaaS) applications. Examples of such include platforms such as GitHub [29], Google Docs [30], Google Colaboratory [31], Kaggle [32], and Binder [33]. Each of these can fill a particular niche in a course at the teacher's or student's discretion. Nevertheless, the provided capability often does come with its own burdens, in that the administration of the service is often left to the teaching team responsible for the course. This responsibility typically includes establishing student access, course material distribution to the specific platform, guides on how

Table 1
Subset of Jupyter Cloud Platforms Features

Provider	Native Persistence	Languages	Collaborate	MaxTime (inactive, max)
Binder[37]	None	User specified [1]	Git	10m, 12h[2]
Kaggle [38]	Kaggle Datasets	Python3, R	Yes	60m, 9h
Google Colab [39]	GDrive, GCloud Storage	Python3, R	Yes	60m,12h* [3]
Azure Notebooks [40, 41]	Azure Libraries	Python{2,3},R,F#	NA	60m,8h* [4]
CoCalc [42]	CoCalc Project	Python{2,3}, R, Julia, etc	Yes*	30m, 24h
Datalore [43]	Per Workbook	Python3	Yes	60m, 120h [5]
DAG [16]	ERDA	Python2,3, R, C++, etc	Yes	2h, unlimited [6]

to get started with the service and solving eventual problems related to the service throughout the course. In addition, many of the external cloud services that offer free usage, often have certain limitations, such as how much instance utilisation a given user can consume in a given time span. Instead, providing such functionalities as Science IT services, could reduce these overheads and enable seamless integration into the courses. Furthermore, existing resources could be used to serve the service by scaling through an established Grid of Clouds.

In terms of existing public cloud platforms that can provide Jupyter Notebook experiences, DAG is similar to Google Colaboratory, Binder, Kaggle, Azure Notebooks [34], CoCalc [35], and Datalore [36]. All of these online options, have the following in common. They all have free tier plans available with certain hardware and usage limitations. All are run entirely in the web browser and don't require anything to be installed locally. At most they require a valid account to get started. Each of them present a Jupyter Notebook or Notebook like interface, which allows for both export and import of Notebooks in the standard format. An overview of a subset of the supported features and usage limits across these platforms can be seen in Table 1, and their hardware capabilities in Table 2. From looking at the features, each provider is fairly similar in terms of enabling Languages, Collaborating, and Native Persistence (i.e. the ability to keep data after the session has ended). However, there is a noticeable difference, in the maximum time (MaxTime) that each provider allows a given session to be inactive before it is stopped. With CoCalc being the most generous, allowing 24 hours of activity before termination. In contrast, internal hosted services such as DAG allow for the institution to define this policy. At UCPH, we have defined this to be 2 hours of inactivity, and an unlimited amount of active time for an individual session. However, as Table 2 shows, we currently don't provide any GPU capability, which is something that could be changed through the utilisation of an external cloud with GPU powered compute resources.

Given this, the DAG service seemed as the ideal candidate to empower with external cloud resources. Both because it provides similar features as the public cloud providers in terms of Languages and Collaborate ability, but also since it is integrated directly with UCPHs data management service.

Table 2
Hardware available on Jupyter Cloud Platforms

Provider	CPU	Memory (GB)	Disk Size (GB)	Accelerators
Binder	NA	1 Min, 2 MAX	No specified limit*	None
Kaggle1	4 cores	17	5	None
Kaggle2	2 cores	14	5	GPU [7] or TPU [8] [44]
Google Colab Free	NA	NA	GDrive 15	GPU or TPU (thresholded access)
Azure Notebooks (per project)	NA	4	1	GPU (Pay)
Cocalc (per project)	1 shared core	1 shared	3	None
Datalore	2 cores	4	10	None
DAG	8 cores	8	unlimited [9]	None

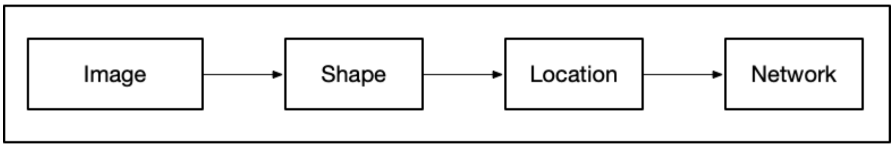

Figure 3: Workflow for orchestrating a compute node

3.2. Cloud Orchestration

Cloud resources are typically provided by the infrastructure service through some form of orchestration. Orchestration is a term for providing an automated method to configure, manage and coordinate computer systems [45]. Through orchestration, an organisation or individual is able to establish a complex infrastructure through a well defined workflow. For instance, the successful creation of a compute node involves the processing of a series of complex tasks that all must succeed. An example of such a workflow can be seen in figure 4. Here a valid Image, Shape, Location and Network has to be discovered, selected, and successfully utilized together in order for the cloud compute node to be established. An Image is the target operating system and distribution, for instance Ubuntu 20.04 LTS. A Shape is the physical configuration of the node, typically involving the amount of CPU cores, memory and potential accelerators. Location is typically the physical location of where the resource is to be created. Cloud providers often use the term Availability Zone instead but it generally defines which datacenter to utilize for the given task. Network encompasses the entirety of the underlying network configuration, including which Subnet, Gateway, and IP address the compute node should utilize. In the context of a federated network like a Grid, the orchestration would ideally involve the automated provisioning of the computational resource, the configuration of said resource, and ensure that the resource is correctly reachable through a network infrastructure.

Multiple projects have been developed that automate development and system administration tasks such as maintenance, testing, upgrading, and configuration. These includes packages such as TerraForm [46], Puppet [47], Chef [48], and Ansible [49], all of which open source projects that can be utilized across a range of supported cloud providers. Nevertheless, in terms of enabling workflows that can provide orchestration capabilities, these tools are limited in that they typically only focuses on a subset of the orchestration functionalities such as provisioning and deployment or configuration and maintenance. For instance TerraFrom is a tool that focuses on infrastructure deployment whereas Puppet, Chef and Ansible are primarily concerned with configuration and maintenance of existing systems. In contrast commercial cloud providers typically also provide their own orchestration-like tools and Software Development Kits (SDK)s, enabling the ability to interact with their respective cloud system. For instance, Oracle provides the Oracle Cloud Infrastructure CLI [50] tool that can interact with their infrastructure. The same applies to the Amazon AWS CLI [51], in addition to a vast complement of tool-kits [52] that provide many different AWS functionalities including orchestration. In contrast, commercial cloud provided tools are often limited to only support the publishing cloud vendor and do not offer cross-cloud compatibility, or the ability to utilize multiple cloud providers interchangeably.

Cloud orchestration developments for the scientific community, especially those aiming to provide cross-cloud deployments, have mostly been based on utilizing on premise cloud IaaS platforms such as OpenStack [53] and OpenNebula [54]. Developments have focused on providing higher layers of abstraction to expose a common APIs that allow for the interchangeable usage of the underlying supported IaaS platforms. The infrastructure is typically defined in these frameworks through a Domain Specific Language (DSL) that describes how the infrastructure should look when orchestrated. Examples of this include cloud projects such as INDIGO-cloud [55] [56], AgroDAT [57] and Occupus [57]. These frameworks, nonetheless do not allow for the utilization of commercial or public cloud platforms, since they rely on the utilization of organisationally defined clouds that are traditionally deployed, managed, and hosted by the organisation itself. Although required, if as stated, we are to establish a Grid of Clouds which should allow for the inclusion of public and commercial cloud platforms. The corc framework was developed and designed to eventually support the scheduling of cloud resources across both organisations and public cloud providers.

4. The first cloud enabled service

To establish a Grid of Cloud resources, we started with enabling the usage of a single public cloud provider to schedule DAG Notebooks on. Through this we created the foundations for the eventual Grid structure that would allow the resources to be scheduled across multiple clouds and organisations.

4.1. Corc

The corc framework was implemented as a Python package. The package establishes the foundations for essential functions such as orchestration, computation, configuration, and authentication against supported cloud providers and cloud resources. Overall, corc is a combination of an Infrastructure as a Service (IaaS) management library, and a computation oriented

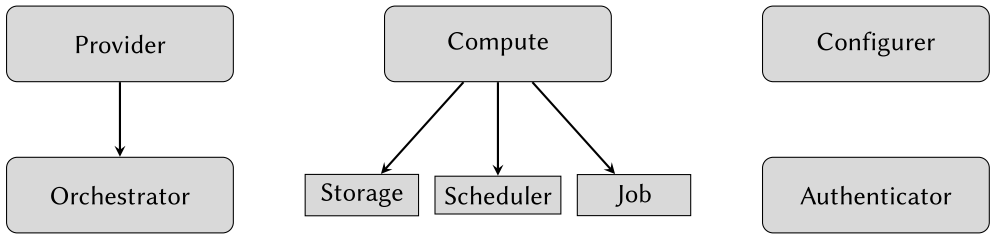

Figure 4: Cloud Orchestrator Framework Overview

scheduler. This enables the ability to schedule services on a given orchestrated resource. An overview of the architecture can be seen in figure 4.1.

The first provider to be integrated into the framework was the OCI IaaS. This was chosen, because the UCPH had a preexisting collaboration with Oracle, that enabled the usage of donated cloud resources for testing and development. As also highlighted, this does not limit the integration of other cloud providers into the framework, which the framework was designed for. Furthermore, as explored in section 2.3. A new Spawner, named MultipleSpawner was introduced, to provide the necessary dynamic selection of cloud providers.

As Figure 4.1 indicates, for each provider that corc supports, an orchestrator for that provider needs to be defined within corc. In addition, the framework defines three other top level components, namely Compute, Configurer, and Authenticator. All three are abstract definitions allowing for specific implementations to support the targeted resources which they apply to. A service can therefore be enabled with the ability to utilize cloud resources by integrating the corc components into the service itself. This method is limited to services that are developed in Python. In addition, corc also defines a Command Line Interface (CLI), that can be used to interact with the cloud provided resources directly. Details about how the framework and CLI can be used will not be presented in this paper, but can be found in [13].

```
{
    "virtual_machine": [
        {
            "name": "oracle_linux_7_8",
            "provider": "oci",
            "image": "Oracle Linux 7.8"
        }
    ]
}
```

Listing 1: Spawner Deployment configuration

4.2. MultipleSpawner

MultipleSpawner [58] is a Python package allowing for the selection of dynamic Spawners and resources. Structurally, it is inspired by the WrapSpawner [27], through the MultipleSpawner integrates corc into the Spawner ifself. This enables the JupyterHub service to manage and utilize cloud resources on a dynamic set of providers. In order to enable the MultipleSpawner to support these dynamic resources providers, two JSON configuration files needs to be defined. One of these is shown in listing 1, and defines the specific resource type that should be deployed on the provider. Currently the MultipleSpawner supports deploying, ‘virtual_machine‘, ‘container‘, and ‘bare_metal‘ resources. The other configuration file is shown in listing 2. It defines the template configuration settings that specify which Spawner, Configurer, and Authenticator the MultipleSpawner should use to spawn, configure and connect to the deployed resource.

```
[
    {
        "name": "VirtualMachine Spawner",
        "resource_type": "virtual_machine",
        "providers": ["oci"],
        "spawner": {
            "class": "sshspawner.sshspawner.SSHSpawner",
            "kwargs": {
                "remote_hosts": ["{endpoint}"],
                "remote_port": "22",
                "ssh_keyfile": "~/.corc/ssh/id_rsa",
                "remote_port_command": "/usr/bin/python3
                /usr/local/bin/get_port.py"
            }
        },
        "configurer": {
            "class": "corc.configurer.AnsibleConfigurer",
            "options": {
                "host_variables": {
                    "ansible_user": "opc",
                    "ansible_become": "yes",
                    "ansible_become_method": "sudo",
                    "new_username": "{JUPYTERHUB_USER}"
                },
                "host_settings": {
                    "group": "compute",
                    "port": "22"
                },
                "apply_kwargs": {
                    "playbook_path": "setup_ssh_spawner.yml"
                }
            }
        },
        "authenticator": {
            "class": "corc.authenticator.SSHAuthenticator",
            "kwargs": {"create_certificate": "True"}
```

```
        }
    },
]
```

Listing 2: Spawner Template configuration

5. Results

By integrating corc into the MultipleSpawner, we enabled the architecture shown in figure 5, where the DAG service is able to dynamically schedule Jupyter Notebooks across the two resource providers. As is indicated by figure 5, the UCPH and OCI providers are defined to orchestrate resources, in this case cloud compute instances, in preparation for scheduling a requested Notebook. In order to validate that the architecture worked as expected, we setup a test environment on a separate machine. This machine was configured with a corc and JupyterHub environment, where OCI was defined as a corc provider and the MultipleSpawner as the designated JupyterHub Spawner. With this in order, the JupyterHub service was ready to be launched on the machine.

The MultipleSpawner was configured to use the template and deployment settings defined in listing 1 and 2. This enables the MultipleSpawner to create Virtual Machine cloud resources at the OCI. Subsequently, the MultipleSpawner uses the SSHSpawner [59] created by the National Energy Research Scientific Computing (NERSC) Center to connect and launch the Notebook on the orchestrated resource. Prior to this, it uses the corc defined SSHAuthenticator and AnsibleConfigurer to ensure that the MultipleSpawner can connect to a particular spawned resource and subsequently configure it with the necessary dependencies.

An example of a such a spawn with the specified requirements can be seen in figure 6. To validate that this resource had been correctly orchestrated, the corc CLI was utilized to fetch the current allocated resources on OCI. Listing 3 shows that an instance with 12 oracle CPUs, 72 GB of memory and one NVIDIA P100 GPU had been orchestrated. This reflects the minimum shape that could be found in the EU-FRANKFURT-1-AD-2 availability domain that met the GPU requirement.

```
rasmusmunk$ corc oci orchestration instance list
{
    "instances": [
    {
        ...
        "availability_domain": "lfcb:EU-FRANKFURT-1-AD-2",
        "display_name": "instance20201018103638",
        "image_id": "ocid1.image.oc1.eu-frankfurt....",
        "shape": "VM.GPU2.1",
        "shape_config": {
            ...
            "gpus": 1,
            "max_vnic_attachments": 12,
```

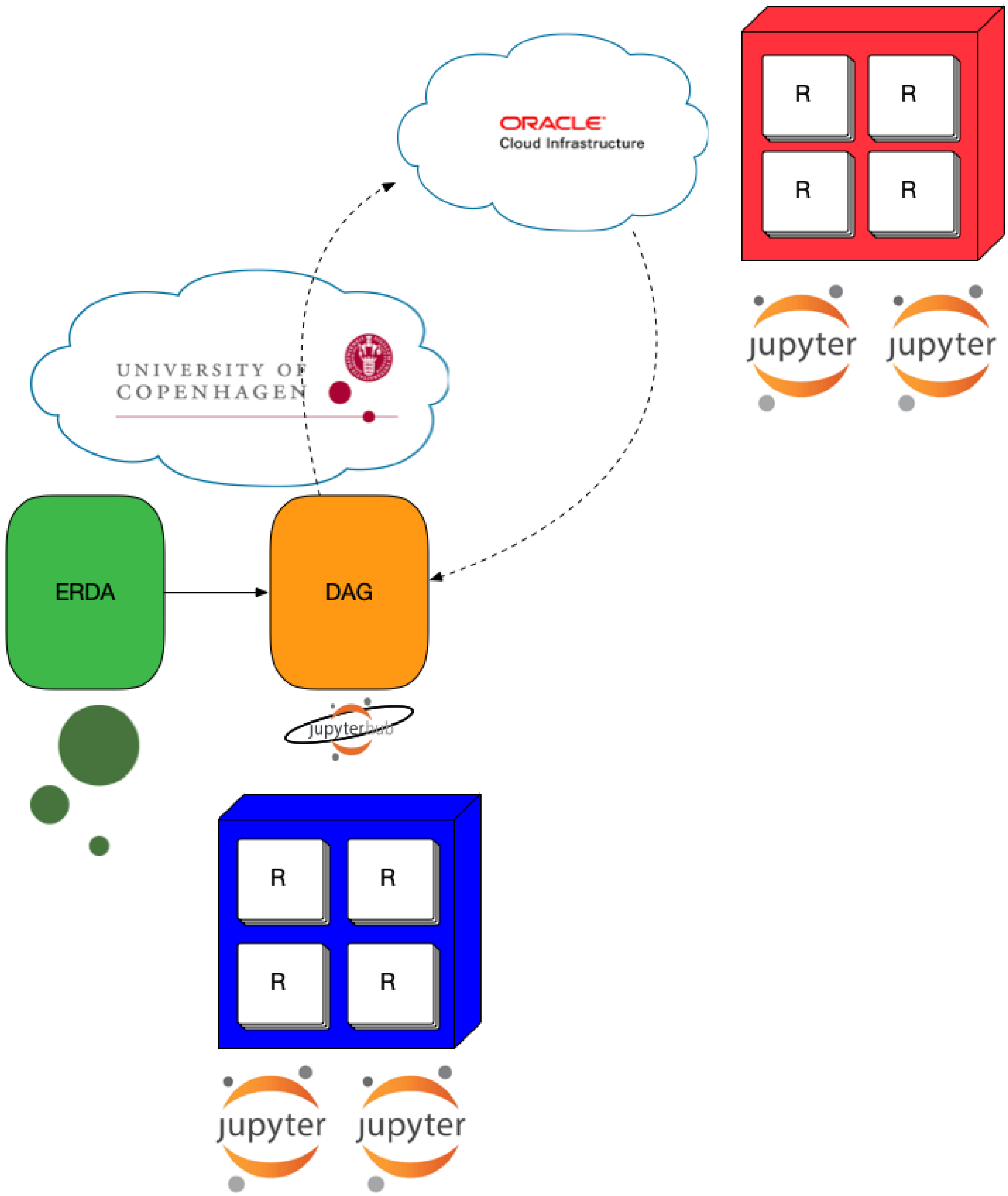

Figure 5: DAG MultipleSpawner Architecture, R = Resource


```
                "memory_in_gbs": 72.0,
                "ocpus": 12.0,
            },
        }
        ],
        "status": "success"
```

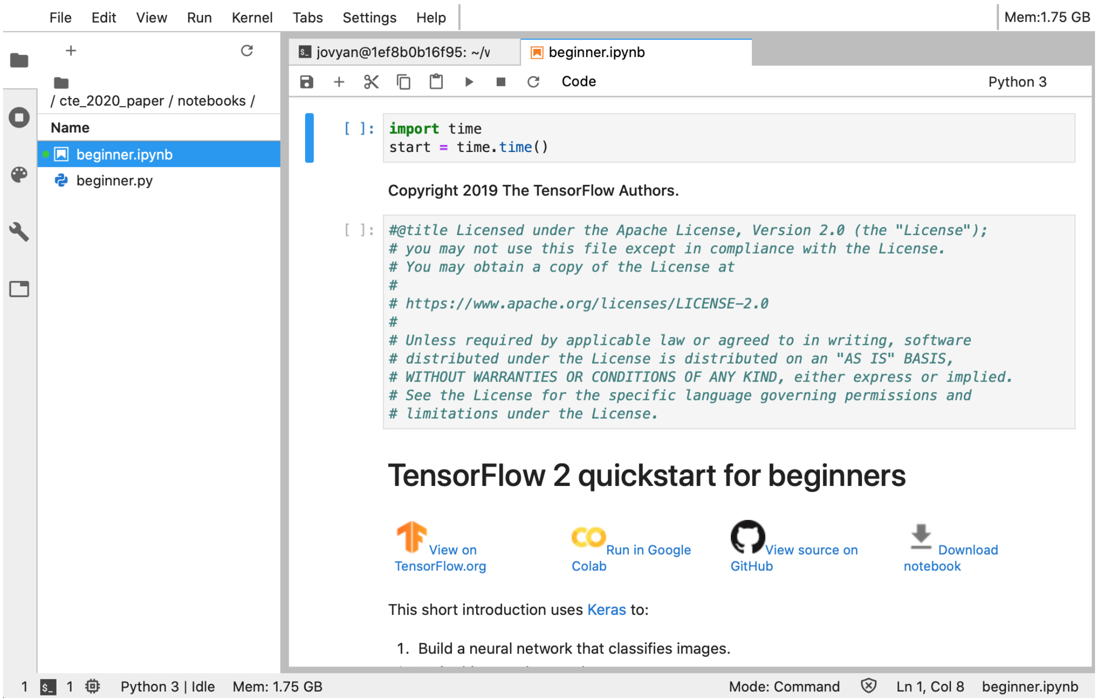

Figure 6: MultipleSpawner Interface

```
}
```

Listing 3: Running OCI Notebook Instance

As shown in figure 7, the JupyterHub spawn action redirected the Web interface to the hosted Notebook on the cloud resources. Relating this to the mentioned courses at UCPH, this then enabled the students with access to an interactive programming environment via the JupyterLab interface.

Building upon this, a simple benchmark was made to evaluate the gain in getting access to a compute resource with a NVIDIA P100 GPU. A Notebook with the Tensorflow and Keras quick start application [60] was used to get a rough estimate of how much time would be saved in building a simple neural network that classifies images. Listing 5, shows the results of running the notebook on the GPU powered compute resource for ten times in a row, and listing 4 shows the results of running the same benchmark on an existing DAG resource. As this shows, the GPU version was on average 24,7 seconds faster or in other words gained on average a 2,8 speedup compared to the DAG resource without a GPU.

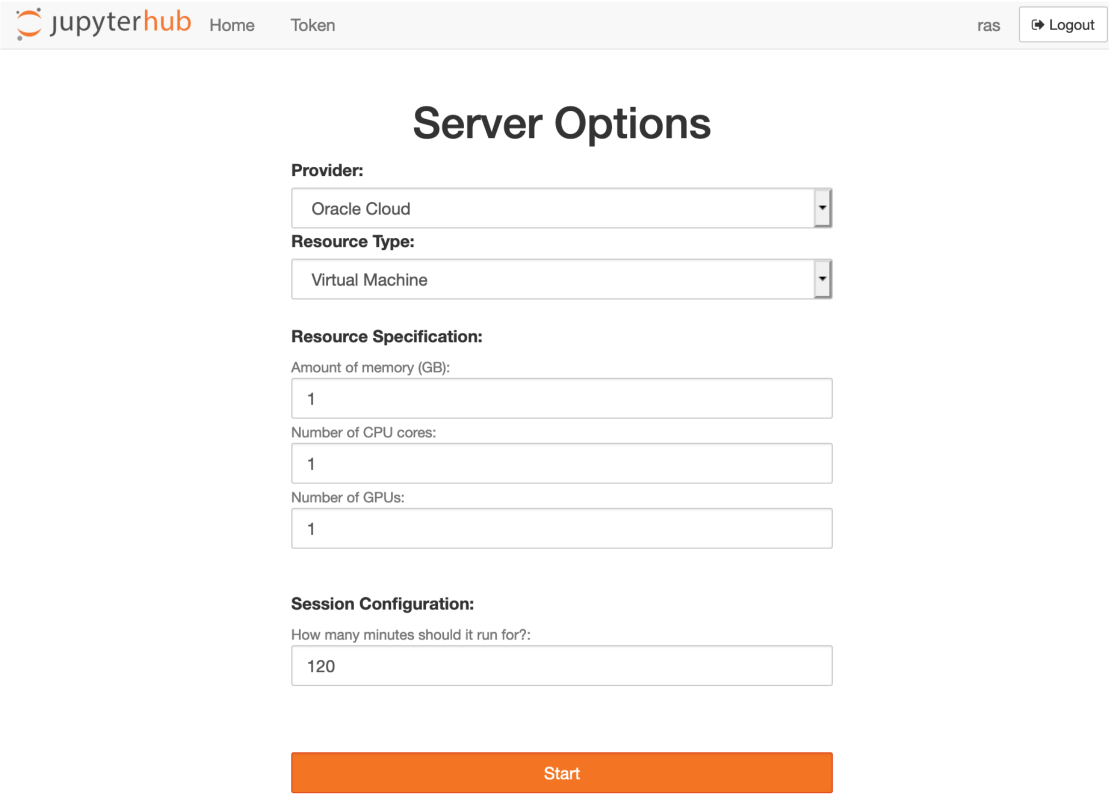

Figure 7: A Tensorflow + Keras Notebook on an OCI resource

```
(python3) jovyan@d203812f76e8:~/work/cte_2020_paper/notebooks$ \
> python3 beginner.py
Took: 38.107945919036865
Took: 36.123350381851196
Took: 37.37455701828003
Took: 37.69051790237427
Took: 41.16242790222168
Took: 37.24052095413208
Took: 38.685391902923584
Took: 40.02782320976257
Took: 38.40936994552612
Took: 39.34704780578613
Average: 38.41689529418945
```

Listing 4: DAG compute resource Tensorflow times

```
(python3) jovyan@56e3c30c2af6:~/work/cte_2020_paper/notebooks$ \
> python3 beginner.py
Took: 19.479900360107422
Took: 12.859123706817627
Took: 13.047293186187744
Took: 13.296776056289673
Took: 13.002363204956055
Took: 13.118329048156738
Took: 13.067508935928345
Took: 13.089284658432007
Took: 13.160099506378174
Took: 13.032178401947021
Average: 13.715285706520081
```

Listing 5: OCI GPU compute resource Tensorflow times

From this simple benchmarking example, we can see that by utilizing the MultipleSpawner in combination with corc, users are able to get access through a simple gateway to the expected performance gains of accelerators like a GPU. Expanding on this, the teachers and students at UCPH will now be able to request a compute resource with a GPU on demand, thereby gaining simple access to achieving similar faster runtimes in their exercises and assignments.

6. Conclusions and Future Work

In this paper, we presented our work towards establishing a Grid of Clouds that enables organisations, such as educational institutions to share computational resources amongst themselves and external collaborators. To accomplish this, we introduced corc as a basic building block enables the ability to orchestrate, authenticate, configure, and schedule computation on a set of resources by a supported provider.

OCI was the first provider we chose to support in corc, foremost because of the existing collaboration with UCPH and the associated credits that got donated to this project. This enabled us to utilize said provider to cloud enable part of the DAG service at UCPH. This was made possible through the introduction of the MultipleSpawner package that utilized corc to dynamically chose between supported cloud providers. We demonstrated that the MultipleSpawner was capable of scheduling and stopping orchestrated and configured resources at OCI via a local researcher's machine.

In terms of future work, the next step involves the establishment of a Grid layer on top of the UCPH and OCI clouds. This Grid layer is planned to enable the establishment of a federated pool of participating organisations to share their resources. By doing so, we will be able to dynamically utilize cross organisation resources for services such as DAG, allowing us for instance to spawn Notebooks across multiple institutions such as other universities. Enabling the sharing of underused resources across the Grid participants. To accomplish this, corc also needs to be expanded to support additional providers, foremost through the integration of the Apache libcloud [61] library which natively supports more than 30 providers, we will allow corc and subsequently the MultipleSpawner to be utilized across a wide range of cloud providers.

Acknowledgments

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Methodology of formation of modeling skills based on a constructive approach (on the example of GeoGebra)

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Abstract

Author's methodology of forming modeling skills involves 4 steps: Step 1 – the teacher step by step constructs the curve by means of cloud based service GeoGebra; Step 2 – the teacher offers a description-definition of the curve and provides a ready-made algorithm by which students model the curve independently in GeoGebra; Step 3 – the teacher offers an algorithm for constructing a curve model, and students need to characterize the properties of the curve or give its definition based on the results, Step 4 – students are offered definitions of curves that they have to model in GeoGebra). An example of realization of the author's methodology is given, the pedagogical experiment on proof of its effectiveness is described.

Keywords

modeling skills, skills development methodology, cloud service, GeoGebra cloud service, constructive approach, modeling, interesting curves, professional training

1. Introduction

Modern science operates with various methods, among which modeling is one of the most popular. Method allows you to move away from the object's ideal representation and use its analogue, which retains the most important characteristics that allow you to talk about the object properties after certain changes or influences on it.

The development of computer technologies has contributed not only to the revival of the modeling method, but also led to the emergence of specialized environments, where it became possible to model various objects (processes) based on a constructive approach. At the same time, the widespread use of smartphones and tablets that have access to the Internet has led to the emergence of cloud services, which also allow you to model objects of different nature [1, 2]. However, methods of using cloud services to develop modeling skills are just beginning

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to be developed and implemented, and therefore are not well established and need experimental confirmation.

The importance of developing constructive skills of youth is emphasized in the findings of Laksha [3], Kononenko [4], Ivanina [5], and the formation of modeling skills by individual scientists is associated with the formation of research skills [6].

Analysis of the problem shows that with the advent of specialized mathematics software, its solution has focused not so much on understanding the algorithms of elementary constructions, but on the ability to use computer tools and the ability to visualize the result. The latter, in particular, is emphasized in the finding of Bilousova and Zhytyenyova [7].

Regarding the first (the ability to use tools) it should be noted the emergence of cloud services, including specialized services. Analysis of the latter showed the following.

Different aspects of educational using of cloud technologies and services are examined in the studies of national and foreign researchers. For example, Alkhansa et al. [8] explore advantages of using cloud technologies in research, such as availability of various tools and applications for analyses and collecting data, for managing and organizing references, for communication with peers and experts, the absence of constraints, the access to cloud resources from anywhere any time that has an active Internet connection, etc. They offer the approach to applying of cloud services for enhancing the productivity of university research activities, increasing competitiveness and flexibility of educational institutions. Smith et al. [9] core focus addresses Education as an area of cloud application with a cloud based e-learning system developed to demonstrate the capabilities and effectiveness of cloud technology.

Shyshkina and Popel [10] explore the problems of implementation of cloud technology tools and services in the educational process, describe the current state of development and use of cloud technology services in educational institutions and analyze the content of educational and scientific components of cloud-based educational environment.

Scientific research on the involvement of cloud services for the formation of various skills in specialists in various fields of knowledge is spreading [11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23].

Currently, cloud versions of known environments with mathematical modeling capabilities are available, including Maple, MATLAB, WebMathematica, Calculation Laboratory, etc. [24]. We will also add CoCalc [25, 26, 27, 28] and GeoGebra [29, 30, 31, 32, 33, 34, 35] cloud services to this list.

Experience in using GeoGebra cloud service (visualization of mathematical objects; organization of not only analytical but also empirical search for answers in determining individual characteristics of mathematical objects; organization of home computer experiment) allowed to consider GeoGebra as means for formation of skills to model based on constructive approach. However, the analysis of scientific findings confirmed the lack of established methods for its use, and therefore the method of formation of skills to model interesting curves by GeoGebra cloud service based on a constructive approach required testing and experimental confirmation of its effectiveness.

The purpose of the paper is to describe the method of forming the skills to model interesting curves through GeoGebra cloud service based on a constructive approach and to confirm its effectiveness.

2. Material and methods

To test the effectiveness of the methodology of forming modeling skills, a pedagogical experiment, which lasted 3 years (2018–2020) was conducted among pre-service mathematics and computer science teachers.

Makarenko Sumy State Pedagogical University, Borys Grinchenko Kyiv University were the experimental base. The total number of respondents was 86 people (pre-service mathematics and computer science teachers).

The author's methodology was implemented using the freely distributed GeoGebra cloud service (https://www.geogebra.org) in the special courses. The experimental module "Modeling of interesting curves" with a volume of 10 classroom hours (2 hours of lectures and 8 hours of laboratory classes) was introduced.

Two tests of educational achievements (at the beginning and after studying the module) were organized to confirm the effectiveness of the methodology.

Students were offered a typical test problem for modeling a conic by its geometric definition (problems differed from each other in the input conditions, for example, the distance between the foci was different or one of the foci was in the specific point in a given coordinate system, etc.).

The solution of the problem was evaluated by the following indicators (table 1).

Table 1
Indicators of the formation of modeling skills

No	Indicators	Marks
1	Ability to take into account the analytical relationship between the elements	1
2	Ability to take into account the geometric relationship between the elements	1
3	Ability to use the Locus tool	1
4	Ability to use the Trace tool	1
5	Ability to demonstrate the change of the curve shape when changing the input data	1
6	Ability to construct a model visually correct (location, color, size and style of geometric objects)	1
7	Ability to add dynamic text to study numerical characteristics	1
8	Ability to write an algorithm for constructing a model	1
9	Ability to reproduce the steps of the algorithm to construct the model	1
10	Ability to interpret the result of a computer experiment	1

Since the results of the tests were dependent and each time provided for the accumulation of marks, the sign test was used. The number of respondents, whose total score decreased ("–"), did not change ("0") and increased ("+"), was fixed.

In accordance with the purpose of the experiment and the sign test, the null hypothesis was formulated: the author's methodology does not contribute to the formation of modeling skills by means of GeoGebra cloud service. Then the alternative hypothesis was "the author's methodology contributes to the formation of such skills".

The constructed hypotheses define the one-sided sign test for checking the dependent samples.

According to the decision-making rule [36] the null hypothesis of inefficiency / effectiveness of the author's methodology was accepted or rejected.

3. Constructive approach

The constructive approach is characterized by the fact that acquaintance with the properties of concepts begins with constructive activities for their "discovery" and assimilation with a gradual transition to definitions and logical proofs. This, in particular, simplifies the perception of the Geometry course, makes it more accessible, while raising the scientific level through the intensification of educatees' research activities.

The use of the constructive approach contributes to the fact that the activity is manifested in the gradual transition of actions for the construction of objects from the executive level (is characterized by external regulation), then to reproductive (is marked by internal regulation of actions in the construction of known structures), then to the applied level (using the method of construction), and, finally, the creative level (involves the construction of new objects) (figure 1) [37].

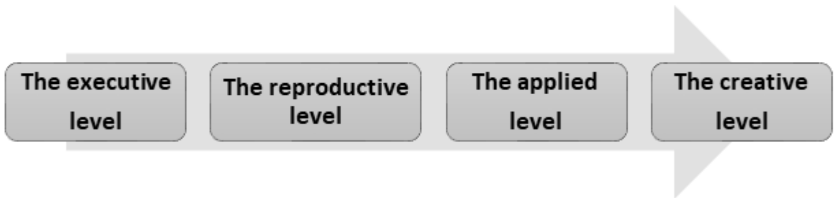

Figure 1: Constructive approach activity levels.

We consider constructive tasks to be one of the means of implementing a constructive approach. Many authors use the term "constructive tasks" in a sense identical to construction problems. However, the peculiarities of the constructive approach require the use for its implementation and other tasks, the solution of which requires the implementation of a particular constructive activity. Therefore, for example, Lisimova [38] considers constructive tasks as tasks for construction, imaging, measurement, geometric design and structural-geometric modeling. Dalinger [39] considers constructive tasks as "problems in the process of solving which reveal the material conditions of geometric figures. Their purpose is to identify the essential features of ideas that are formed through the material conditions of their origin".

Constructive tasks can be a base for establishing new properties of figures (concepts formation), for the consolidation of knowledge, for repetition, control, intensification of research activities. "The peculiarity of constructive tasks is that they can be solved both logically and figuratively or visually effective" [38].

When solving constructive tasks, there is a productive activity that motivates to think independently (methods of constructing have to be developed independently), and not reproductive activity, which is often not an independent mental process, but is a repetition of known steps [40].

Mastering the system of knowledge and skills can take place on two levels: constructive and analytical. The main feature of the constructive level of mastery of the material is its visual and constructive awareness. This is manifested:

- in the ability to recognize objects that belong and do not belong to the content of this concept, give examples, demonstrate the existence of the studied figures by construction;
- in the knowledge of their most essential properties and the ability to apply known properties in solving problems.

The constructive approach provides "points of support" for Geometry study at a higher abstract level, which is characterized by the ability to formulate definitions of concepts, statements and prove already in formal language, rather than the language of geometric images.

4. Methodology of forming skills to model interesting curves based on a constructive approach in GeoGebra cloud service

Any methodology involves the presence of five elements (figure 2): purpose, content, forms, methods and means. Let us explain them in more detail.

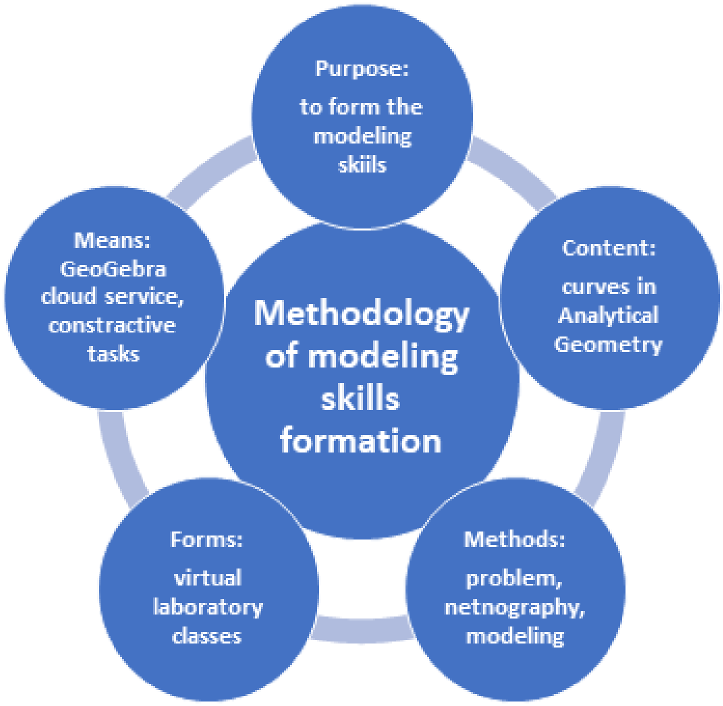

Figure 2: Components of the author's methodology.

The purpose of the author's methodology is to form the skill to model interesting curves using cloud services.

Interesting curves of the course of Analytical Geometry are the content on which the author's methodology is realized. Nowadays, their study in the classical course of Analytical Geometry is possible in three ways:

- analytical description and further study of curves – at first analytical (parametric, implicit, explicit) equations, usually of conics, are given and then they are investigated;
- study of curves as locus with a given property – at first the geometric definitions of curves are given, on the basis of which their analytical equations are written (as a rule, these are conics, conchoid of Nicomedes, limaçon of Pascal, strophoid, cissoid of Diocles, lemniscate of Bernoulli, Cassini oval);
- study of curves generated in the kinematic way (as the trajectory of a point), usually cycloidal curves, folium of Descartes, witch of Agnesi, logarithmic spiral.

Due to lack of time, there is only the first way of the study of interesting curves in the course of Analytical Geometry at universities. This limits the possibility to develop the skills to model mathematical objects.

The form of realization of the author's methodology is virtual lecture-practical classes or a combination of visualized lectures and virtual laboratory classes.

Among the teaching methods problem method and netnography method are used.

GeoGebra cloud service, constructive tasks and instructional materials are learning means.

Elementary knowledge in Analytical Geometry is required to use the author's methodology.

In general, the methodology of forming the skills to model interesting curves is as follows: the teacher on a common online platform informs about constructive approaches to the construction of various curves, which were studied in ancient times (the netnography method). He briefly tells about how such constructions were done (compass and ruler, one compass, two compasses, one or two rulers, etc.), or gives an example of practically oriented problems that are solved using interesting curves. After that, the teacher demonstrates one of the described constructions in GeoGebra cloud service, and then asks students to write an algorithm for the above construction (the problem method). Then the teacher asks students according to the algorithm (provided to each student) to reproduce the construction and demonstrate the result, to analyze errors, and if not, to analyze possible limit cases. After that, students are offered the definition of curves generated in mechanical way together with the algorithms of their construction in the cloud service; students must model this type of curve according to the existing algorithm. Then together with students, the task of the following type is carried out: algorithms of curves construction are offered and after their construction, students need to characterize properties of the modeled curves, to give them definitions or kinematic characteristics. After completing this type of task, students are offered only the definition of the curves or their kinematic characteristics, and they must model the curve themselves.

The methodology should be briefly described as follows.

Step 1 – the teacher offers an example of a curve model through the definition (the teacher step by step models the curve), and students must independently compile an algorithm for constructing the model.

Step 2 – the teacher offers a description-definition of the curve and provides a ready-made algorithm according to which students model the curve independently.

Step 3 – the teacher offers an algorithm for constructing a curve model, and students need to characterize the properties of the curve or give its definition based on the results.

Step 4 – students are offered definitions of curves that they have to model them.

We will briefly demonstrate the application of the methodology of forming the skiils to model interesting curves based on a constructive approach in GeoGebra cloud service on the example of the hypocycloids study.

The teacher formulates the problem. The calculation of the action of the kneading machine consists of a description of the trajectory of the point belonging to the working body. The trajectory of the working body does not always fill the container with the substance, as a result, the mixing time increases, which leads to unnecessary energy consumption. Determine the optimal trajectory of the point of the mixer working body [41].

History of the curve discovery (netnography method). Hypocycloid (from Greek words $\upsilon\pi o$ – "under, below" and $\kappa\upsilon\kappa\lambda o\zeta$ – "circle") – is a curve "under the circle". The most famous hypocycloids are the astroid (from Greek "star-shaped") and the deltoid (Steiner curve). The name of the astroid (from "cusp" – exacerbation) was proposed by the Austrian astronomer Carl-Ludwig von Littrow (1811–1877). The shape of the deltoid resembles the capital Greek letter delta, its properties were studied by Leonard Euler in the XVIII century, and then by Jacob Steiner in 1856, after whom it was renamed the Steiner curve.

Definition of the curve. A hypocycloid is a curve generated by the trace of a fixed point on a small circle that rolls within a larger circle.

Next, the teacher demonstrates an example of a ready-made hypocycloid model (figures 3-4), and then offers to describe the algorithm for its construction to students.

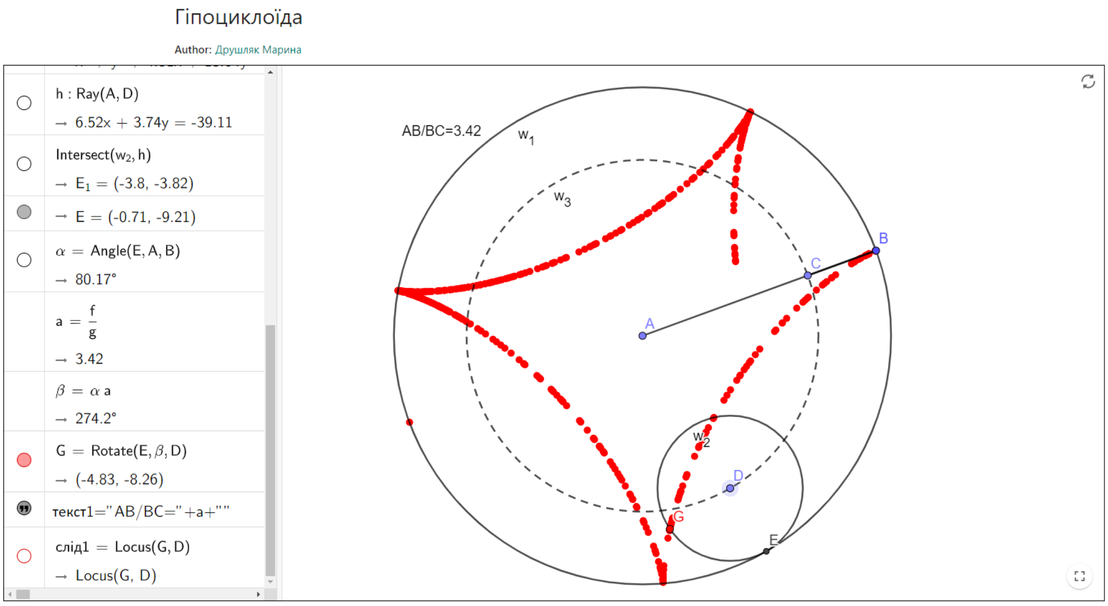

Figure 3: Construction of a hypocycloid using the Trace tool.

Let the circle ω_2 roll inside the circle ω_1. Let's construct a curve generated by a point on the circle ω_2.

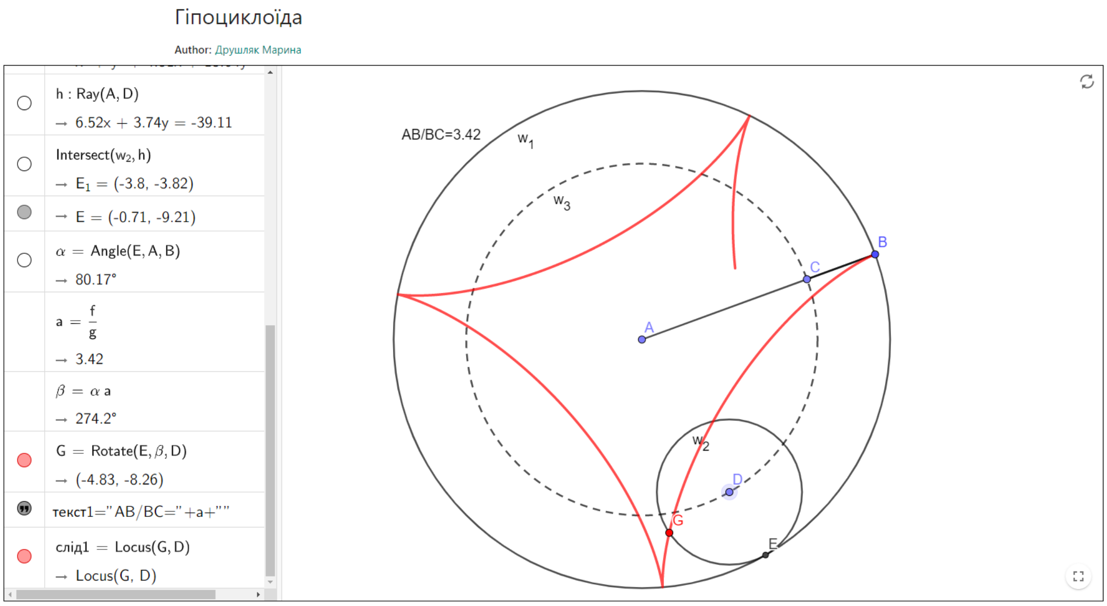

Figure 4: Construction of a hypocycloid using the Locus tool.

Algorithm for hypocycloid model constructing

1. Construct a circle ω_1 with center A passing through point B.
2. Construct the segment AB.
3. Construct an arbitrary point C on the radius AB.
4. Construct the circle ω_3 with center A passing through point C (dotted line).
5. Construct an arbitrary point D on the circle ω_3.
6. Construct the circle ω_2 with center D, the radius of which is equal to the length of the segment CB.
7. Construct the ray AD.
8. Constract the point E – the intersection of the circle ω_2 with the ray AD.
9. Hide the ray AD.
10. Let the center D of the circle ω_2 coincides with the point C in the initial position. If we move the point D around the circle, it will rotate around the point A, and remains tangent to the circle ω_1. Let the circle ω_2 rotate around it when moving the center to create the illusion that the circle ω_2 rolls on the circle ω_1. Only one point of the circle ω_2 should be investigated. Let this point coincides with the point B at the initial moment, and is the point of tangency of the circles ω_1 and ω_2. If the circle ω_2 rolls on the arc BE, then the center D of the circle will return around the point A at the angle $\psi = BAE$. Simple calculations show that all points of the circle ω_2 will rotate around its center at the angle $\psi * \frac{AB}{CB}$.
11. Construct the point G, which is obtained from the point E by rotating around the point D by the angle $\psi * \frac{AB}{CB}$.

12. Hide the point E.
13. a) Make the point G leave a trace by rolling the point D on the circle ω_2 (Fig. 3).
    b) Use the Locus tool: the point G is the "pencil point", the point D is the "driver point" (figure 4).

Next, the lecturer at the visualized lecture offers students to explore the analytical equation of the curve, which is described through the parameter.

Let R be the radius of a fixed circle, r be the radius of a rolling circle, $k = \frac{R}{r}$, then the parametric equation of a hypocycloid is

$$x = r * (k-1) * (cos\psi - \frac{cos(k-1) * \psi)}{k-1}), y = r * (k-1) * (sin\psi - \frac{sin(k-1) * \psi)}{k-1}).$$

The modulus of k determines the shape of the hypocycloid: $k = 2$ the hypocycloid is described by Tusi couple (diameter of a fixed circle), $k = 4$ by the astroid $x^{\frac{2}{3}} + y^{\frac{2}{3}} = R^{\frac{2}{3}}$.

Study of the curve and establishment of properties (problem method). When the hypocycloid is constructed, we pass to establishment of its properties at the level of practical research.

Note that the curve constructed in this way is open. Let us investigate the conditions under which the constructed hypocycloid will be a closed curve. By changing the radius of the circle ω_3, thereby changing the ratio $k = \frac{R}{r}$ of the radii of fixed and rolling circles, we conclude that the curve will be closed when the ratio $k = \frac{R}{r} \in Z$ (figure 5). In addition, in this case, the hypocycloid consists of k identical arcs, the ends of which lie on a fixed circle (figure 6).

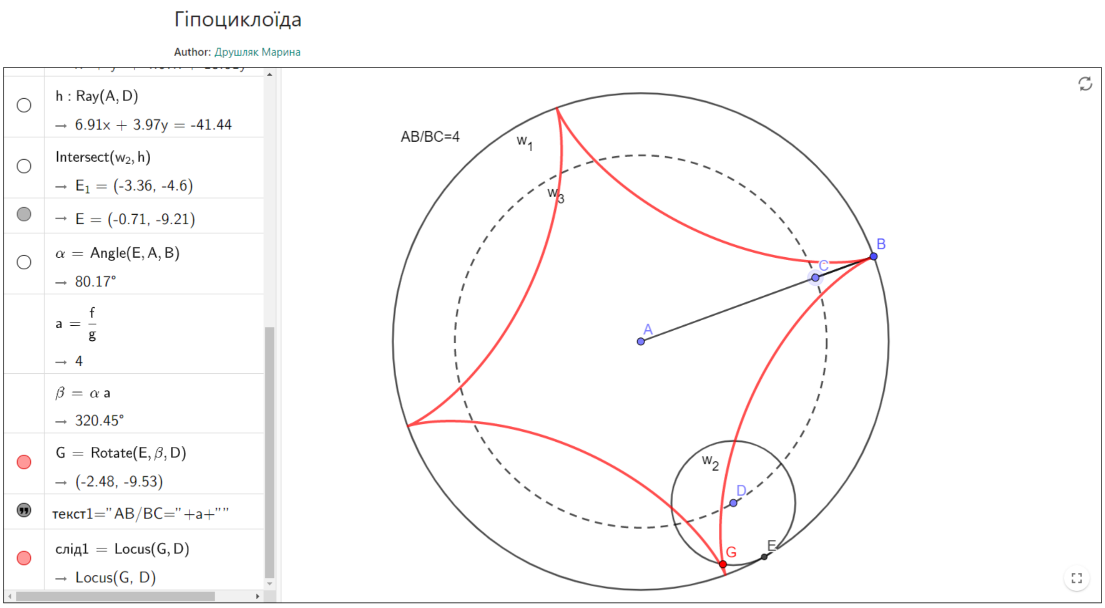

Figure 5: Closed hypocycloid, $k = \frac{R}{r} \in Z$.

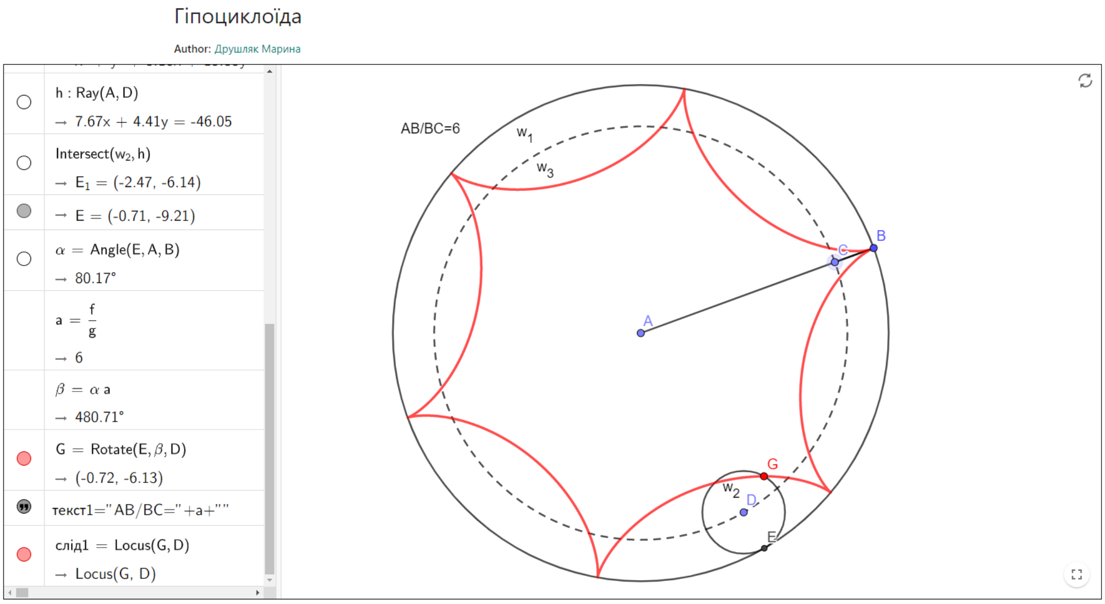

Figure 6: The hypocycloid consists of $\frac{R}{r} = 6$ of identical arcs.

If the radius r of the rolling circle is twice smaller than the radius R of the fixed circle, then the hypocycloid degenerates into a segment (figure 7). This statement is well known as Copernicus theorem.

After the lecture, students are first asked to construct curves models according to the given definition and algorithm, for example, to costruct a cycloid, which is a curve generated by a point of a circle rolling on a straight line, reproducing all the steps of the algorithm. Not only instructions but also possible consultations are provided.

The next lesson tasks such as: "Establish the relationship between the number of arcs of the epicycloid, generated by a point of a circle rolling on the outside of another circle, and the ratio of the radii of these circles", are offered.

Then, at the next two lessons, tasks such as: "A point and a line, the distance between which is equal to a, are given. A line is drawn through an arbitrary point X of the line and the point. The points at a distance b from point X are marked. Find the locus of such points".

The described methodology differs from the traditional one, as the latter usually involves only step 2 and step 4, which does not allow students to understand the algorithms involved in the constructing the model, to develop the ability to compare step-by-step construction ideas and the algorithm steps. There is also no practice of qualitative analysis of the algorithm (which is provided by step 3 and which is supported by the "step-by-step playback service" in GeoGebra). This is what we consider fundamentally important for effective formation of skills to model and what GeoGebra service makes possible.

Let us note also that in terms of distance learning, it is GeoGebra service that allows the demonstration of constructions and the ability to work with models at anytime from anywhere.

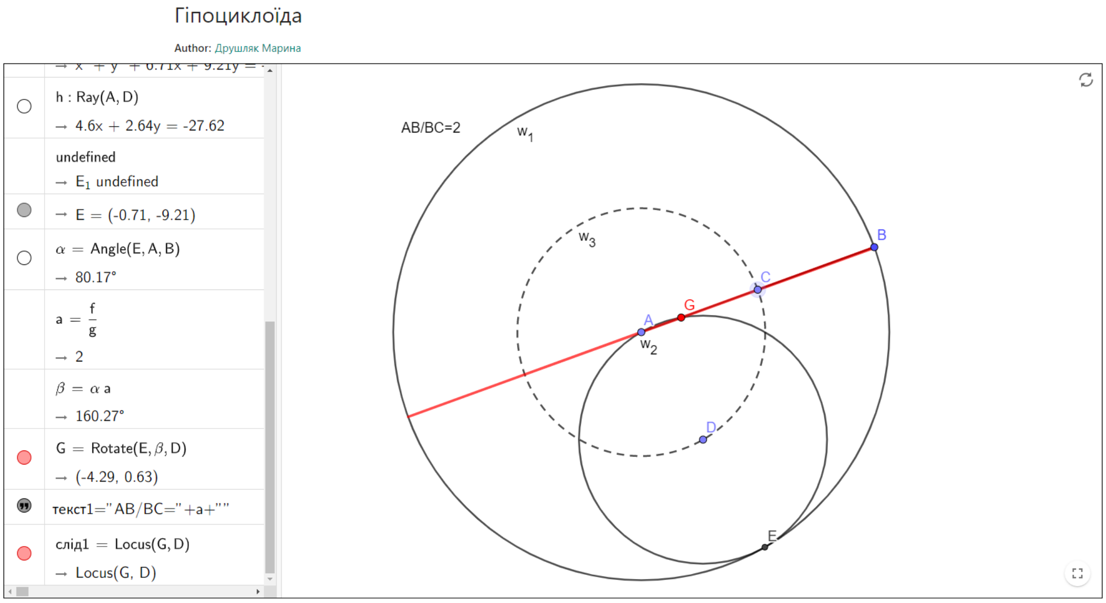

Figure 7: Degenerate hypocycloid, $\frac{R}{r} = 2$.

5. Statistical analysis of experiment results

Verification of the effectiveness of the author's methodology was carried out based on two tests. Students had to solve the problem 1 (for example, to construct a curve, for each point of which the sum of distances to two given points is constant) before studying the topic and the problem 2 (for example, to construct a curve, each point of which is equidistant from the point lying in the third quarter, and a line that forms an acute angle with the abscissa) after studying the topic.

The evaluation of solutions was carried out through the assessment of skills: to take into account the analytical and geometric relationship between the elements; to use the Locus and Trace tools; to visualize the model successfully; to add dynamic text to study numerical characteristics; to write an algorithm for constructing a model; to reproduce the steps of the algorithm to construct the model; to interpret the result of a computer experiment (in more detail in table 1).

The results of the controls are presented in table 2.

These marks were used to determine the number of respondents whose total score decreased ("–"), did not change ("0") and increased ("+") (table 3).

According to the decision-making rule [36] we have: the value of $T_{exp} = 46$ (this is the number of "+" signs in the sample), $n = 67$ (this is the number of respondents who have changed the results), the acceptance interval of the hypothesis H_0 is $[26, 41]$ at the significant level of 0.05.

Since T_{exp} is not included in the acceptance interval of the hypothesis H_0, we reject the hypothesis H_0 and accept the alternative one with the conclusion that the author's methodology contributes to the formation of modeling skills. Since the value of T_{exp} is beyond to the segment on the right, it is necessary to conclude there is the positive dynamics of the number of such

Table 2
The results of students' tests

No	Test 1	Test 2	No	Test 1	Test 2	No	Test 1	Test 2
1	3	4	30	3	5	59	4	5
2	4	5	31	4	4	60	3	4
3	5	4	32	4	6	61	3	4
4	4	3	33	4	6	62	5	4
5	5	3	34	4	7	63	5	5
6	5	5	35	5	4	64	5	4
7	5	6	36	5	3	65	6	4
8	6	6	37	5	3	66	5	6
9	4	5	38	5	5	67	4	7
10	3	4	39	6	6	68	3	7
11	3	3	40	5	7	69	2	6
12	3	3	41	4	5	70	7	5
13	4	2	42	4	4	71	5	8
14	4	6	43	6	4	72	4	8
15	5	6	44	7	5	73	3	9
16	4	7	45	6	6	74	3	8
17	5	6	46	5	7	75	4	7
18	4	5	47	7	7	76	5	6
19	7	4	48	8	7	77	5	6
20	6	5	49	8	6	78	5	6
21	6	3	50	3	6	79	6	7
22	5	5	51	4	7	80	5	6
23	7	6	52	4	7	81	5	8
24	7	6	53	4	7	82	6	7
25	7	7	54	1	7	83	5	6
26	4	4	55	2	7	84	6	6
27	5	3	56	4	5	85	5	5
28	5	5	57	4	4	86	3	6
29	5	5	58	3	4	-	-	-

Table 3
Dynamics of marks according to the results of students' tests

Dynamics	Negative "–"	Without changes "0"	Positive "+"	Changes n="–"+"+"
Members	21	19	46	25

students who have developed the skills to model interesting curves using GeoGebra cloud service.

6. Conclusions

1. Author's methodology of forming modeling skills involves 4 steps: Step 1 – the teacher offers an example of a curve model through the definition (the teacher step by step constructs the curve), and students must write the constructing algorithm independently; Step 2 – the teacher offers a description-definition of the curve and provides a ready-made algorithm by which students model the curve independently; Step 3 – the teacher offers an algorithm for constructing a curve model, and students need to characterize the properties of the curve or give its definition based on the results, Step 4 – students are offered to define curves that they have to model). The methodology effectiveness was confirmed by the sign test at the significant level of 0.05.
2. GeoGebra cloud service is effective for being perceived as a means for the formation of students' (pre-service mathematics and computer science teachers) modeling skills. At the same time, we consider it is also possible to use this methodology in the conditions of traditional training with GeoGebra installed on PC.

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The learning process simulation based on differential equations of fractional orders

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Abstract

This article is an integrated study conducted to develop a learning model which would make it possible to identify the students' changes of knowledge, abilities and skills acquisition over time as well as the formation of special features of their individual background. Authors have justified the application of the cybernetic model based on fractional equations for the description and evaluation of the student's learning process. Learning is dealt as a transformation of young people's knowledge, abilities and skills into a complex background, which envisages its implementation in the future professional activity. The advantage of the suggested model is better approximation characteristics which allow the consideration of a wide range of factors affecting the learning process including the youth's neurodynamic and psychological nature. The research has employed both mathematical modeling methods and psychodiagnostic techniques (surveys, questionnaires). As a result of the findings, students who assimilate the content of teaching information and form personal experience in different ways have compiled different groups; the learning curve constructed on the basis of the heterogeneous differential equation of second order with integer powers has been compared with the set of models with equations of fractional order of aperiodic and fractional power components. The prospect of the issue to explore is the improvement of the suggested model considering special characteristics of cognitive processes aimed at the formation of an individual path of the student's learning.

Keywords

learning process, learning simulation, cybernetic model, differential equations of fractional order, teaching

It will lead to a paradox, from which one day many useful consequences will be drawn.
– Leibniz on fractional derivatives in his letter to l'Hospital, September 30, 1695

1. Introduction

Changes in higher education in recent years focus on providing the system of high quality training of stress resistant and creative specialists who acquire a complex of competencies and social skills and are able to respond quickly to modern social and economic challenges. The research will make it possible to track online the changes over time of knowledge, abilities and

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skills acquisition as well as to reveal and suggest the best way to high quality education of future professionals.

Modern information systems provide a means of development of models which allow us to monitor the learning process, detect upturns and downturns of the learning activeness; all this eventually affects the final result – knowledge, abilities and skills acquisition [1]. The purpose of the research is to generate and describe a cybernetic model of learning which is based on differential equations of fractional order.

Dmitriy A. Novikov has described the facilities of the learning model. Investigating the iterative learning, which is the simplest type, the researcher has proved that the quantification of the learning process can be demonstrated through curves and graphs if external impacts are permanent. The result is meant to be a level of learning which might be measured by time, speed and informational criteria and accuracy of the assignments [2].

The search for means of modelling is presented in works by Vsevolod V. Vasilyev and Lilija A. Symak [3], Yong Zhou, Clara Ionescu and J. A. Tenreiro Machado [4], Devendra Kumar and Dumitru Baleanu [5]. These researchers made a comparative analysis of fractional calculus and classical mathematical analysis and revealed the possibility to use fractional calculus in different scientific spheres as a means for description and modelling of the systems which change over time. The advantage of this approach lies in the flexible transformation from one type of the equation to another, change of the task's physical parameters and the type of initial and final conditions. However, the researchers think that the usage of these equations might be restricted by the complication of the models having two independent variables.

There is an idea grounded in current studies that the obtained equations could be correlated with the models of a blood system [6] and distribution of neural patterns' signals in the nervous tissues of biological objects [7, 8]. Thus, this research has used differential equations of fractional order which consider the learning subjects' nature in the most efficient way and allow us to build an appropriate model that would disclose the change of knowledge and skills formation over time being the basis of the gained experience.

2. Synthesis of the learning process simulation based on differential equations of fractional orders

Having analysed the survey of 130 students of the Institute of Electromechanics, Energy Saving, and Automatic Control Systems of Kremenchuk Mykhailo Ostrohradskyi National University it has become evident that a large number of boys and girls are incapable of their own learning strategy development, they struggle to master teaching information and decide on the best learning method, etc. Tutorials as a means of individualising of learning do not contribute to the task solution. For instance, it has been found out that 30% of students are hesitant about attending tutorials as they think they are a waste of time, 52.3% are confident they can cope with the problem on their own, 17.7% have troubles comprehending the subject's content and fail to formulate questions.

A similar situation is with the results of students' independent work. Despite the individual approach to the development of tasks for independent work (entry testing, potential mathematical expertise evaluation, general and specific skills assessment) it should be acknowledged that their accomplishment is merely pro forma for obtaining a mark and getting the ratings up, which do not contribute to the main goal achievement – readiness for working for an enterprise, comprehension of operating processes and making managerial decisions. In order to actualise the need, virtual laboratory complexes (VLC) have been evolved.

They allow us to use a variety of virtual devices, measurement systems and software and hardware complexes created with the help of diverse software tools of powerful modern computer equipment. These systems are flexible and adaptable to a number of tasks, for example, they facilitate the formation of engineering competencies trough planning skills training and conducting engineering experiments with further analysis of their results. Furthermore, VLC can be exploited as simulators that, due to their mathematical model, assist in studying properties of electrical objects, as software tools to simulate and study the system modes (usual conditions, pre-emergency, emergency), and as hardware and software tools for computer-assisted research [1]. Moreover, VLC serve to record studying results and construct curves of learning.

Using the method of mathematical modelling we attempted to develop a model which would clearly describe the pilot testing results and make it possible to reveal both specific features of teaching information acquisition and formation of students' individual background. Since the obtained data form a curve similar to an exponent, the authors have chosen a cybernetic model for the approximation. It is worth noting that starting from H. Ebbinghaus onwards many researchers point at the exponential nature of memorisation and forgetting [4]. The exploration of recent scientific papers [3, 4, 8, 9] places on record an appreciable quantity of suggested cybernetic models with the second-order equation which would describe any process [2].

The suggested model of the rate of information flow assimilation expressed by a second-order heterogeneous differential equation is an example of cybernetic approach:

$$m\frac{d^2S}{dt^2} + r\frac{dS}{dt} + (\alpha - c)\,S = H, \tag{1}$$

where S is the flow of digestible information as a function of time, t; r – coefficient of resistance to the learning process; α; c – coefficients of forgetting and inference; H – the flow of initial information as a function of time, t; m – inertia value.

In [10] the average values are indicated: coefficient of resistance to the process, $r = 0.5$; coefficient of forgetting $\alpha = 0.3$; inference coefficient $c = 0.25$; inertia value $m = 0.65$.

To calculate the coefficients of differential equations of the information assimilation (1) there has been conducted a pilot testing among the third-year students of Kremenchuk Mykhailo Ostrohradskyi National University during studying the discipline "Theory of Electric Drive". One hundred and thirty eight students who participated in the experiment took a test containing 20 multiple-choice questions with 5-6 options after each lecture. In total they had 14 tests. The average values of students' academic performance according to testing are presented in figure 1.

To process the data, a shift along ordinate axis has been performed so that the "transition process" begins at zero initial conditions ($\Delta_0 = 0.341$). The mean-square error of the approximation is $Std.err. = 0.0306597$, the steady-state value is 0.434615. The final level of knowledge corresponds to the value $Q = k + \Delta_0 = 0.776$.

In modern science the number of applications of fractional calculus in various fields of science and technology that use mathematical methods and computer simulation tools is increasing rapidly.

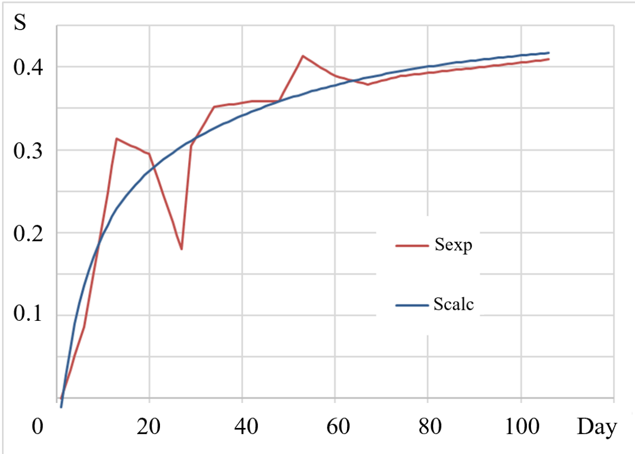


Figure 1: Experimental data and their approximation by a second-order differential equation (1).

For more than three centuries specialists in theoretical mathematics have had no doubts about existence of fractional derivatives. At the same time experts dealing with practical issues have been looking for physical meaning of fractional derivatives.

Nevertheless, the following example clearly demonstrates the understanding of the introduction of fractional orders in degrees of equations. Svante Westerlund has proposed a generalisation of Newton's second law and demonstrated that Hooke's law in elasticity theory ($F = kx$), Newtonian fluid model ($F = kx'$) and Newton's second law ($F = kx''$) can be regarded as the isolated cases of more general relation of the type: $F = kx^{(\mu)}$, where the order of derivative μ can be any real number. Of course, this generalisation cannot be called a conclusion; most likely it is an interpolation between models of processes which are described by whole-order derivatives.

From this point of view let us also consider the learning process the results of which have been demonstrated above. Analysis of the curve construction (figure 1) on the basis of model (1) does not allow us to assert unequivocally that the best solution has been found. Form the mathematical viewpoint, the algorithm based on the minimum mean-square errors method has provided the best possible approximation to the experimental data. Taking into account that the learning process is connected with the information assimilation, short-term and long-term memory, forgetting and inference, the nature of the model, the learning curve may also differ from the classical ones [9]. Starting from the first classical works William Love Bryan and Noble Harter [11] and Edward C. Tolman [12, 13] which studied the learning curve onwards, it is noted that in the beginning the learning process goes quite fast and then starts to slow down [4, 9]. The resulting dependence resembles a curve corresponding to an aperiodic first-order unit or to series connection of two first-order units. Deviations from the experimental curve were attributed to dissimilarity of the students' physiological parameters, mutual influence in the group, and individual abilities to remember and restore information which are stipulated by the nervous system features. More importantly, scholars in the field of pedagogy did not have mathematical methods to use fractional degree equations. The curve obtained from equation

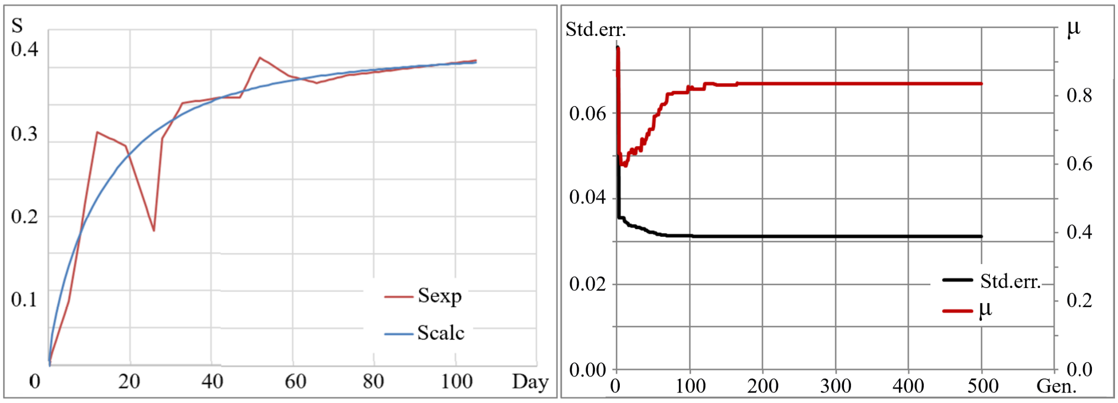


Figure 2: Experimental data and their approximation by model (2): a) initial data and approximating function changing over time; b) iterative process of finding a solution.

(1) will be approximately the same for all groups of students, which makes differentiation by psychophysiological properties impossible. However, the works [3, 4, 9, 14] demonstrate the possibility to use fractional calculus in various fields of science and technology and even to describe both the processes of information assimilation and mastery and the process of decision-making in a group. Scientists prove conclusively that the models and simulations of the processes changing over time, which the processes of information accumulation are, go beyond the framework of equations with derivatives of integer order.

Let us explore the models based on the fractional degree differential equations according to the learning results.

To process the data at a constant step of one day a piecewise linear interpolation between the known modules has been performed. Consider several models whose structure is similar.

Approximation by a fractional aperiodic unit:

$$H\left(p\right) = \frac{k}{a_0 p^{\mu} + 1}. \tag{2}$$

Parameter $a_0^{(1/\mu)} = 17.672$ corresponds to the physical time constant being measured in days. The graphs on the figure 2 show the initial data and the approximating function changing over time; the graphs on the right display the changes in the mean square error and the order of fractional component in the iterative search for a solution. It confirms the convergence of this process. Also, the attention should be paid to the best agreement between the calculated and experimental graphs in the middle and final parts ($t > 20$).

We also perform the approximation by the fractional aperiodic unit of order $1 + \mu$ (figure 3) that can be expressed in two forms:

$$H\left(p\right) = \frac{k}{a_1 p^{\mu+1} + a_0 p^{\mu} + 1} = \frac{k}{T_0^{\mu} p^{\mu}\left(T_1 p + 1\right) + 1}. \tag{3}$$

Physically, this transfer function is the inertial and fractional-integrating units with negative feedback. Parameter $a_0^{(1/\mu)} = T_0 = 21.78$ corresponds to the physical time constant. If $a_1 = T_1 T_0$ than $T_1 = 0.8723$ days.

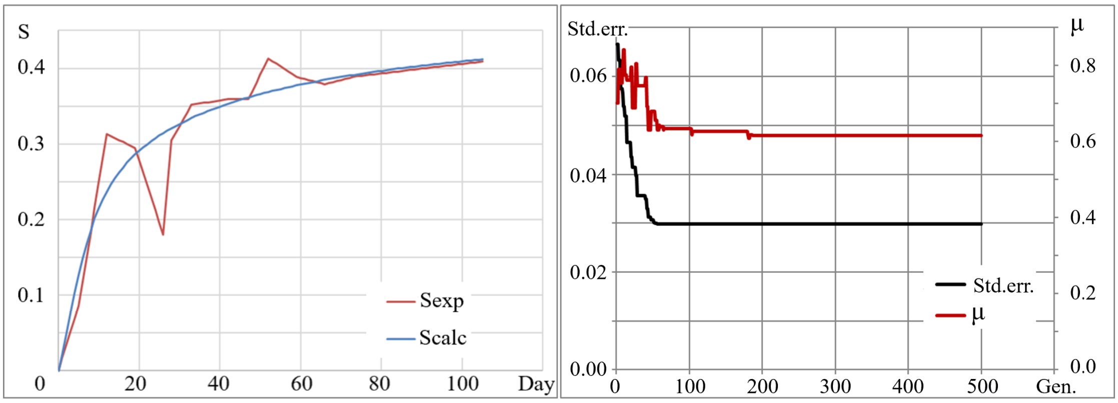


Figure 3: Experimental data and their approximation by model (3): a) approximating function changing over time; b) iterative process of finding a solution.

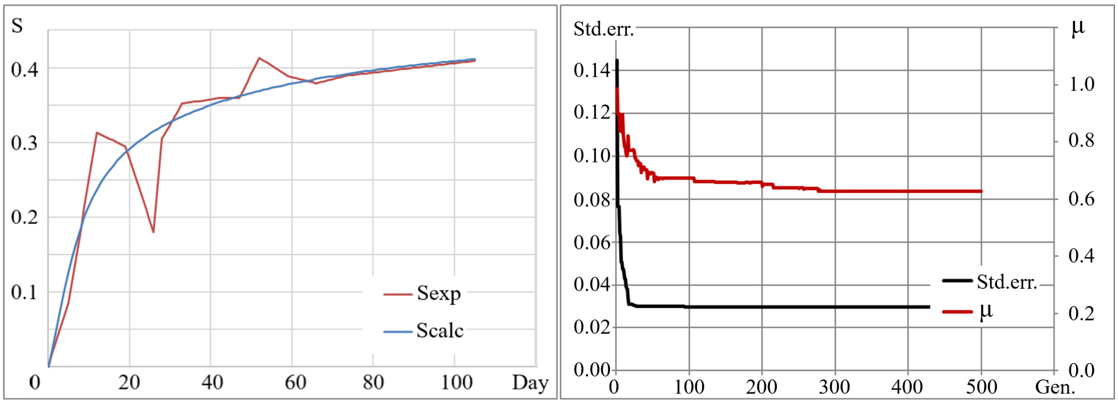


Figure 4: Experimental data and their approximation by model (4): a) approximating function changing over time; b) iterative process of finding a solution.

Approximation by inertial and fractional aperiodic units (figure 4):

$$H\left(p\right)=\frac{k}{\left(Tp+1\right)\left(a_0p^{\mu}+1\right)}. \tag{4}$$

Parameter $a_0^{(1/\mu)}=T_0=21.09$ corresponds to the time constant which together with the order of fractional aperiodic component corresponds to the physical time constant and is as close as possible to the level gained previously. Moreover, it is clearly seen that T_0 is close to the break point between the initial and final stages.

Finally we perform the approximation by the unit (figure 5):

$$H\left(p\right)=\frac{k}{\left(Tp+1\right)\left(a_1p^{\mu+1}+a_0p^{\mu}+1\right)}. \tag{5}$$

Although this function is the most complex, its similitude to the almost the same solutions at repeated starts, as in the previous cases, is worth noting. Here the inertial components

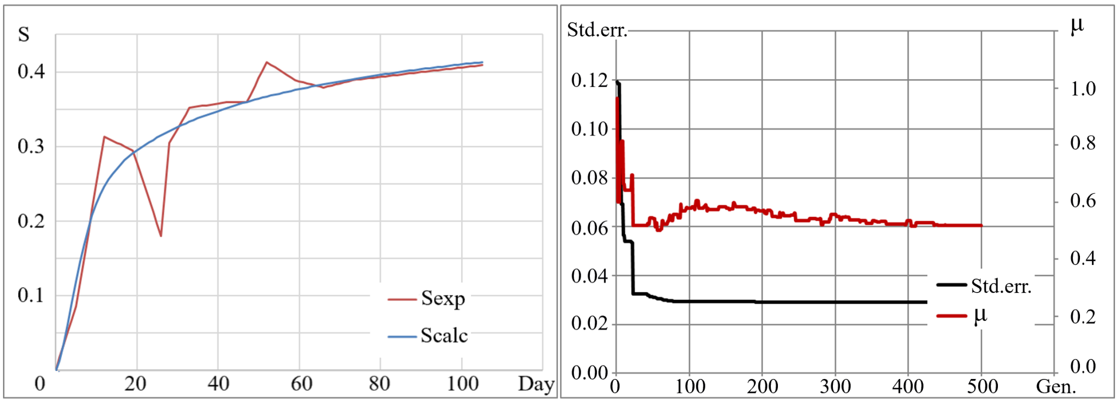


Figure 5: Experimental data and their approximation by model (5): a) initial data and approximating function changing over time; b) iterative process of finding a solution.

$T = 1.865...1.971$ and $a_0^{(1/\mu)} = T_0 = 28.14...29.46$ correspond to the physical time constant which is close to the values obtained in the previous case. Therewith, the additional time constant is calculated: $T_1 = 0.3826...0.4027$.

Summarized data of the models are given in table 1.

The obtained results are quite significant. Firstly, the accuracy of the approximation comparing with the classical model (1) has increased almost by 10%. Secondly, the fractional order in the transfer functions of models (2) – (4) is close to 0.5 which coincides with the description of diffusion processes, turbulent and laminar flows, penetration of nonviscous liquids into porous media, which also allows us to illustrate a concept by an analogy with the signal transmission from axons to dendrites [2], [15].

3. Analisys of the personal data of students

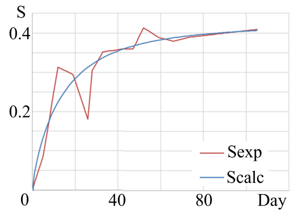
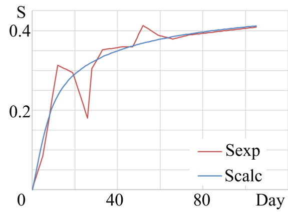
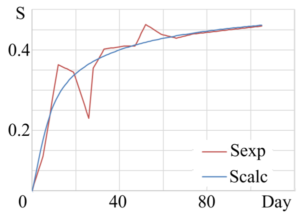
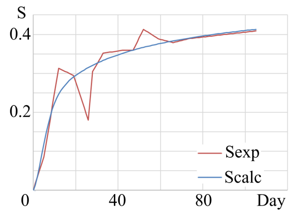
To study the learning of individual students we adopt model (4) which is based on inertial and fractional aperiodic components because it contains only two time constants and one exponent, so, taking into account modern ideas about the learning process, it will be possible to give physical meaning to these parameters.

In further studies the comparison of models' parameters with information transfer processes in the brain will allow the usage of more complex models, for example (5).

Analysing the obtained data, we can specify the elements which are characteristic of the identified groups of students.

I. Students who quickly reached the maximum level of assimilation of information. The speed of the content mastery and the achievement of high and medium levels are characteristic of students of a strong type of nervous system which determines the speed of all cognitive processes and flexibility. They work hard for a long period of time, respond flexibly to questions of varying complexity, are able to use the gained knowledge in new situations, can easily update the necessary information, correlate it with the new; compare, draw analogies, align with their own experience, etc. Furthermore, their resistance allows them to confront negative phenomena

Table 1
Model summary

Model	$T_0 = a_0^{(1/\mu)}$, days	T, T_1, days	Graphics
$H\left(p\right) = \frac{k}{a_0 p^{\mu} + 1}$	17.67		
$H\left(p\right) = \frac{k}{a_1 p^{\mu+1} + a_0 p^{\mu} + 1} = \frac{k}{T_0^{\mu} p^{\mu}\left(T_1 p + 1\right) + 1}$	21.78	0.87	
$H\left(p\right) = \frac{k}{\left(Tp+1\right)\left(a_0 p^{\mu} + 1\right)}$	21.09	2.73	
$H\left(p\right) = \frac{k}{\left(Tp+1\right)\left(a_1 p^{\mu+1} + a_0 p^{\mu} + 1\right)}$	28.80	$T = 1.92$, $T_1 = 0.39$	

which arise during the learning activities (influence of classmates and the teacher, adverse conditions of the organization of training, etc.).

Boys and girls fearlessly take progress tests and work efficiently under conditions of limited time. High level of motivation, awareness of the value of the future profession and the necessity of gradual development as well as intellectual and special aptitudes allow them to adsorb teaching information quickly and effectively. Typical diagram for this group is presented on figure 6 and numerical values of their parameters are $k = 0.3642$, $T = 4.2012$, $a_0 = 3.086$, $T_0 = 5.597$, $\mu = 0.6543$, $\Delta_0 = 0.400$.

II. Students who quickly reached the intermediate level and then slowly improved it. The second group includes students with an inert type of nervous system; however, they are motivated to study and conscious about the value and necessity of their own development and mastery of the future profession. The same scheme of learning is true for boys and girls

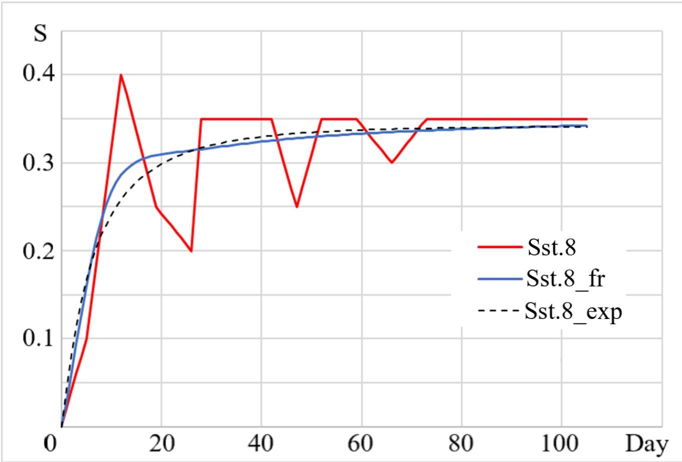


Figure 6: Data of Student No 8.

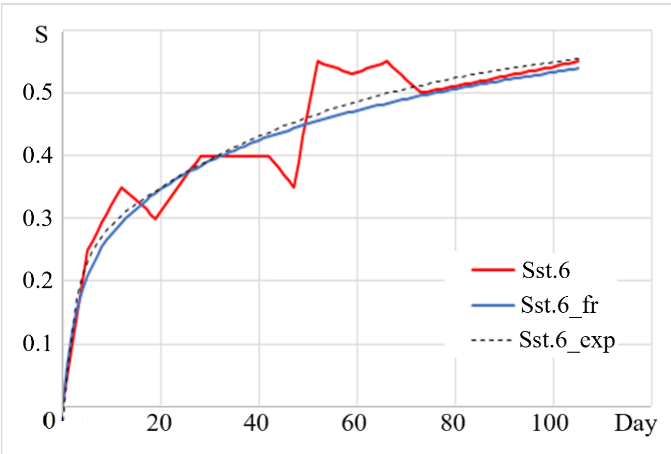


Figure 7: Data of Student No 6.

with a strong nervous system yet lacking motivation, possessing weak intellectual and special (professional) aptitudes (figure 7). Their parameters are $k = 0.9735$, $T = 0.8759$, $a_0 = 8.523$, $T_0 = 116.6$, $\mu = 0.4503$, $\Delta_0 = 0.250$.

III. Students who slowly master the teaching material are of weak and inert types of nervous system. They are fatigued by continuous, hard and responsible work. Even if the classroom climate is favourable and the teacher is reserved and sensible, unexpected questions and false answers significantly affect the final result of the content acquisition. In addition, progress tests and work under conditions of limited time inhibit the progress significantly. Although the students are well motivated and conscious about such values as development, freedom, etc., the slowness of the cognitive processes exerts an impact.

Boys and girls with an inert type of nervous system with parametes $k = 0.3855$, $T = 5.937$, $a_0 = 12.263$, $T_0 = 21.24$, $\mu = 0.8202$, $\Delta_0 = 0.350$ and typical diagram on figure 8 can more

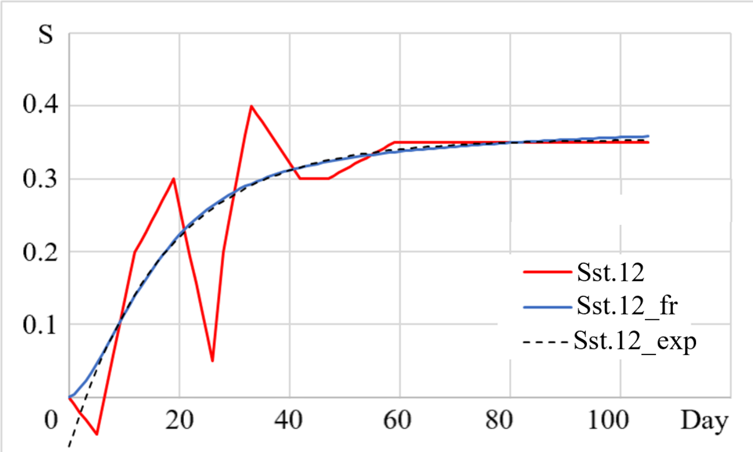


Figure 8: Data of Student No 12.

easily withstand the difficult conditions of persistent and responsible work; nevertheless, a lack of preliminary training and motivation, low level of awareness of values and imperfection of special aptitudes determine the special features of the learning process which are characteristic of the students of Group III.

Thus, the neurodynamic and psychological characteristics of a personality, which impact the effectiveness of learning, can be taken into account by the cybernetic model using equations of fractional order.

4. Conclusions

The developed cybernetic model of learning based on differential equations of second order with fractional degrees allows us to describe the process of learning more accurately, quickly responds to the changes in students' acquisition of the information, increases the efficiency of the content assimilation, enables us to guide the formation of an individual path of the student's development through the improvement and optimization of the class schedule, teaching methods and the system of control measures. The proposed simulation of the learning process facilitates in flexible and timely adjustments to the teaching process; the decay in knowledge and skills acquisition can be altered by a methodically correct presentation with due regard to the neurodynamic and psychological traits of students. So, to work with students of the second group it is necessary to apply methods of motivational and value based stimulation emphasizing the practical value of the information received, outlining the ways of its practical application, analyzing examples from real enterprises, investigating the causes of possible pre-emergency and emergency situations. The diversification of control methods, questioning aimed at stress reduction and creation of a cooperative and emotionally favorable climate contribute to the effectiveness of learning. Work with students of Group III requires additional diagnostic assessment of the level of training, formation of general and special skills, motivational in order to decide on the methods of learning activation.

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Cloud technologies and learning analytics: web application for PISA results analysis and visualization

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Abstract

This article analyzes the ways to apply Learning Analytics, Cloud Technologies, and Big Data in the field of education on the international level. This paper provides examples of international analytical researches and cloud technologies used to process the results of those researches. It considers the PISA research methodology and related tools, including the IDB Analyzer application, free R intsvy environment for processing statistical data, and cloud-based web application PISA Data Explorer. The paper justifies the necessity of creating a stand-alone web application that supports Ukrainian localization and provides Ukrainian researchers with rapid access to well-structured PISA data. In particular, such an application should provide for data across the factorial features and indicators applied at the country level and demonstrate the Ukrainian indicators compared to the other countries' results. This paper includes a description of the application core functionalities, architecture, and technologies used for development. The proposed solution leverages the shiny package available with R environment that allows implementing both the UI and server sides of the application. The technical implementation is a proven solution that allows for simplifying the access to PISA data for Ukrainian researchers and helping them utilize the calculation results on the key features without having to apply tools for processing statistical data.

Keywords

learning analytics, Cloud Technologies, PISA, web application

1. Introduction

Currently, we can observe the rapid growth of the demand in Big Data Analytics and Business Analytics [1]. Big Data and Cloud Computing solutions empower real-time decision-making, identify trends, and allow for creating data models within the most powerful Data Analytics

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solutions. Cloud Technologies provide for a brand-new way of data processing to retrieve data and analytics valuable for business and decision-making [2].

The recent research [3], as well as the agenda of the latest international conferences [4, 5, 6, 7], prove that the Big Data processing approaches are applicable and relevant for education as well.

Horizon Report 2020 [8] considers Learning Analytics and Analytics of Student Data to be the most promising areas in educational technologies. Being powered by Cloud Technologies by Google, IBM, Amazon, and Microsoft [9], Learning Analytics can empower effective decision-making on the level of an educational institution, a region, or the whole world. Besides, a vast amount of data is available for the public, so it is easy to utilize for research.

On the local level, introducing the Learning Analytics can facilitate:

- building the educational trajectories for the college undergraduate students [10],
- leveraging data on the students' activities to support them during online learning [11], analyzing the influence of group behavior on the individual student's success [12],
- analyzing the External Independent Evaluation (EIT) data to decide on the school for a pupil [13].

Across the world, the researchers analyze the volumes of data received from the international exams. For instance, the educational community keeps on track of research that studies the influence of the family background (including social, economic, and cultural factors) on the students' success [14, 15].

However, many analysts still cannot take the advantage of the analytics provided by international research such as PISA, TIMSS, PIRLS, PIAAC, NAEP, and TALIS [16].

The results are available for the public, and it's possible to access the databases and technical data, but not every researcher has a full understanding of the research methodology and tools. For instance, to make full use of data, analysts require background knowledge of calculation methodology, data structure and data processing algorithms of the research they work with.

Focusing on the PISA project, which it is currently the most noticeable and comprehensive evaluation project in Ukraine [16]. In 2018, Ukraine participated in the Program for International Student Assessment (PISA) for the first time, yet the question of efficiently utilizing the PISA data is still open to negotiation [17].

The Ukrainian researchers would have leveraged PISA data as a consistent input for analysis and synthesis, indicating and solving problems in our education system. Though, published at the end of 2019, the PISA analytical reports were hardly utilized to analyze the current state of education in Ukraine.

We cannot get away from the fact that PISA reports contain analytical data that reveal how our cultural, social, economic, and educational environment influences the success of Ukrainian students. The data is evidenced by precise calculations and introduces the researchers to the most entire gamut.

However, not every analyst can manage the research results without additional training, which takes them time and effort.

Challenges that arise for them when it comes to processing data provided by PISA or any other international research are the following:

- the analysts have not enough background understanding the research structure and evaluation techniques,

- the analysts receive too much data, that seems to them unstructured and difficult to process,
- the analysts can be confused with the research-specific terminology.

We aim to make the results of any international research more accessible, to allow more analysts to use the analytical results for their independent research and get the most out of the supplied data.

This research suggests developing a web application that would allow the educational community to assess PISA results in the most transparent and user-friendly format.

2. Analysis of PISA tools for results processing

PISA utilizes three main software tools for data processing: the *IDB Analyzer* application, free environment for static data analysis R *intsvy*, and the *PISA Data Explorer* web application powered by cloud technologies.

IDB Analyzer is free software that allows for generating scripts for commercial SPSS (Statistical Package for the Social Sciences) or SAS (Statistical Analysis Software) packages, each of those has a cloud solution. The tool considers the students' selection when calculating the standard deviation and the scheme of the test book rotation (Plausible Value – the probable values of the students' results). IDB Analyzer generates code that allows users to process descriptive statistics and verify the statistical hypothesis without writing the code in SPSS or SAS. Though, utilizing *IDB Analyzer* requires both skills with SPSS and/or SAS, and installing commercial software. Besides, it requires data preprocessing (uploading and cleansing). Also, the researchers require certain skills and expertise with data processing.

intsvy is a free R program package for processing the PISA, TIMSS, PIRLS, PIAAC and ICILS results. This package includes such functions as data import, data analysis and results visualization. The data analysis function considers the complicated selection construct and possible values when calculating grades and standard variance, regression coefficients, correlation coefficients, and frequency array. The visualization tools allow for demonstrating aggregated data in standard graphic form, that can be adjusted via the open function code. Likewise, working with *intsvy* requires users minimal experience with R language and RStudio.

PISA Data Explorer is a cloud-based solution for processing PISA results, available at https://www.oecd.org/pisa/data/. PISA Data Explorer requires from the users at least minimal skills and background with statistical data processing. The main advantage of this tool is that the PISA data should not be uploaded and preprocessed. The whole data is available online. The calculations are conducted online as well. The tool's disadvantage is limited to the fact that a researcher can only conduct the data analysis limited to the built-in PISA Data Explorer functions.

We shall refer to the *Education GPS/Explore Data* service available at https://gpseducation.oecd.org/Home, as an example of an internationally applied application for PISA data display that allows for receiving the PISA estimate indicators.

This service generalizes data on results, publications, and conclusions of the researches held in OECD (PISA, TALIS, PIAAC). *Education GPS/Explore Data* organizes the research data according to the countries, topics and research agendas. Using this service does not require any specific skills in data analysis. The navigation panel has useful data filters that allow for displaying values for the selected countries. The system stores huge amounts of data, yet due to the structure issues, sometimes it prevents users from finding the data they need.

Thus, we came to a conclusion, that any researcher who is interested in an independent study requires either a considerable experience with data analysis and statistical data processing, or should search for generalized data at the Education GPS resource.

Using international research results, many local researchers face challenges in understanding the data processing methods utilized by particular research centers. These challenges can occur both on the level of statistical data analysis and on the level of understanding the deep context of the research [18].

For instance, the problem with processing statistical data on student's contextual characteristics and learning environments can be caused by terminology.

Also, some PISA conclusions rely on the indexed received from a complicated mathematical model, which bases upon the survey results. These conclusions can be unobvious. To calculate all the values exponents, indexes, or distributions percentage the researcher has to process a big amount of data and understand the whole PISA evaluation strategy.

Thus, we can see how data processing issues make research complicated and prevent many researchers from utilizing Learning Analytics.

This paper suggests designing a web application that would ensure the Ukrainian researchers' quick access to PISA data in a comprehensive, interactive, and user-friendly format. This solution can become a highly effective tool to analyze PISA results for individual research and get the most out of the PISA data.

3. Results

3.1. The challenges addressed by the application

This work aims to design a web application for displaying PISA results for Ukraine and launch it at http://pisa.testportal.gov.ua/ to make the research data available for the public.

The proposed application will allow analysts, researchers, and teachers from various institutions to get the most out of the PISA research experience, including:

- retrieving the data on the evaluation of semantic and contextual assessments from the complicated PISA research structure,
- retrieving the PISA calculation on students' success (shown in PISA scores and the level passing of students' competence),
- retrieving the PISA calculations on contextual characteristics of the learning environment (including students' gender, institution's location, student's social and economic background),
- retrieving the PISA results that demonstrate the research indicators for the national level (e.g. the type of the educational institution can be specified on the national level),
- assessing the interactive data visualizations for Ukraine with descriptions for the PISA indicators,
- accessing open PISA data on Ukraine and the benchmark countries,

- PISA content localized for Ukrainian users.

The detailed descriptions for PISA indicators and results implementation in the format of hypertext guide users through the process of searching and help them understand the strategic evaluation results.

The content in Ukrainian allows more Ukrainian speaking users to utilize PISA results for their research.

3.2. Application structure

The application structure aligns with the structure of PISA research. The survey results allow the researchers to assess various factors that determine the current condition of educational institutions and their effects on the students' success. This allows for analyzing the causes and effects of the education system in a selected country.

The PISA program is a three-year cycle. The evaluation takes place every three years and the results are revealed at the end of each cycle. The results of each cycle are not connected. These results can be compared in a timeline on the countries and key indicators, that provides a thorough grounding for strategic solutions in education.

The research structure consists of two main parts: the results on student's subject competence in math, reading, and natural science and the meaning of various indexes that demonstrate the contextual student's characteristics, educational environment, motivation, and other factors that can influence the students' success.

The data should be displayed both for each cycle separately and in a timeline. Figure 1 demonstrates the main elements of the PISA research results structure.

The questions from the student's survey reflect the main goals and objectives of the PISA research. These questions highlight the key factors required to analyze what influences the students' success. The survey also allows for collecting data on such important for representative analytics factors as:

- gender,
- educational institutions' locations,
- education programs and
- students' social and economic status.

The key indicators shaped on the international level allow for comparing the results and backgrounds both for the same and different categories of students within one country. This allows us to compare results for students from different countries based on their gender, region or social and economic status. The type of educational institution or educational program serves as a national indicator and allows for evaluating results only on the level of a particular country.

The index values serve as self-sufficient research results that can be analyzed on the international level to compare students within the country, or countries on the given parameters, and also as factor values which influence student's success and a range of other indicators.

For instance, the index of students' social, economic, and cultural statuses demonstrates not only the financial situation in a family, but the social and cultural aspects of their lives including their parents' education, availability of books, musical instruments, educational software, etc.

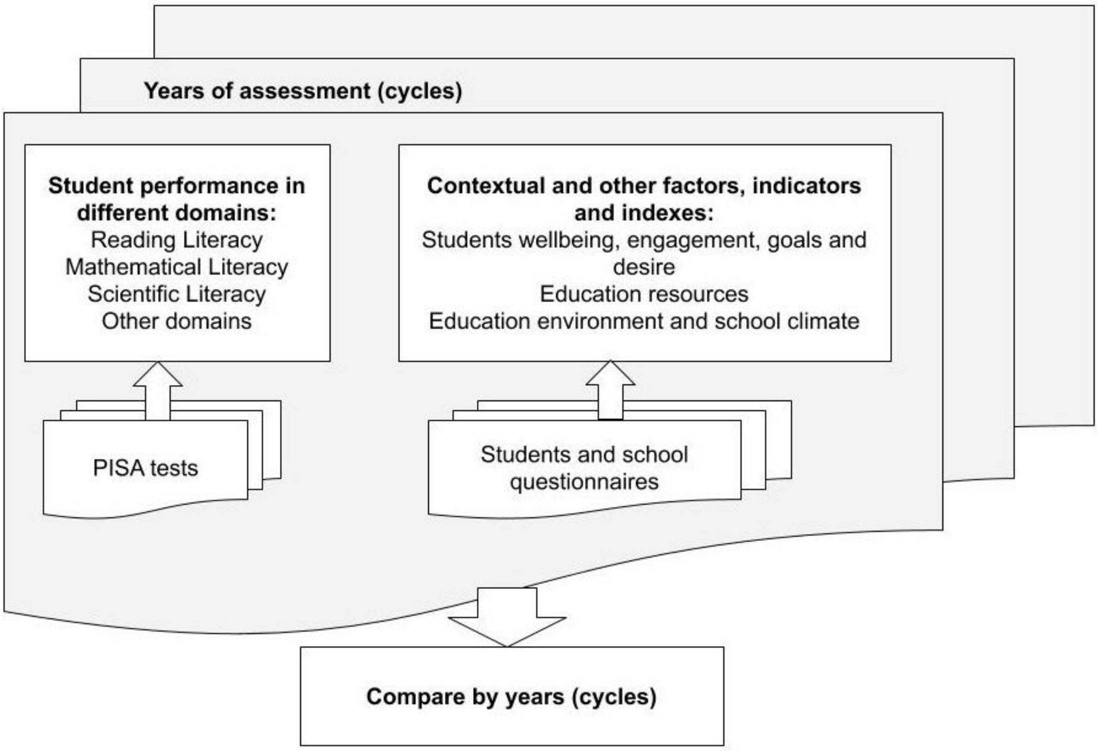

Figure 1: The structure of the PISA study.

The index value is an important indicator of the students' social, economic, and cultural statuses compared to their peers from other countries. Besides, index value influences both students' success and other indexes received during the analysis.

The values of the main indexes, criteria and characteristics can be divided into several categories:

- wellbeing, students' ambitions, expectations, and attitude to education,
- resources invested in education,
- the learning environment and school climate.

Each category has a set of indexes and criterias, received from the questioning students and their educators. Calculated via complicated mathematical models, these indexes allow for comparing values on the international level and separate categories of students. The indexes mostly summarize student' input to the survey and are considered to be imputed relative values that characterize some aspect of the research.

The indexes are compared based on OECD, an average of the countries, that equals to 0. Thus, the indexes mentioned on the graphs or in tables should have explanations to help users interpret the displayed data correctly.

Also, we can use interactive graphs to visualize the real-life condition of Ukrainian education compared to the reference countries with similar cultural, social, or economical conditions or shared historical background. With a convenient visualization, the user can concentrate on the appropriate for comparing educational systems with similar social and cultural backgrounds.

Studying the experience of countries with similar backgrounds and factors that influence their students' success is more appropriate than comparing Ukrainian experience to the experience of countries with better initial conditions for education.

3.3. Technical implementation

The Ukrainian Center for Educational Quality Assessment experts calculate PISA results with *intsvy package* in R environment and store them in text documents or tables (.csv or .txt). Based on that data, we build diagrams to demonstrate the distribution of indicators. Figure 2 demonstrates the general structure of the results visualization.

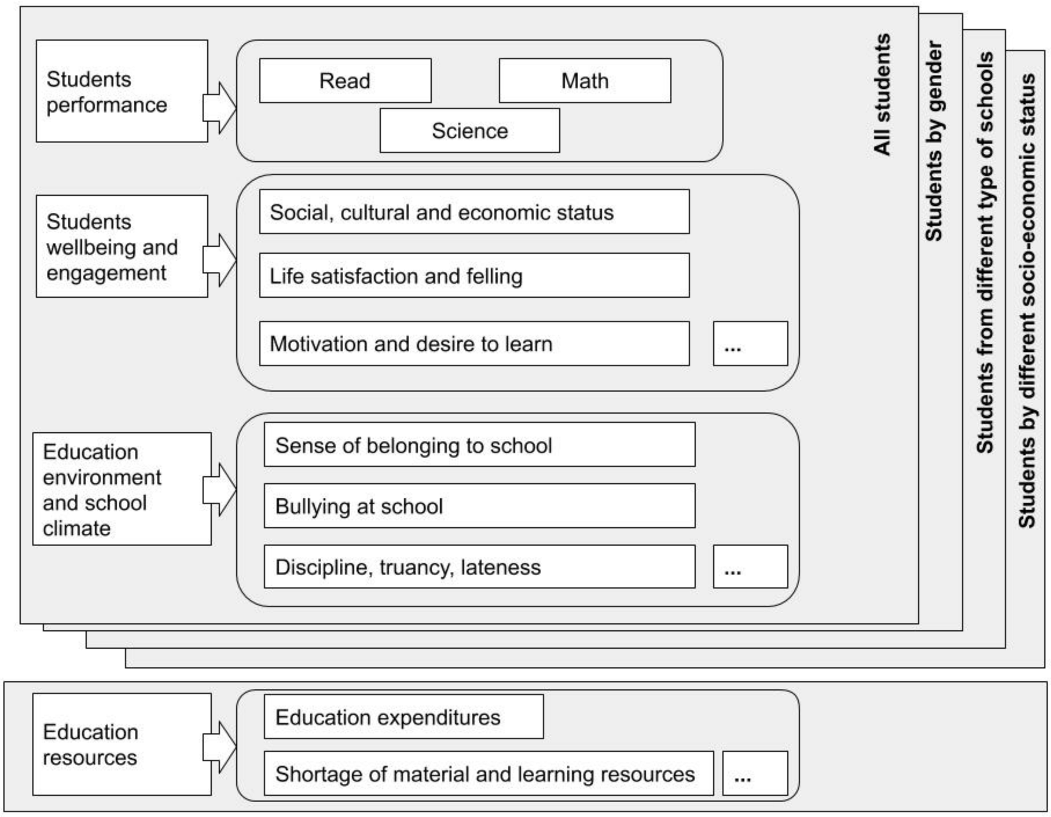

Figure 2: Generalized structure of visualisation of PISA results.

We utilized R Shiny package (https://shiny.rstudio.com/) to design both the application interface and the server sides, and deploy the application to the Cloud [19]. Figure 3 demonstrates the application structure. The application provides for calculating criteria based on PISA results in R via the *intsvy* package. The application stores the calculation results in the text files used to visualize data on the server-side. Thus, the application doesn't conduct any calculations and doesn't require any time to upload data and process the results.

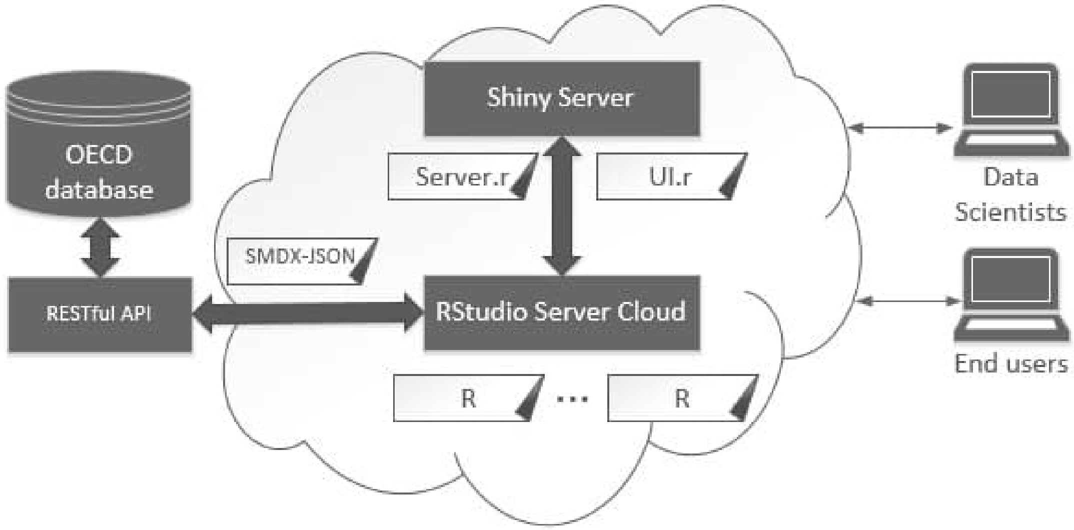

Figure 3: The technical implementation.

The application interface is designed as an interactive dashboard and provides for navigation, interactive menu, graphics, and hypertext links.

Figure 4 demonstrates the application home page and the main navigation elements that allow users to go to the data structure and access the diagrams of PISA scores distribution and students' competence levels.

Figure 5 demonstrates an interactive graphic that displays the data on student's success depending on countries and categories. This graphic allows users to compare different categories of students from different countries and see the factors that influence students' success.

With the Description option, the users can get explanations for the main criteria and indexes. This option is available both from the context menu and from the hypertext prompt message.

4. Conclusion

Working on this project we came to the conclusion that applying Learning Analytics is not only a trend but an effective tool for improving the system of education at all levels. Utilizing the international level results of Learning Analytics can be challenging for the local researchers. These challenges are connected with managing data analysis tools, understanding the research methodology, and the analysed indicators in the local context.

Ukraine participated in PISA in 2018, yet still, only a limited number of researchers work on processing that data. These results are important to understand the problems and make decisions on the different levels of education in Ukraine.

Ukrainian specialists have challenges leveraging the PISA data. The PISA calculations methodology is difficult to understand for researchers without specific background with tooling and a

Figure 4: Home page of application.

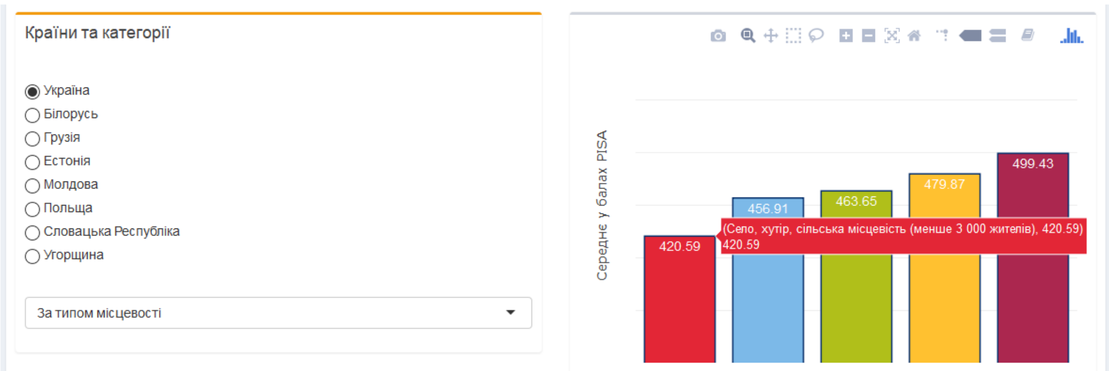

Figure 5: Interactive graphic.

good level of English. Thus, this work proves that having an application that would simplify accessing PISA results is pertinent.

The application we suggest is a convenient tool for a wide range of people working in the education segment who utilize PISA results for their research. This web application will allow for assessing analytical data based on PISA results in the most convenient, comprehensive, and user-friendly format.

This will be an effective tool for accessing PISA data in Ukraine and utilizing the calculations' results on the key indicators. What is more the users should not apply the tools for statistical data processing. Currently, we only implemented a part of the main functionality. Though, we plan the updates that would allow for uploading the calculated results in table format and utilizing the whole learning analytics on PISA results in Ukraine.

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Computer simulation of processes that influence adolescent learning motivation

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Abstract

In order for the learning process to always retain personal value for the learner, it is necessary that his or her motivation be maintained through an awareness of his or her purpose and goals. This article presents a local model (at the individual object level) of enhancing external motivation, which give to determine students' efforts to get rewards. The concept of this model based on describing the behavior of agents (in our case students). The characteristics of the phenomenon in the motivation of learning at different stages of adolescent development are analyzed. The problem of computer modeling of educational processes with the help of agent modeling on the example of studying student motivation is considered. Internal and external factors that may strengthen or weaken the adolescent's motivation to study have been studied. The expediency of using information technologies of agent modeling to study the dynamics of strengthening or weakening student motivation is substantiated. Using the AnyLogic Cloud computing environment the change of dynamics of strengthening of motivation of teenagers on an example of model of strengthening of external motivation is defined.

Keywords

computer simulation, behavior of agents, educational processes, adolescent learning motivation

1. Introduction

Adolescence is a phase of lifespan associated with greater independence, and thus greater demands to make self-guided decisions in the face of risks, uncertainty, and varying outcomes

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[1]. Evidence is mounting to suggest that multiple decision processes are tuned differently in adolescents and adults including reward reactivity, uncertainty-tolerance, delay discounting, and experiential assessments of value and risk [1]. The motivation of adolescents in learning contexts has emerged as an important issue of educational research over the last 20 years, because adolescence is a time of change and preparation for adulthood, and because academic achievement at this time can have significant implications on employment or career opportunities, understanding adolescents' motivation is vital to ensuring students achieve their potential [2].

Cloud technologies has great potential to address the problem solving process of adolescent learning motivation which is a complex activity [3, 4]. In the modern world, it is extremely important to study the complex processes in learning, the development of which can only be effectively predicted by computer simulation [5, 6, 7, 8, 9, 10, 11, 12, 13]. This paper discusses the peculiarities of cloud computing simulation of educational processes with the help of agent modeling based on the study of adolescent learning motivation. Learning motivation [14, 15], due to its multidimensionality, the presence of various (sometimes even opposite) factors that cause its emergence, development and disappearance, is one of the most difficult problems in psychology. A great deal of research is devoted to its solution, but there is still not a sufficiently convincing model of this phenomenon that would allow teachers to successfully control changes in pupils' learning motivation. The reason for this is not only the complexity of the phenomenon, but also its distinctive manifestations at different stages of the child's development.

The latest achievements of psychologists on learning motivation issues are presented in the 2018 annual edition of "How People Learn II" [16] by the American National Academies of Sciences, Engineering, and Medicine, which regularly provides thorough reviews of the latest views in various scientific and technical fields. According to it, learning motivation is defined as a condition that activates and sustains behavior toward a goal. It is critical to learning and achievement across the life span in both informal settings and formal learning environments. For example, children who are motivated tend to be engaged, persist longer, have better learning outcomes, and perform better than other children on standardized achievement tests [17]. Motivation is distinguishable from general cognitive functioning and helps to explain gains in achievement independent of scores on intelligence tests [18]. It is also distinguishable from states related to it, such as engagement, interest, goal orientation, grit, and tenacity, all of which have different antecedents and different implications for learning and achievement [19]. People are motivated to develop competence and solve problems by rewards and punishments but often have intrinsic reasons for learning that may be more powerful.

2. Results and discussion

Learners tend to persist in learning when they face a manageable challenge (neither too easy nor too frustrating) and when they see the value and utility of what they are learning. Children and adults who focus mainly on their own performance (such as on gaining recognition or avoiding negative judgments) are less likely to seek challenges and persist than those who focus on learning itself. Learners who focus on learning rather than performance or who have intrinsic motivation to learn tend to set goals for themselves and regard increasing their competence to be a goal. Teachers can be effective in encouraging students to focus on learning instead of performance, helping them to develop a learning orientation. Given the above characteristic of the phenomenon, it is possible to distinguish several blocks in the learning motivation.

Block 1. **The personal meaning of learning for the student (learning subject).** For a young child learning is a natural process, he or she learns constantly, exploring the world, knowing and realizing it. In the first stages, learning motivation is the innate need to understand the world in which you live. This understanding has always been and is a prerequisite for survival. Senior preschoolers and junior pupils are deepening their knowledge of the world in two ways: practically exploring it and purposefully studying it with the help of specially organized learning. For teens, learning is the main source of knowledge. Learning, according to the "Ukrainian Psychological Terminology dictionary" is "purposeful personal assignment of knowledge and skills of social experience, in the process of which their content is not only transformed to the individual experience of the student, but also directed at the formation of the subject's personalities through his or her needs and motivational sphere" [20]. APA dictionary, which is one of the most respected psychological dictionaries in the world today, views teaching as "the acquisition of novel information, behaviors, or abilities after practice, observation, or other experiences, as evidenced by change in behavior, knowledge, or brain function" [21, 16]. Despite some differences in understanding of the concept of learning in both dictionaries, it is noted that learning is a purely personal process, in contrast to teaching, which is based on the interaction between the teacher (someone, or something that teaches) and the student. A final point to make is that, in the context of the growing expansion of virtual learning systems, the important question is whether such learning systems provide interaction between the learner and the teacher (or program). In the absence of such interaction, even a motivated learning process can stop at the first stage of the assimilation of information, and not proceed to the second main stage of the internalization of information and its transformation into knowledge.

In order for the learning process to always retain personal value for the learner, it is necessary that his or her motivation be maintained through an awareness of his or her purpose and goals. At the same time, more stable motivation for learning is manifested when purposes and goals (the essence of the differences between these concepts will be discussed below) have a long-term character, directly related to future planning and conscious life tasks. Such motivation can be defined as "strategic". Tactical or short-term motivation defines purposes or goals that can be achieved in the near future (lesson, term, school year, etc.). Tactical motivation is often the result of specific external stimulation when a student tries to receive the promised reward or to avoid punishment. The least motivated to learn are those adolescents who do not associate their personal purposes and goals with learning at all. The purpose of the study answers the question "Why am I learning?"

The goal of the goal is to answer the question "What am I learning for?".

Learning motivation of adolescents increases significantly when combined with a well-understood goal and purpose.

Block 2. **Extrinsic and intrinsic learning motivation.** The effectiveness of learning motivation depends largely on the values that are important to a particular individual. What is most important for a adolescent is to achieve something (a life goal or a task); enjoy the process of cognition; raise your image in the eyes of the environment; deserve praise or reward; prove something to yourself or avoid anxiety and defeat. Personal values are directly related to internal or external type of motivation. Intrinsic learning motivation is driven by cognitive curiosity, pleasure from solving intellectual problems, curiosity, desire to learn more. Intrinsic motivation does not need external stimulation (or reinforcement), because it is of value in itself, it is not tied to a specific result. In essence, it contains both motive and stimulus [22, 23, 24].

Extrinsic motivation depends on extrinsic factors, is driven by additional reinforcements, and is carried out using a reward incentive, which can be either tangible (money, valuation, privileges, etc.) or intangible (praise, enhancement of image or status in society, punishment, etc.). Important factors in influencing extrinsic motivation are the lack of real intrinsic motivation and the student's willingness to receive rewards for success in learning or preventing punishment for failure. At the same time, the learning itself is perceived as a burden and does not bring pleasure

Mixed motivation arises in the case of a combination of internal and external factors. This combination can be both positive and negative. In particular, intrinsic motivation can be reinforced by positive externalities when parents support and encourage the adolescent and weaken in case of indifference to the student's successes and failures. A special case of mixed motivation, in E.R. Lai's view, is learning motivation driven by internal pressures such as obligation or guilt [25]. Numerous studies [26, 27, 28, 29, 30] indicate that good intrinsic motivation correlates with both better learning outcomes and overall life success.

Block 3. **Objectives of motivated activity are indicators of what an individual is focused on when performing a particular task.** Broussard and Garrison separate goals of skill and performance. What's the difference? The goals of skill are focused on learning for the sake of learning, self-worth of learning, meeting one's own cognitive needs, while the goals of performance are to show others their achievements. Goals of skill are associated with a high capacity for information analysis and planning, and the belief that effort enhances a person's capabilities. On the other hand, goals of performance are accompanied by thoughts of achievements, evaluations, and external rewards. In the long run, goals of skill are better motivators of learning than goals of performance.

Block 4. **Locus of control is the tendency to attribute successes or failures to internal or external factors.** If an adolescent has an internal locus of control, then the student is aware of the importance of his or her activity to achieve a specific goal and purpose, and therefore his or her motivation for effective learning increases significantly. As research (Connell and Wellborn [23], Weiner [24], Eccles and Wigfield [30]) found in this case. he or she will be as motivated as he or she will feel that he or she is in control of his o her own successes and failures.

The influence of the various factors can enhance or weaken adolescent learning motivation is presented at figure 1 (included the number of conditional points that each factor can add to the motivation). When an exterior locus of control is present in an adolescent, in difficult situations his or her motivation for learning will decrease significantly. In particular, difficulties in completing a task will lead to a decrease in effort and a drop in motivation in students with extrinsic motivation, who believe that they lack skills, parents assist poorly, teachers explain poorly and, conversely, increase motivation in students with an internal locus of control that associates their success or failure with the effort spent, since failure for the first group means impossibility that is difficult to change, whereas failure for the second group means that one simply needs better try.

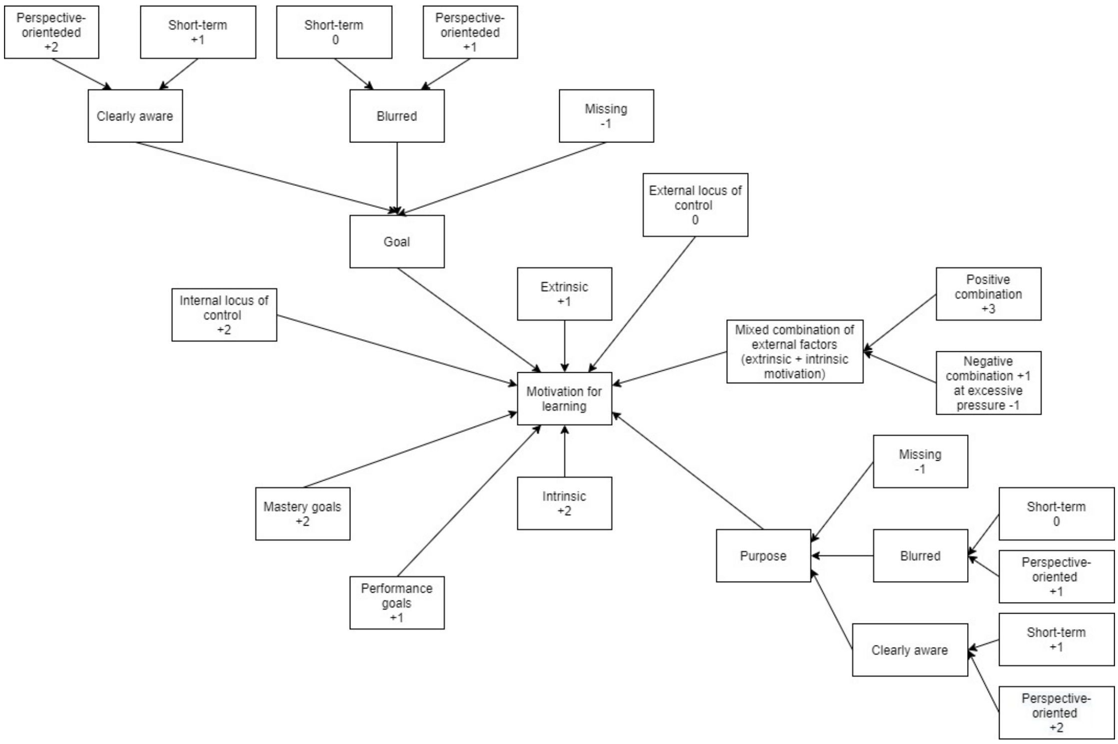

Figure 1: Graphical model of the influence of various factors that can enhance or weaken adolescent learning motivation.

It is advisable to use agent modeling information technology to quickly track and respond to changes in learning, as well as to depict the dynamics of enhancing or weakening learning motivation. The basis for describing the behavior of agents (in our case students) is based on a life cycle model: each agent develops according to his or her own behavior model, which can change within his or her individual life cycle. The life cycle of a particular agent is presented as a system that changes its internal states, and can be specified as a graph of transitions between stages (modes) of its existence. The dynamic model of the transition of the agent from one mode of operation to another is presented in the form of a production model, which consists of agent functioning modes array; transformation rules array (knowledge base); and interpreter (inference machines) [31]. There are two types of agent model definition levels:

- global models (multiple objects grouped on the basis of a particular attribute),
- local models (at the individual object level).

According to the principles of agents building models, there are several approaches (figure 2):

- the use of regression dependencies to determine logic at the level of agents arrays,
- the formation of a knowledge base of agents based on Data Mining to determine the logic of individual agents behavior,
- the use of target functions to determine the logic of agents' behavior.

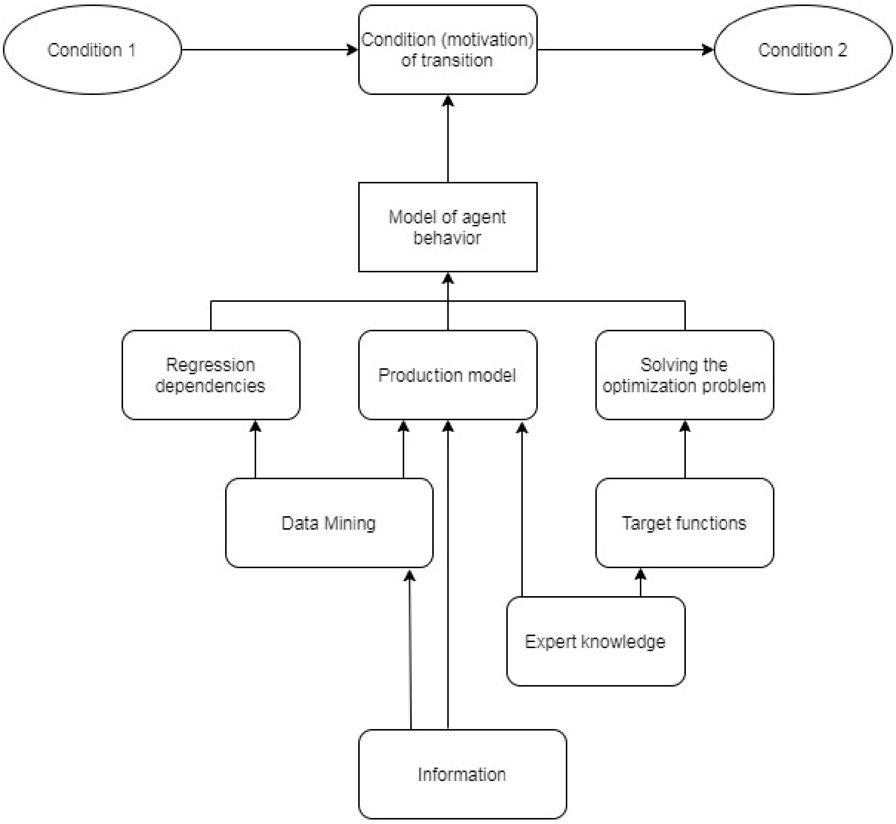

Figure 2: Model of agent behavior.

Investigating the change in the dynamics of enhancing the motivation of agents can be exemplified by the model of enhancing external motivation (figure 3). The first step in building the model will be to determine the criteria and conditions under which the experiment will be started. We will consider a comparatively small educational institution of 5000 people. To implement the model, each student will be an agent. Because it is determined that contingent rewards are new, no one will ever be interested in and will not use them from the very beginning, interest in students may be influenced by advertising. After that, the number of interested people will also be affected by the natural increase that will occur due to the fact that students who have already received awards will share information about them with their acquaintances. The latter will be added to the model indicators that can adversely affect the performance of the system, since they will change the conditions of external motivation in the model under consideration. Using the model implemented in the AnyLogic Cloud software environment [31] (web service for applying simulation operationally) it is possible to determine students' efforts to get rewards (the transition of agents from state 1 to state 2) (figure 3).

Thus, the detected regression dependencies can be used to build models of system dynamics (used in cases where it is impossible to take into account all external factors that affect the behavior of a group of people in modeling the behavior of each person separately). Using the

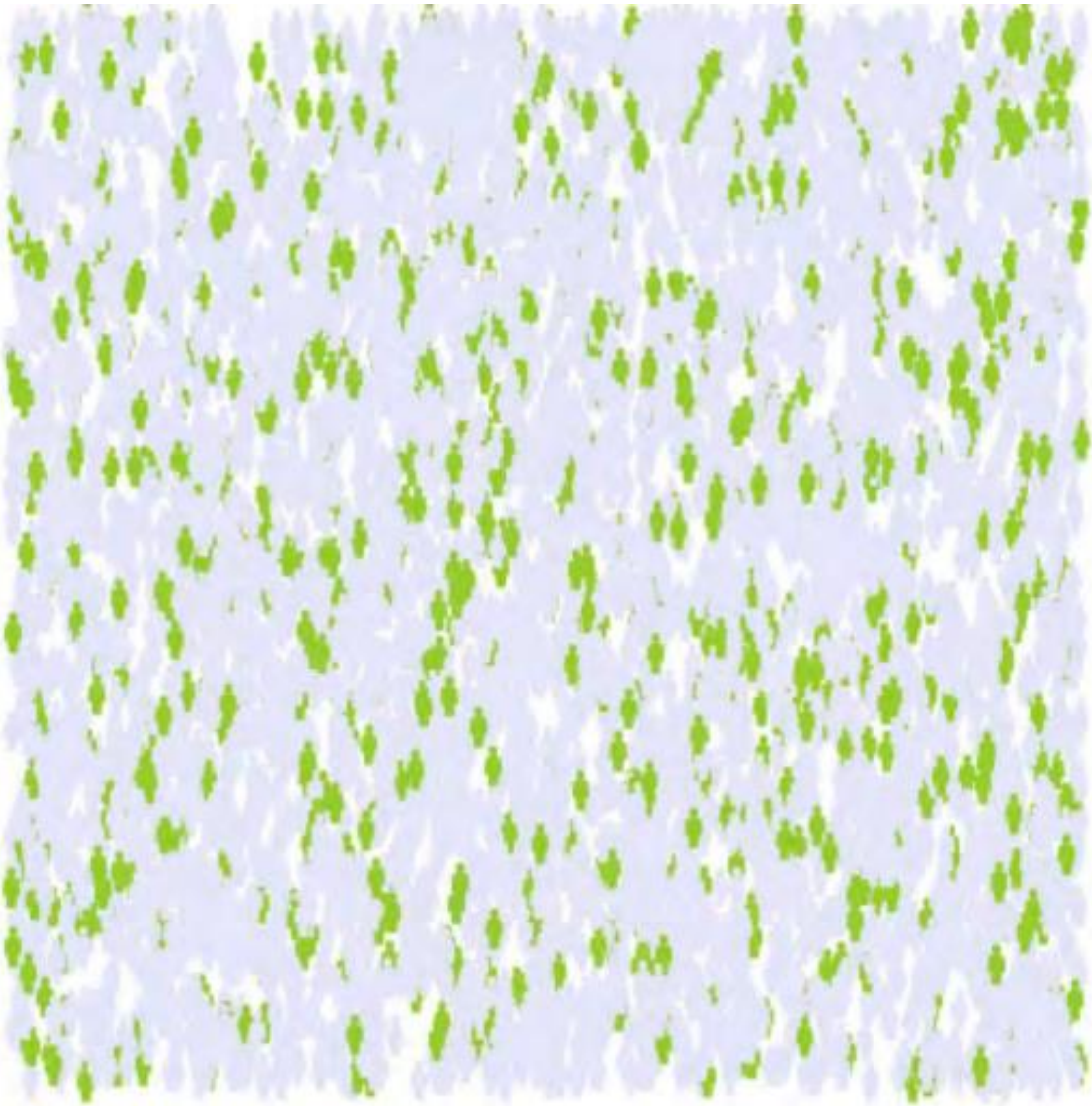

Figure 3: Transition of agents.

knowledge base of agents enables the construction of local models that determine the logic of behavior at the individual agent level.

This approach is based on the assumption that agents who have the same sets of characteristics under the same conditions behave similarly (the likelihood of a positive decision on an issue changes with the change in the characteristics of the agent). These approaches can be used in the presence of a sufficient amount of statistics and the ability to distinguish stable relationships between impact factors and outcomes. When modeling conditions that have not previously been encountered (such as crises), it is appropriate to use target functions to determine the behavior of agents that determine the behavior of model objects in different situations.

Changing the parameters will reflect the growth of agents of one or another category as a graph. As a result, the diagram (figure 4) will show the approximate result that can be expected after the model is started.

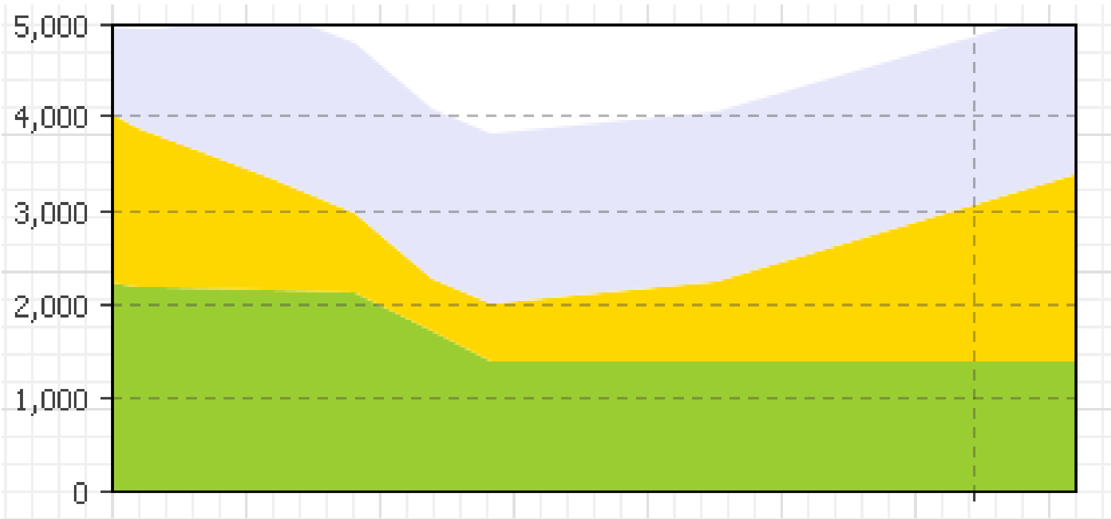

Figure 4: Changing the number of interested agents.

There is a significant group of agents who receive rewards from extrinsic motivation, further some of them are interested and even fewer are completely uninterested. To test the work, you must run the model and follow its execution. The number of interested agents is constantly growing and does not exceed the number of agents who have already received rewards (on most of the schedule). In a certain area (figure 5), agents also successfully switch from one state to another, which is also accompanied by a change in color.

This indicates that the model successfully reflects the processes that occur when students are externally motivated.

3. Conclusion

Motivation plays a key role in the learning process [25]. The effectiveness of learning motivation depends largely on the values that are important to a particular individual [32]. Personal values are directly related to internal or external type of motivation. It is advisable to use agent modeling information technology to quickly track and respond to changes in learning. The detected regression dependencies can be used to build models of system dynamics (used in cases where it is impossible to take into account all external factors that affect the behavior of a group of people in modeling the behavior of each person separately). This approach is based on the assumption that agents who have the same sets of characteristics under the same conditions behave similarly (the likelihood of a positive decision on an issue changes with the change in the characteristics of the agent). These approaches can be used in the presence of a sufficient amount of statistics and the ability to distinguish stable relationships between impact

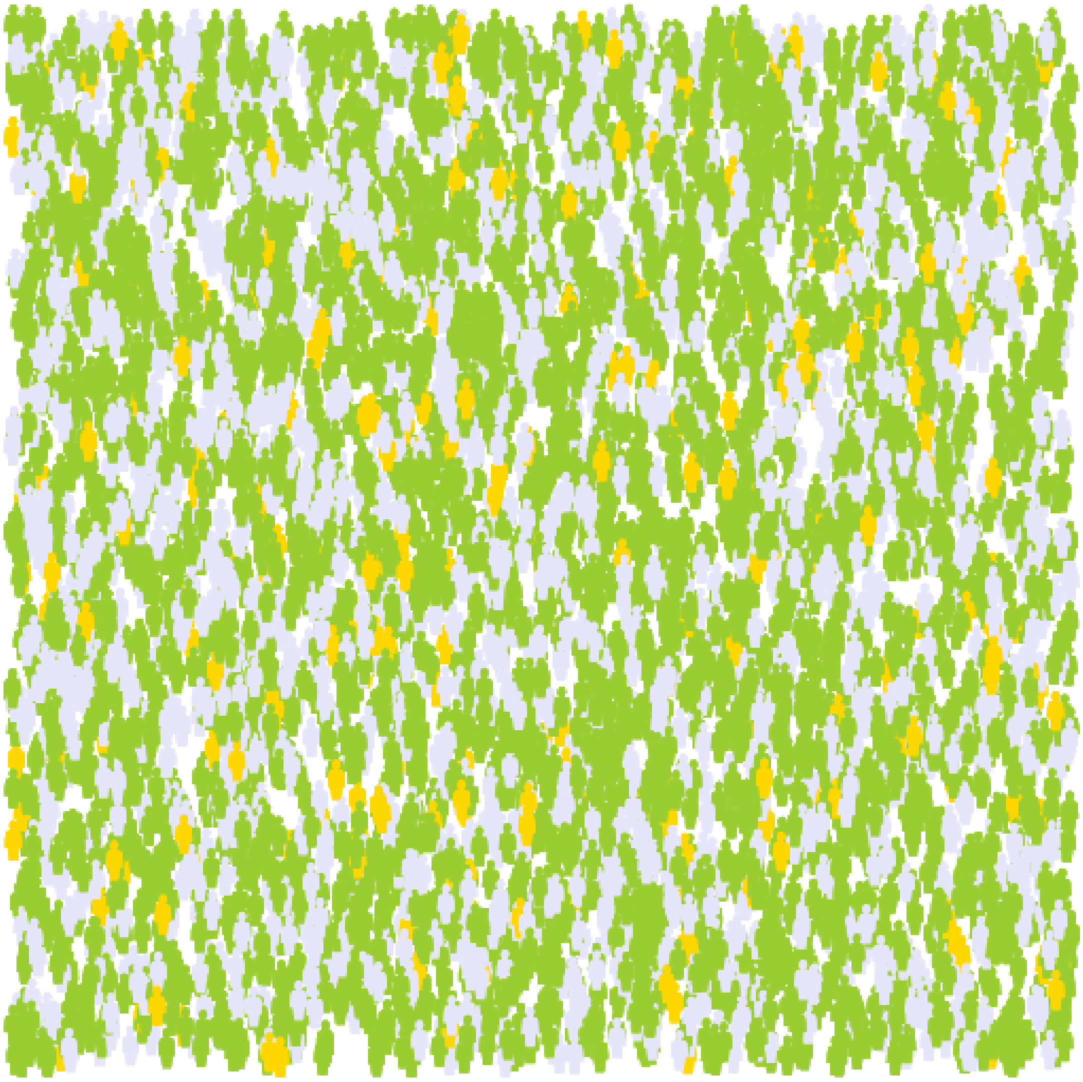

Figure 5: Visualization of agent state transition.

factors and outcomes. When modeling conditions that have not previously been encountered (such as crises), it is appropriate to use target functions to determine the behavior of agents that determine the behavior of model objects in different situations.

Using the knowledge base of agents enables the construction of local models that determine the logic of behavior at the individual agent level. Investigating the change in the dynamics of enhancing the motivation of agents can be exemplified by the model of enhancing external motivation. Using the model implemented in the AnyLogic Cloud software environment it is possible to determine the stransition of agents from completely uninterested to receive rewards from extrinsic motivation. The implementation of an agent model of enhancing external motivation as an element of learning about student motivation provides a significant level of growth for the group of students who receive rewards from external motivation. Involving information technology to agent modeling provides an opportunity to track the conditions when the motivation will be strengthened or weakened.

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Simulation of intellectual system for evaluation of multilevel test tasks on the basis of fuzzy logic

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Abstract

The article describes the stages of modeling an intelligent system for evaluating multilevel test tasks based on fuzzy logic in the MATLAB application package, namely the Fuzzy Logic Toolbox. The analysis of existing approaches to fuzzy assessment of test methods, their advantages and disadvantages is given. The considered methods for assessing students are presented in the general case by two methods: using fuzzy sets and corresponding membership functions; fuzzy estimation method and generalized fuzzy estimation method. In the present work, the Sugeno production model is used as the closest to the natural language. This closeness allows for closer interaction with a subject area expert and build well-understood, easily interpreted inference systems. The structure of a fuzzy system, functions and mechanisms of model building are described. The system is presented in the form of a block diagram of fuzzy logical nodes and consists of four input variables, corresponding to the levels of knowledge assimilation and one initial one. The surface of the response of a fuzzy system reflects the dependence of the final grade on the level of difficulty of the task and the degree of correctness of the task. The structure and functions of the fuzzy system are indicated. The modeled in this way intelligent system for assessing multilevel test tasks based on fuzzy logic makes it possible to take into account the fuzzy characteristics of the test: the level of difficulty of the task, which can be assessed as “easy”, “average", “above average”, “difficult”; the degree of correctness of the task, which can be assessed as “correct”, “partially correct”, “rather correct”, “incorrect”; time allotted for the execution of a test task or test, which can be assessed as “short”, “medium”, “long”, “very long”; the percentage of correctly completed tasks, which can be assessed as “small”, “medium”, “large”, “very large”; the final mark for the test, which can be assessed as “poor”, “satisfactory”, “good”, “excellent”, which are included in the assessment. This approach ensures the maximum consideration of answers to questions of all levels of complexity by formulating a base of inference rules and selection of weighting coefficients when deriving the final estimate. The robustness of the system is achieved by using Gaussian membership functions. The testing of the controller on the test sample brings the functional suitability of the developed model.

Keywords

intelligent system, multilevel test tasks, fuzzy test characteristics, fuzzy assessment, Sugeno inference system,

1. Introduction

Test control is increasingly becoming an integral part of the educational process for all types and levels of educational institutions. Having become widespread in Western European countries and the United States, it is gradually gaining new positions in the domestic higher education. There are many practical implementations of automated testing systems, both in individual disciplines, and universal knowledge assessment systems, fully or partially invariant to specific disciplines and allowing teachers to edit their information content. Analysis of the effectiveness of automated testing in educational institutions shows that the most significant disadvantages of modern approaches to automated testing include [1, p. 4]:

- the need to formulate options for answers to test items on the principle of "one is absolutely correct" – "other N are absolutely wrong";
- the primitiveness and inflexibility of the procedures for calculating the final grade, which can be reduced either to determining the ratio of the number of correct answers to the number of questions asked, or to the summation of points assigned for each correct answer;
- impossibility of automating various methods of knowledge control, widely used in pedagogical practice;
- significant laboriousness of manual formation of such a set of test tasks and options for answers to each of them, which makes it possible to exclude or minimize the likelihood of presenting the same task to different people while simultaneously checking their knowledge.

From this it follows that it is necessary to develop an automated knowledge control system, which requires the use of fundamentally different approaches to the presentation and processing of information based on methods and models developed within the framework of the theory of intelligent computing and knowledge engineering.

A lot of studies in pedagogy are devoted to the issue of assessing knowledge. In particular: monitoring the quality of education (Cherednichenko and Yangolenko [2], He and He [3], Igbape and Idogho [4], Leontev et al. [5], Li et al. [6], Muhd Nor et al. [7], Qin et al. [8], Sorour et al. [9], Wei [10], Zhi and Nan [11] and others); development of modern innovative technologies that are included in the knowledge assessment system (Anohina-Naumeca et al. [12], Anohina-Naumeca

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and Grundspenkis [13], Gierłowski and Nowicki [14], Grundspenkis [15], Schmuck et al. [16], Szöllosi et al. [17] and others); the use of a multi-point scale for assessing knowledge, abilities, and skills (Bespalko [18], Linn [19] and others); theoretical approaches to the assessment of students' knowledge, their development and improvement (Clotfelter et al. [20], Falchikov and Boud [21], Falchikov and Goldfinch [22], Host et al. [23], Hwang and Chang [24], Newble and Jaeger [25], Osadchyi et al. [26], Rust et al. [27], Scouller [28], Topping [29], Wiliam et al. [30] and others); evaluation of test results in an adaptive automated testing system, taking into account the ambiguity of the formulations of answers (Barker [31], Phankokkruad and Woraratpanya [32], Rudinskiy [1] and others). In [33] we substantiated the structural model of the neuro-fuzzy system of professional selection of students for training in IT specialties by studying the psychological characteristics, personal qualities and factual knowledge, skills and abilities of students as a unity of fuzzy and stochastic data base of the intellectual system. The issue of using fuzzy logic to describe the indicators of expert competence assessment using linguistic variables instead of numerical ones or in addition to them and the development of Sugeno's intelligent system for determining expert competence was covered by us in [34]. The process of modeling intelligent systems based on fuzzy logic in various fields and analysis of the effectiveness of systems implemented in MATLAB is disclosed in the works of: Taylor [35] – fuzzy logic methodology, which is widely used in research and engineering practice and education, Lutsyk et al. [36] – use of parametric identification and adaptive neuro-fuzzy technologies to determine energy efficient modes of production equipment, Shtovba – the theory of fuzzy identification, methods of fuzzy clustering and their application for fuzzy rule extraction, as well as the method of decision-making in fuzzy conditions based on the merger of goals and constraints, author's package solutions for designing fuzzy classifiers, building hierarchical fuzzy systems, training of fuzzy knowledge bases such as Mamdani, as well as for logical output with fuzzy source data [37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50].

2. Materials and methods

Models based on fuzzy logic are more flexible, as they mostly allow taking into account the experience and intuition of a specialist in a particular field. They are more adequate to the simulated reality and make it possible to obtain a solution correlated in accuracy with the initial data [51].

As a rule, the following characteristics are referred to fuzzy test characteristics:

1) the level of difficulty of the task, which can be assessed as "easy", "average", "above average", "difficult";
2) the degree of correctness of the task, which can be assessed as "correct", "partially correct", "rather correct", "incorrect";
3) time allotted for the execution of a test task or test, which can be assessed as "short", "average", "long", "very long";
4) percentage of correctly completed tasks, which can be assessed as "small", "medium", "large", "very large";
5) final mark for the test, which can be assessed as "bad", "satisfactory", "good", "excellent".

Among the fuzzy models for evaluating test results, adaptive models are interesting. In the work of Rudinskiy [1, p. 49], an adaptive model for evaluating the results of a "fuzzy" test is described. The idea is that the set of reference answers for each test item has a fuzzy grading scale. This fuzzy scale corresponds to the normalized numerical scale $(1, t_1, t_2, t_3, 0)$, where $t_i \in (0, 1), i = 1..3$. All answers, except for the correct one, are assigned a subsequent question with a subset of answers. If an inaccurate answer is given to question D at the i-th step of testing, a clarifying question is asked next, and the subset of answers contains both "more correct" ("correct", "incomplete") and "less correct" ("uncertain", "wrong") answers. If this question is answered differently from the correct one, no further additional questions are asked (otherwise the laboriousness of compiling such a structure of questions with subsets of answers to them would be very great), testing goes to the next step (question). Thus, the testing process can be represented as a movement along a directed graph, where vertices are questions, and arcs are transitions from the previous question to the next.

An adaptive testing model using the apparatus of fuzzy logic is considered by Duplik [52, p. 60]. As a scale for evaluating test results, a 12-point scale proposed by Bespalko [18] is used. At the same time, the author proposes a correspondence between the percent of correct answers of the student and estimates on 12-point and 5-point scales, which, in turn, correspond to fuzzy concepts.

Danilova [53, p. 17] developed an adaptive fuzzy model for evaluating the results of automated testing with division of tasks according to the levels of assimilation, proposed by Bespalko [18]. The paper presents models for evaluating test results: formalization of question-answer relations in test tasks according to the levels of assimilation is carried out for recognizing the answers of the tested person and formal presentation of test results; the scaling of the value estimates of the test items was performed; the bases of rules of fuzzy productions for evaluating test items of closed and open types have been developed; in order to ensure the adaptability of testing, a base of rules for fuzzy products has been developed for ranking tasks in the test; the calculation of the integral assessment of the test performance was done based on the assessment results of each test task. The fuzzy inference for evaluating the test results, based on the Mamdani method of fuzzy inference, is described.

Belov [54] considers the problem of building an automated testing system (ATS) with the analysis of the respondent's answers in natural language (NL). To recognize the responses of the person and the reference in the automated testing system, a linguistic analyzer module has been developed, which processes text in NL. The result of the surface-syntactic analysis of the phrases of the reference and user answers are syntactic dependency trees, including the word forms of the phrase, with the definition for each of them morphological descriptors and syntactic properties that combine words into syntactic fragments and groups.

A limitation of the presented comparison model is the use of well-formed sentences. A sentence that is not well-formed is discarded by the linguistic analyzer with the requirement to the respondent to reformulate the answer. Each type of response is associated with a so-called syntactic template (SynT), which determines a set of typical syntactic constructions of a sentence and their significance. The obtained result – the degree of correspondence (relevance of phrases) – is taken as the degree of "correctness" of the respondent's answer on the scale $[0; 1]$.

3. Results

Thus, all the methods for evaluating test methods that we have considered have both advantages and disadvantages, which we have summarized in table 1 for clarity.

Table 1
Advantages and disadvantages of test assessment methods

Author	Advantages	Disadvantages
Rudinskiy [1]	The introduction of fuzziness in the organization of the adaptive test, which allows the compilers of the test at the stage of its creation for each test task to build a hierarchical structure of questions in the form of a directed graph.	When evaluating test tasks and the test, the apparatus of fuzzy logic is not used, and the obtained linguistic values are simply projected onto a normalized numerical scale. The values obtained on this scale determine the degree of correctness of the answers, which are substituted into a specially designed formula to obtain the final grade.
Duplik [52]	The use of a fuzzy logic apparatus to obtain an integral assessment of test results. The integral assessment is influenced by such indistinct characteristics of the test as the current level of training, the percentage of correct answers, the complexity of the task, and the time it takes to complete the task.	The 12-point assessment scale, proposed by V. P. Bespalko, is used only to evenly distribute the traditional 5-point scale on it and is not tied to the levels of assimilation of knowledge.
Danilova [53]	The sophistication of models for assessing test tasks, adaptive testing, integral assessment of test results.	The set of fuzzy production rules for evaluating test tasks with an open-ended question is applicable only to test tasks of the “Substitution” type.
Belov [54]	Revealed classification of question types and corresponding types of answers in natural language.	The graph comparison method is very labor intensive and complex. Firstly, the syntactic templates of all reference answers must be built in advance, and secondly, the proximity of two phrases is determined on the scale [0; 1] by means of a complex algorithm, which would be easier to do using the apparatus of fuzzy logic.

The considered methods for assessing students are presented in the general case by two methods: using fuzzy sets and corresponding membership functions; fuzzy estimation method and generalized fuzzy estimation method. The assessment system should be regularly reviewed and improved to ensure its suitability to assess students impartially and fairly.

It makes sense to use a fuzzy model to describe an object when we do not have its analytical description, or it is too cumbersome to use, but at the same time there is a sufficiently large amount of experimental data on the behavior of an object and/or heuristic rules for its functioning.

In this work, the Sugeno production model is used as the closest to the natural language. This closeness allows for closer interaction with a subject area expert and build well-understood, easily interpreted inference systems.

It is important for us to develop an assessment strategy based on fuzzy sets, which requires careful consideration of the factors included in the assessment. These include: the level of difficulty of the task, the degree of correctness of the task, the final mark for the test, which can be assessed as “bad”, “satisfactory”, “good”, and “excellent”. The system is presented in the form of a block diagram of fuzzy logical nodes in figure 1 and consists of four input variables, corresponding to the levels of knowledge assimilation and one initial one. With this method, the system contains two nodes. The first node takes into account the level of complexity of the task and the degree of correctness of the task, depending on the supported task type of the automated system that is used for testing, for example Moodle [55].

The next three nodes behave like a fuzzy logic controller with two inputs with corresponding weights and one output, as in figure 2.

4. Fuzzy system implementation

From the subject expert, we get the value of the matrix and the dimensions that describe the degree of importance of each question in the fuzzy domain, that is, the set of all allowed atomic values of the matrix column. The clear values are given as a vector. In the first node, the resulting data will be the experimental data, while the next nodes work as a fuzzy controller, the input of which is the output of the previous node (corresponding to the levels). The output of each node can be in the form of fuzzy values or in the form of linguistic variables. Each node has weighted coefficients that can be set equal to one with the equal influence of each input parameter. The output occurs according to the inference mechanism of the Sugeno fuzzy system. Here is a description of the system.

System name: Correctness.

Input variables: Level 1, Level 2, Level 3, Level 4.

Initial variable: Final grade.

The names of the terms of input variables: correct, wrong.

The names of the terms of the original variable: correct, almost correct, partly correct, rather correct, probably wrong, wrong, zero.

Fuzzy membership functions of the system are defined in the interval $[0; 100]$ (see figure 3), the parameters of the input and initial ones, respectively, are given in tables 2 and 3.

Set of rules “ If … then”:

1. If (level1 is wrong) and (level2 is wrong) and (level3 is wrong) and (level4 is wrong) then (final grade is zero) (1)

2. If (level1 is wrong) and (level2 is wrong) and (level3 is wrong) and (level4 is correct) then (final grade is probably wrong) (1)

3. If (level1 is wrong) and (level2 is wrong) and (level3 is correct) and (level4 is wrong) then (final grade is probably wrong) (1)

4. If (level1 is wrong) and (level2 is wrong) and (level3 is correct) and (level4 is correct) then (final grade is partly correct) (1) …

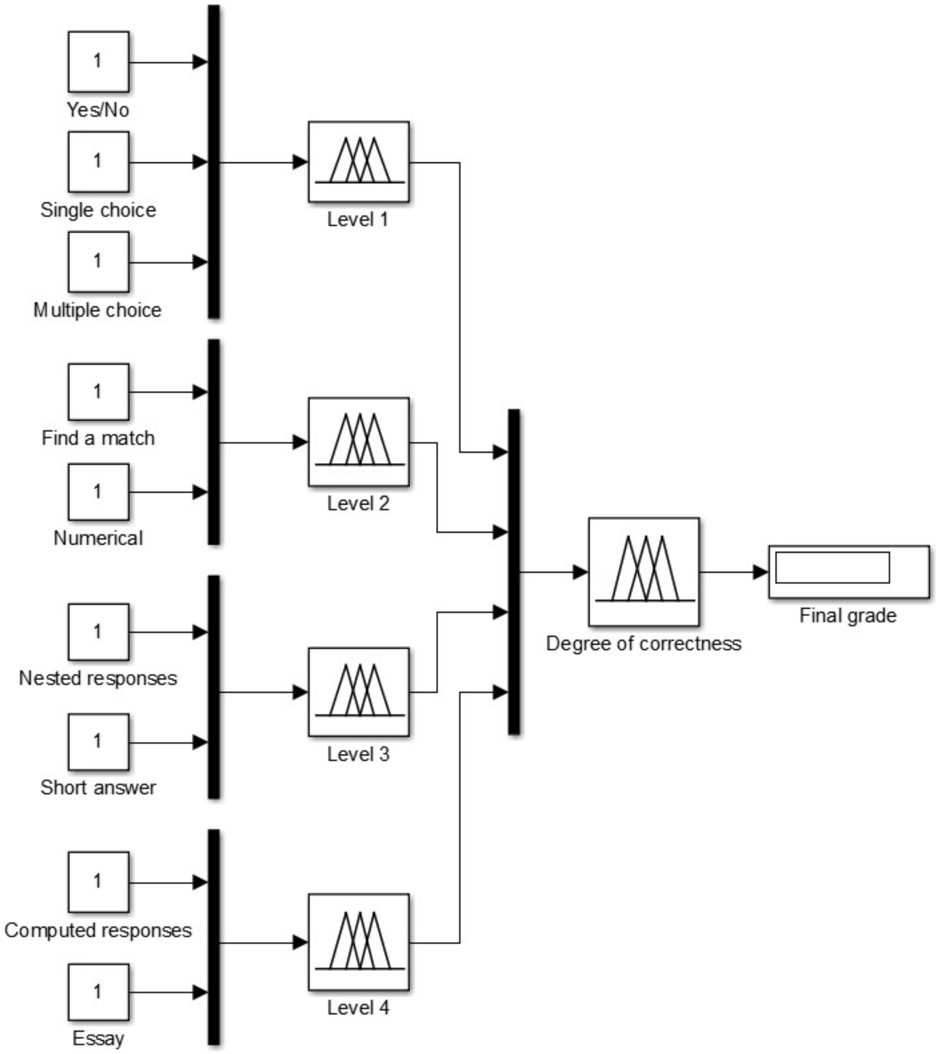

Figure 1: Block diagram of a fuzzy estimation system.

14. If (level1 is correct) and (level2 is correct) and (level3 is wrong) and (level4 is correct) then (final grade is almost correct) (1)

15. If (level1 is correct) and (level2 is correct) and (level3 is correct) and (level4 is wrong) then (final grade is partly correct) (1)

16. If (level1 is correct) and (level2 is correct) and (level3 is correct) and (level4 is correct) then (final-grade is correct) (1)

As a result of modeling this system in the MATLAB application package, in particular the Fuzzy Logic Toolbox package, we obtained the response surfaces of the system at constant values of the input variables level3 and level4 equal to 50: in figure 4a – manually configured by an expert; in figure 4b – configured according to the ANFIS algorithm. Analysis of the response surface of a manually tuned system shows incorrect operation at intervals corresponding to

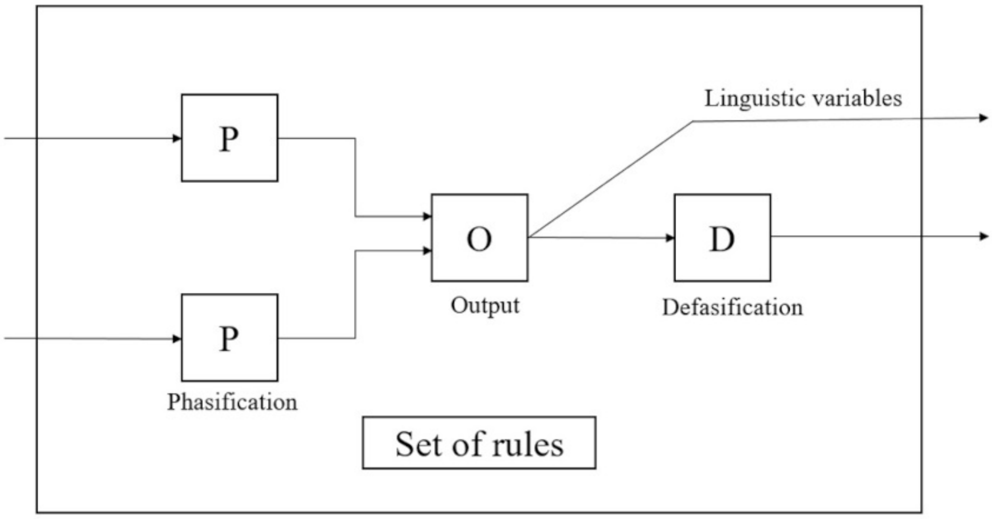

Figure 2: Node of presentation in the form of a fuzzy logical controller.

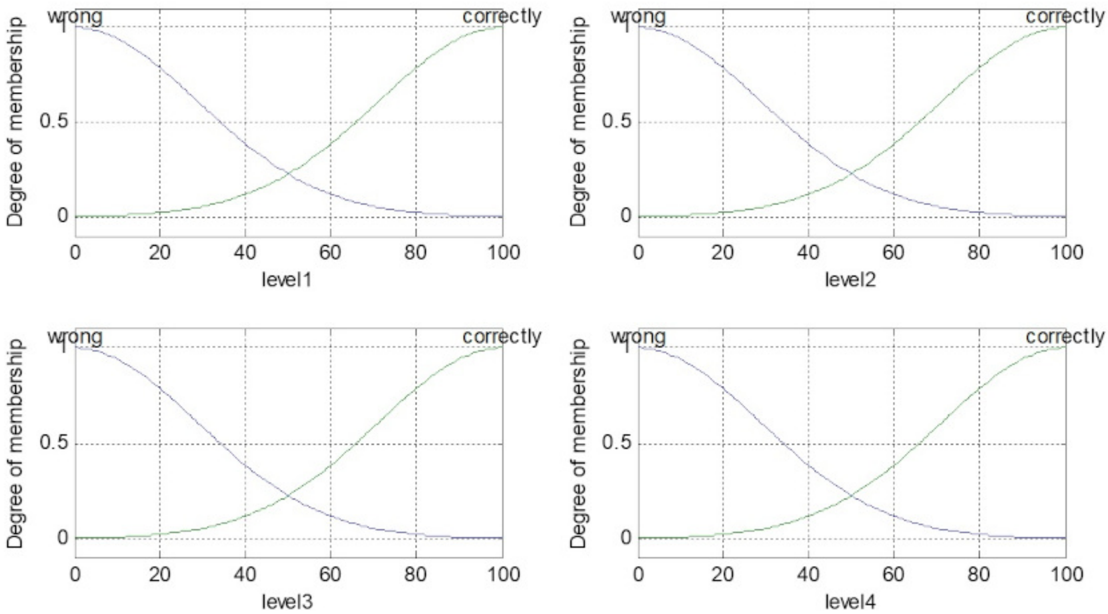

Figure 3: Membership functions of input linguistic variables of a fuzzy system.

intermediate values of functional membership such as constants of the output variable. To eliminate these differences, the fuzzy system was trained using the ANFIS algorithm based on the training sample.

Training program:

Table 2
Parameters of membership functions of initial variables

Name	Type	Parameters
`correct`	constant	100
`almost correct`	constant	80
`partly correct`	constant	65
`rather correct`	constant	50
`probably wrong`	constant	35
`wrong`	constant	20
`zero`	constant	0

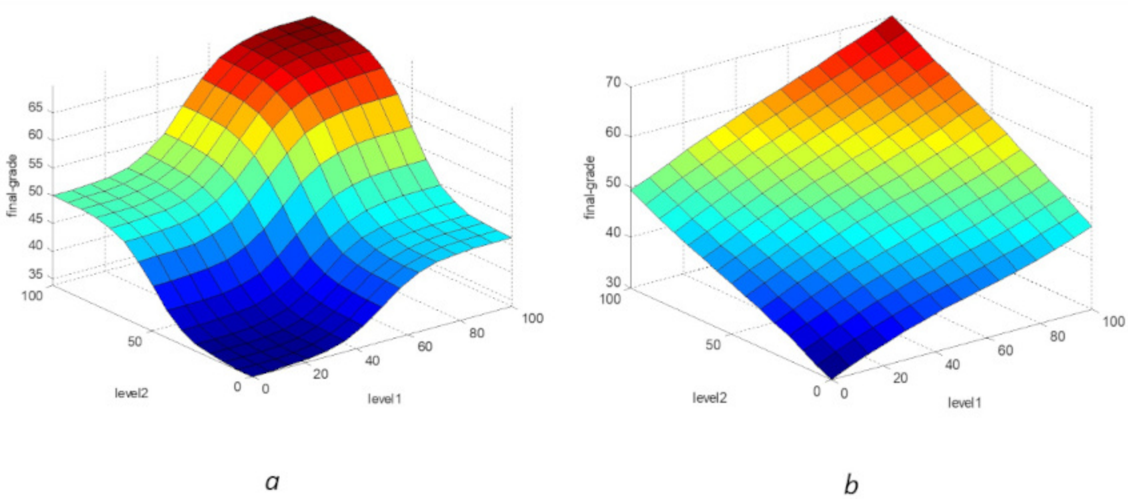

Figure 4: The surface of the system response at constant values of the input variables level3 and level4 equal to 50: a – manually configured by an expert; b – configured according to the ANFIS algorithm.

```
initfis = resdfis ('correctness');
(learn, error) = anfis (tr_data, initfis, 10);
```

where the initial parameters: `learn` – a tuned system of the Sugeno type, the parameters of which minimize the error on the training set; `error` – system error at each training iteration; input parameters: `tr_data` – training sample; `initfis` – the original fuzzy output system; number 10 is responsible for the number of training iterations.

As can be seen from figure 4b, the trained system according to the ANFIS algorithm reproduces the expert's opinion as accurately as possible, which makes it possible, accordingly, to more accurately formulate the final assessment, taking into account the level of the tasks done correctly. The results of testing the fuzzy system are shown in table 4.

Table 3
Fuzzy system testing results

Difficulty level 1	Difficulty level 2	Difficulty level 3	Difficulty level 4	Final Grade
20	25	21	36	26
50	65	75	25	52
60	45	25	0	28
98	78	60	10	52
27	35	15	0	18
60	68	50	35	50
85	90	50	54	66
85	87	80	76	81
15	7	2	0	6
56	45	90	84	73

5. Conclusion

An intelligent system for assessing multilevel test tasks based on fuzzy logic modeled in this way makes it possible to consider all the above factors using fuzzy logic that are included in the assessment. This approach ensures the maximum consideration of answers to questions of all levels of complexity by formulating a base of inference rules and selection of weighting coefficients when deriving the final grade. The stability of the system is achieved by using Gaussian membership functions, as discussed in [56, p. 14]. We see the prospect of further research in the processing of the information received from the fuzzy system and the formulation of appropriate recommendations for specialists in different fields of knowledge for interpreting the final grade using multilevel test tasks.

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Peculiarities of cloud computing use in the process of the first-year students' adaptive potential development

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Abstract

Technologies based on cloud computing is one of the demanded and actively developing areas of the modern information world. Cloud computing refers to an innovative technology that allows you to combine IT resources of various hardware platforms into a single whole and provide the user with access to them via a local network or the global Internet. Cloud services from various providers offer users access to their resources via the Internet via free or shareware cloud applications, the hardware and software requirements of which do not imply that the user has high-performance and resource-consuming computers. Cloud technologies represent a new way of organizing the educational process and offers an alternative to traditional methods of organizing the educational process, creates an opportunity for personal learning, collective teaching, interactive classes, and the organization of psychological support. The scientific article is devoted to the problem of integrating cloud technologies not only in the process of training highly qualified specialists, but also in the formation of professionally important personality traits. The article describes the experience of introducing cloud technologies into the process of forming the adaptive potential of students in conditions of social constraints caused by the COVID-19 pandemic.

Keywords

cloud technologies, adaptive potential, information technology, group interaction, individualization of training

1. Introduction

The introduction of cloud computing into the modern world is a necessary condition for the progressive development of the society. The results of the research, conducted in 2018 by Gartner, IDG and RightScale, prove that cloud computing use has become a widespread practice around the world. According to the RightScale survey, publicly available cloud infrastructures are in the lead in terms of implementation: 81% of companies choose a multi-cloud strategy that uses up to five clouds on average. The hybrid strategy, which is a combination of public

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and private cloud infrastructures, is followed by 51% of respondents, and 75% of organizations use private clouds. Increasing competition between cloud service providers promotes greater availability of services and helps to expand the capabilities of analytics and integration of cloud computing into various areas of public practice. Global changes in social interaction and communication, growing need for social isolation, caused by the COVID-19 pandemic conditions, actualize the search for optimal ways of indirect interaction, communication and learning [1, 2].

Higher education, like many other areas of human activity, has been involved in the process of transformation, caused by the need to meet the realities of today and actively explore the heuristic possibilities of digital reality, generated by the Internet environment development. First of all, it is resulted in the formation of a digital educational environment [3] and development of distance and e-learning [4, 5]. At the same time, traditional methods of getting higher education have not lost their relevance, they are still in demand, but in the digital age (era of digital technology dominance) they acquire new features, determined by the formation of a new type of learning – blended, which integrates traditional and e-learning [6]. This is primarily happens due to a transfer of a part of educational process in a cloud environment, which is a result of a free distribution of tools and software services in the academic environment provided by these products manufacturers. Informatization and improvement of cloud computing learning occupies one of the main places among numerous new areas of education [7, 8]. The relevance of new information technology use in education is based on the fact that they serve as a tool, which can solve certain psychological and pedagogical problems. They also provide education with qualitatively new learning opportunities; contribute to the development of independent learning skills. There also appear the opportunities for internalization of theoretical knowledge and practice-oriented experience, as they stimulate the development of didactics and methodology, contribute to the creation of new forms of learning [9]. With the development of computer tools and introduction of cloud computing into the educational process, its participants receive new opportunities, because new approaches are being implemented.

One of the main problems of modern higher education is a choice of optimal combination between the best traditions of current educational system and tools of information and communication technology, modern pedagogical innovations and trends. An urgent problem today is a need to find the most effective cloud computing tools that take into account dynamic changes in the educational environment and are focused on the development of various forms of thinking, creativity, high social and adaptive capabilities of higher education applicant.

2. Related work

The history of cloud computing is presented in [10]. Since the 1990s cloud computing is viewed as a new computer paradigm where the boundaries of computer technology itself are blurred. Consequently, there appeared new economic opportunities of the computer technical tools use. At that time cloud computing was actively used by commercial companies. In 1999, Salesforce first used the Internet to provide access to its software. In 2002, Amazon introduced the first web service using cloud computing for the retail sale of consumer goods [11]. Since 2008 “cloud computing” has occupied its place in the educational process of many countries.

Badger et al. [12] defined cloud computing as a model provides easy network access to a shared pool with con-figured computing resources (for example, networks, servers, storage systems, programs, services). Cloud model promotes accessibility and is characterized by the following main elements (on-demand self-service, wide network access, pooled resource, independent location, fast flexibility, measurable services).

We have analyzed research works on the implementation of cloud services into the educational process, and come to the conclusion that scientific description of the development of basic web application http://cloudcomputingreview.muhammadsuhaib.com for data collection is quite a priority. Suhaib [13] emphasizes that cloud computing use in educational institutions provides many benefits with minimal costs, so many institutions in Asian countries are adapting to this digital service. Most scholars focus their research on the priority areas of cloud services implementation into higher education.

Allam et al. [14] highlight the benefits and challenges, discuss potential strategic issues and demonstrate the results of surveys of both higher education applicants and IT experts.

Kumar and Sharma [15] consider cloud computing useful for modeling and prototyping for various STEM subjects, analyze the benefits of using cloud computing for students pursuing a career in STEM, and describe case studies of successful cloud computing implementations in STEM courses.

Within the framework of empirical practice-oriented research, Lu [16] gives a quantitative assessment and analysis of cloud computing integration into the curriculum. The scholar conducts a comparative study of traditional teaching and that, which is carried out by means of cloud computing use.

Marienko et al. [17] offer a general model of adaptive cloud system of education and professional development of teachers, methods of using adaptive systems (Google Docs, IBM Box, Microsoft Office 365) in order to support cooperation in virtual teams. They also describe a methodology of supporting the processes of adaptive creation and use of electronic educational resources (WPadV4, AWS).

Nosenko et al. [18] research the issues of using adaptive cloud computing of the education system (ACLS) in the modern high-tech educational environment and offer to expand an access to them as they become the tools of educational and research activities in higher educational institutions of Ukraine. Scientists pay special attention to the analysis of the conceptual apparatus of application and design of adaptive learning systems, based on cloud computing; reveal their main characteristics; describe the ways of their pedagogical application. In the context of empirical research, the authors analyze the experience of Institute of Information Technologies and Learning Tools of NAES of Ukraine in terms of the design and application of the cloud environment for learning and research.

Markova et al. [19] demonstrate ways to implement models of cloud services SaaS, PaaS, IaaS, which should be used in the academic courses of mathematical, scientific cycles and in the future specialists' professional and practical training in the field of information technology, on the example of software engineering, computer science and computer engineering. Researchers identify and analyze the most significant benefits of cloud computing use in the training of future information technology experts, namely they research a possibility of using modern parallel programming tools as the basis for cloud computing.

Taking into account the pandemic conditions of higher education transformation and introduction of cloud computing into the educational environment, the issue of using available cloud computing tools in the process of psychological support and development of students' adaptive potential remains uncovered.

3. Research methods

Interdisciplinary research was conducted as part of research work, carried out at the expense of the state budget general fund: "Adaptive system for individualization and personalization of future professionals' training in the conditions of blended learning", number of state registration 0120U101970. Taking into account the pandemic conditions and social isolation, from 2019 to 2020, it was proposed to implement the program "The first-year students' adaptive capacity development in a modern educational institution". This program, which was based on the cloud computing elements use, was implemented in Bohdan Khmelnytsky Melitopol State Pedagogical University with the support of University Psychological Center. Methods used in the research process: method of theoretical analysis of literature sources on the introduction of cloud computing into the educational process of higher education, analysis of modern experience of psychological and pedagogical support of the integrative process of the first-year students' adaptive potential development, analysis of practical implementation of Google Workspace for Education Edition into the process of the first-year students' adaptive potential development, a set of psychodiagnostic tests using Google Form.

4. Research results

4.1. Theoretical foundations

In the study of the National Institute of Standards and Technology there are 3 models of cloud services (figure 1).

Recommendations for the effective use of cloud computing in universities are given in the technical report of the research group of the University of California at Berkeley [20]. This report presents 10 obstacles and 10 opportunities that clouds provide to businesses, including educational institutions. Cloud providers, which own data centers, use cloud utilities to enable cloud users and SaaS providers to use web-based "Software as a Service" (SaaS).

The analysis allowed us to identify the following advantages of using cloud computing in the educational environment:

- *economic*: the main advantage for many educational institutions is cost effectiveness. This is especially noticeable when services, such as e-mail, are provided for free by external providers. Equipment for these services may be used for other purposes;
- *technical*: minimum hardware requirements (the only one condition is access to the Internet);
- *technological*: most high-level cloud services are either fairly easy to use or require minimal support;
- *didactic*: a wide range of online tools and services that provide a secure connection and opportunities for cooperation between teachers and students;

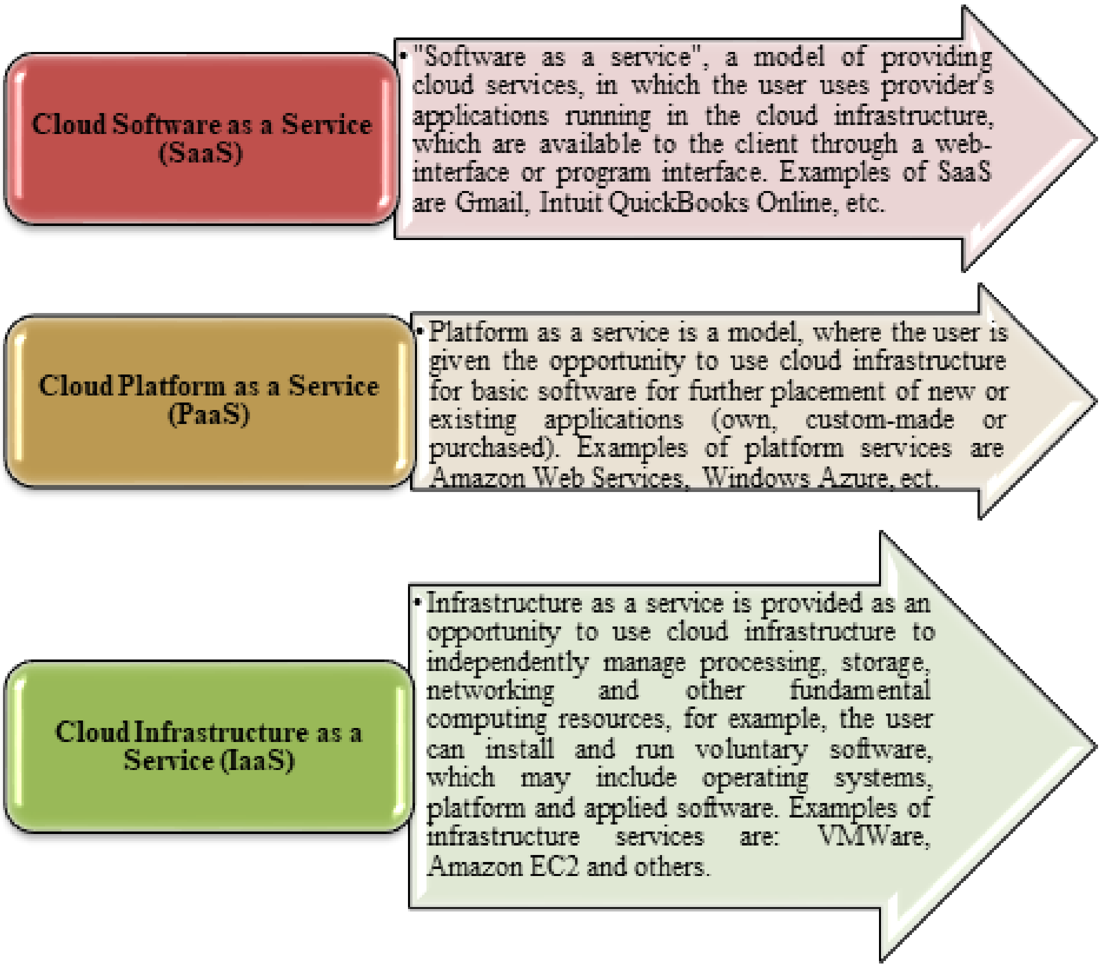

Figure 1: Architectural components of “clouds”.

- *health-saving*: in pandemic conditions support and possibility of continuous educational activities are provided, even in the conditions of self-isolation.

Currently, the major providers for educational institutions in Ukraine are Microsoft and Google, which provide clouds and SaaS to schools, colleges and universities on a free basis. In addition, cloud computing challenges software developers and this fact is connected with a merge of new generation of software applications [21]. The use of cloud computing in the educational process allows educational institutions to use computing resources and software applications as a service via the Internet. It also allows to intensify and improve the learning process. Examples of modern services for education, based on cloud computing, are Office 365 Education from Microsoft and Google Workspace for Education. When using the Google Workspace for Education cloud platform, students and teachers can use the following basic tools: Gmail with support for text, voice (Google Talk) and video chat; Google Drive (a storage size is 15 GB by default) for saving files and providing access rights to them; Google Docs –

a tool for creating documents, spreadsheets and presentations of any complexity with the ability to use templates; safe, an additional tool of Google Workspace for Education, which allows you to manage information, i.e. to organize a quick search for necessary information, archive and export e-mail message to standard formats; organize protection of information from accidental or intentional deletion; create databases on user's activity and data history [22]. Google Workspace for Education have been constantly expanding a range of services for educational institutions, creating additional services such as Apps Marketplace (implementation and integration of web services compatible with Google Workspace for Education); Google Moderator (a service for creating categories of questions for discussion), etc. [23] (figure 2).

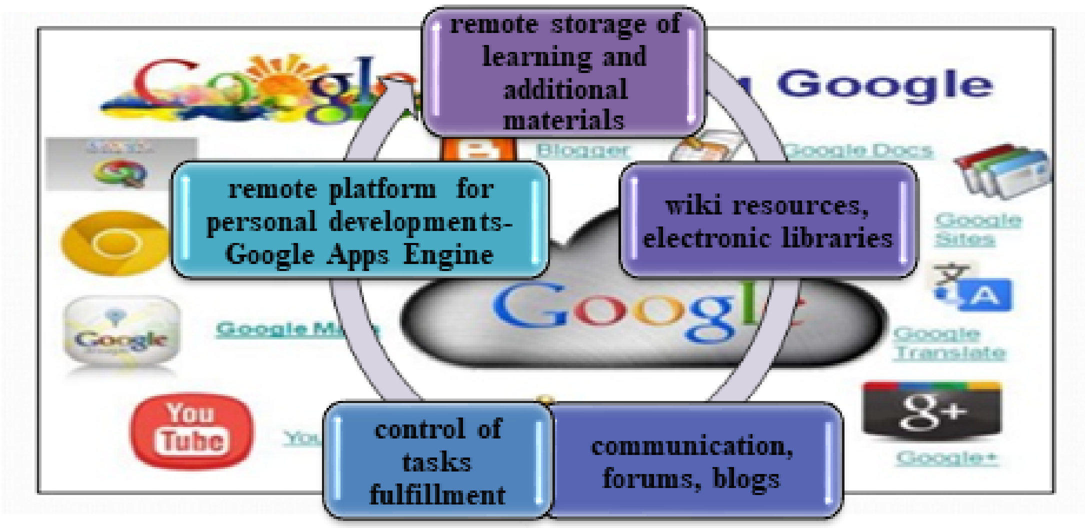

Figure 2: Functional opportunities of Google Workspace for Education.

Given that future specialists use information technology in almost any activity, and taking into account huge popularity and versatility of Google, the use of educational resources, created on its basis, allows us to organize the learning process in such a way that students actively and enthusiastically master the educational materials. In these terms the Google Classroom, a learning management system, is especially convenient (figure 3).

This system has many advantages:

- access to materials from any place;
- creation of a task and distribution of its individual copy for each student;
- joint work on tasks, implementation of project activities;
- real-time communication;
- possibility of conducting interactive classes online;
- tasks assessment.

Currently, in order to work with the service, you need only an Internet connection, a browser, and any freely available operating system. The only condition is to register your own mailbox

Figure 3: Advantages of Google Classroom implementation into the educational process.

in Gmail and get the access key, which is generated by Google Classroom for each class. It should be noted that in order to use Google Class in your school, you have to create a free account in Google Workspace for Education. The Google Classroom can contain not only tasks to be performed during the lessons, but also links to useful resources, including a discipline site, created by means of Google service. It is advisable to fill the course with lectures, practical classes, individual tasks for students and links to information resources that may be needed while doing a course: textbooks, manuals, regulations, Internet resources, videos, etc. Such availability of teaching aids, opportunity to review and look through them again and again provide necessary conditions for the internalization of the learning materials. The Google Classroom e-learning environment also allows users to import elements from other services, including small interactive LearningApps.org modules, which can be used directly as educational or training resources and allow students to learn the most important categories of the course in a form of a game. The advantages of cloud computing in the educational environment provide an opportunity to consider them as a deterministic component of the impact on professionally important and personality-oriented competencies development [24].

4.2. Empirical implementation

In the period of education reform, the problems of students' adaptation to new forms and conditions of life are becoming increasingly important. It causes the need to improve psychological support of educational process. The first-year students adaptation to higher education is one of the important issues, because it is a period of the most intensive flush of intellectual and moral forces of a person. Personal adaptive potential (as an integral feature of mental development) is viewed as personality's interconnected psychological features which determine the success of adaptation and provide a possibility of maintaining professional health. Characteristics of personal adaptive potential can be obtained by assessing the level of behavioral regulation (BR), communicative potential (CP) and the level of moral norms (MN). Adaptive potential is considered to be a person's systemic feature, which determines the limits of his or her adaptive capabilities and reaction to the influence of certain factors and conditions of the environment. Adaptive abilities provide adequate fulfillment and high efficiency of work under the influence of psychogenic environmental factors. Under the sociopsychological adaptation, we understand the process and result of active human adaptation to the conditions and requirements of social environment through mastering and acceptance of the requirements, values, and norms of behavior which are common for this environment [25]. In this context, the main function of adaptation is a person's acceptance of norms and values of new social environment, forms of social interaction that have developed in it, formal and informal relationships, as well as forms of learning. Thus, taking into account the pandemic limitations, teachers of the Department of Psychology together with leading experts of the Department of Informatics and Cybernetics have developed and tested the program "Adaptive" using the functional opportunities of Google Workspace for Education. The program is designed for 10 days, 2 hours daily, and is carried out during the first weeks of September.

This adaptation program for the first-year students contributes to more intensive and purposeful habituation of students to university conditions, enhances team building, on the other hand it helps students and curators to establish interaction, create a friendly atmosphere in the group, form a positive internal motivation. The innovative information component of the program is its configuration and implementation through the cloud computing use in the conditions of social isolation, caused by the COVID-19 pandemic. In order to identify the effectiveness of the program "Adaptive", based on Google Workspace for Education, we conducted a comparative analysis of students' adaptive potential. There were two groups: control group (28 people) – the first-year students (future psychologists) who participated in the traditional program "Adaptive" in 2019 without the use of cloud computing; and experimental group (30 people) – the first-year students (future psychologists) who participated in the program "Adaptive", implemented on the basis of cloud computing in 2020.

After the formative experiment, there was a tendency to an increase of the adaptive abilities of experimental group students (table 2).

Thus, as it can be seen from the table 2, the average level of adaptive abilities in the experimental group has increased by 13.33% (from 20.00% to 33.33%) due to a decrease of 26.67% in the number of students with a low level of this indicator (from 80.00% to 53.33%). This proves that first-year students have become less vulnerable to adaptation problems; they have developed the skills necessary for the adaptation to the new educational environment and acquired basic adaptation mechanisms. In addition, due to the work done in the experimental group, students with a high level of adaptive abilities (13.34%) were identified. They demonstrated the ability to successfully adapt to various requirements of new educational environment, they can easily and adequately orient in the new situation, quickly choose the strategy of their behavior and socialization, which is manifested in the use of certain adaptive mechanisms in the conditions of study in university. In contrast, the indicators of adaptive abilities of the control group students have remained almost unchanged (the percentage of students with a satisfactory level has increased from 25.00% to 28.57%, and a low level of this parameter has decreased by only 3.57%). These minor changes are insignificant. In addition, we didn't identify a high level of

Table 1
Design of the program “Adaptive” based on Google Workspace for Education services)

Stages of program implementation	Basic activities
Preparative unit	1. Development and approval of the program “Adaptive”. 2. Uploading elements and tasks of the program into the Google Classroom environment. 3. Training of trainers (teachers of the Department of Practical Psychology), who are responsible for conducting Adaptive at the faculties. 4. Training of group curators for the Adaptive use. 5. Organizational work, carried out by heads of the program and people responsible for it at the faculties.
Implementation of program “Adaptive”	first-year students’ acquaintance with peculiarities of work in Google Classroom environment and functional opportunities of Google Workspace for Education which will be used within the framework of the program; acquaintance with the legal framework of University; demonstration and discussion of “Checklist for the first-year students”; viewing and discussing 3D tours; acquaintance with the information base of the university site
Corrective-developmental unit	delivery of psychological transformation games, trainings aimed at the development of personal adaptive potential (for example, T-game “Wings”, “Our State"”); group forum “We are a single team”, “Getting to know the worldviews of group members”; group online quest “Close-knit team”; watching and discussing the video “Principles of team building”; creation of online art collages and presentations “My future profession”, “Learning to be together”; activities for interaction and communication; presentation of online projects of microgroups “Rules and values of our group”
Preventive unit	diagnosis of psychological personality traits, using the Google form, in order to identify the first-year students’ adaptive potential and prevent the manifestation of maladaptive forms of behavior; keeping online diaries “Emotional state map”, in order to prevent mental stress; Group discussion – “Successful communication”, 16 principles of building interpersonal communication, “Consilium”, “Live line”; corrective activities to prevent mental stress during the period of the first-year students’ adaptation
Reflexive unit	receive feedback using the Google Forms; diagnostics of levels of development of the first-year students’ adaptive abilities by means of the Google Forms; online presentations of the essay “I am a future specialist. My profession in 10 years”
Analytical stage	processing of the results of psychodiagnostic research; feedback survey analysis; making a list of “first-year students’ risk groups”, people, who demonstrate initial manifestations of maladaptation; development of a list of recommendations and a plan for psychological support of “risk groups”

Table 2
Quantitative indicators (%) of levels of adaptive abilities development of the first-year students of experimental ($n = 30$) and control ($n = 28$) groups after a formative experiment. Indicators in % (absolute number)

Level of adaptive abilities	Experimental group before	Experimental group after	Control group before	Control group after
High level	0	13.34(4)	0	0
Satisfactory level	20.00 (6)	33.33 (10)	25.00 (7)	28.57 (8)
Low level	80.00 (24)	53.33 (16)	75.00 (21)	71.43 (20)

adaptability among the students of the control group.

This work helped to increase *the neuropsychological stability* of students. According to the results of the formative experiment, there was an increase in the level of neuroemotional stability in both experimental and control groups. But more significant changes took place in the experimental group. In particular, a number of students with a low level of neuroemotional stability has decreased by 10% (from 66.66% to 56.66%) and a number of the first-year students with a high level of this indicator has increased by 10%. This states that participants have become more optimistic about reality in terms of adaptation, they realistically assess their role in a team and relationships, focus on compliance with generally accepted norms of behavior, adequately perceive new requirements of the intellectual and educational environment. The same changes in the control group were identified only partially (a number of students with a low level has only decreased by 3.57% and, accordingly, the percentage of students with a high level of neuro-emotional stability has increased).

The introduced system of psychological and pedagogical support has somewhat affected the indicators of development of the first-year students' *communicative skills*. Positive changes in the development of communicative skills are more significant among the first-year students of the experimental group. In particular, a high level of development of these skills in the experimental group has increased by 10% (3 63.33% to 73.33%) and, accordingly, the indicator of a low level of development of these skills has decreased by 10% (from 36.67% to 26.67%). Students became less conflicted, more open and tolerant to each other in the process of communication; it became easier for them to establish contacts with others. The work contributed to more effective interaction and mutual understanding in the process of joint intellectual activity. Due to the developed skills of effective communication of the experimental group students there was an improvement in relationships in the group and beyond. It has to be noted that there were also changes in the control group, but they were not so significant. The changes in the indicators of high and low levels of the development of communicative skills were only by 3.57%. This number of the first-year students was able to get rid of problems in establishing contacts with others in the process of joint intellectual activity.

The conducted work also had a positive impact on the indicators of moral norms of the first-year students. Positive changes in the indicators of *moral norms* are present only in the experimental group, but they are also insignificant. A number of students with a high level has increased only by 3.34% (from 90.00% to 93.34%) and, accordingly, a number of respondents with a low level of development of moral norms has decreased by 3.34% (10.00% to 6.66%). Thanks to the acquired skills of adaptive behavior, the first-year students learned to accept the proposed new social role, moral and ethical norms of behavior and requirements of the new intellectual and educational environment. In the control group, these indicators, according to the formative experiment results, remained constant. In our opinion, this is due to the fact that students have not experienced adaptive behavior, they haven't been aware of the ways to overcome difficult situations, and therefore they can not always clearly assess their place and role in a team. These students do not even try to stick to generally accepted moral and ethical norms of behavior and new educational environment requirements.

The students of the experimental group have also shown positive changes in the indicators of the level of adaptability (table 3).

Table 3
Quantitative indicators (%) of levels of adaptability of the first-year students of experimental ($n = 30$) and control ($n = 28$) groups after a formative experiment. Indicators in % (absolute number)

Level of adaptability	Experimental group before	Experimental group after	Control group before	Control group after
adaptability	43.33 (13)	63.33 (19)	46.43 (13)	50.00 (14)
maladaptability	56.67 (17)	36.67 (11)	53.57(15)	50.00 (14)

Table 3 shows that a number of experimental group students, who became more adaptive, increased by 20.00% (from 43.33% to 40.00%). This indicates that students have become more able to adapt to the changing conditions of the educational environment, they analyze and adequately perceive it, maintain their integrity and avoid destructiveness under the influence of change, correlate their goals and outcomes. While participating in the program, they learned to orient more adequately in a new learning situation, while maintaining the optimal level of their mental capacity. Due to this fact, a number of people, who showed maladaptation, has decreased by 20.00% (from 43.33% to 63.33%) and all of them show unsuccessful attempts to achieve the goal, they demonstrate some contradictions between their intentions and actions, plans and their implementation, motivation for action and its results. The results of the control group are almost unchanged, in this sample the level of maladaptability has decreased only by 3.57%.

It should also be noted that our program "Adaptive", based on the use of cloud computing, has influenced the level of the first-year students' *acceptance of others*. The experimental group underwent the most qualitative changes in the levels of the first-year students' acceptance of others. It should be noted that a number of students who have become more able to accept other people as they are has increased by 6.67% (from 86.67% to 93.34%). They have learned to respect the uniqueness of others and their right to be themselves, they have also learned to accept the unconditional value of other people and be able to trust them. The experimental work contributed to the first-year students' acceptance of the inner world, the essence and abilities of other people. Accordingly, a number of respondents, for whom another person is not a unique person capable of their own changes and possessions, has decreased by 6.67% (from 13.33% to 6.66%). According to the formative experiment results there were also some changes in the control group, but they are not so significant. In particular, only 3.57% (from 89.29% to 92.89%) of the first-year students have undergone qualitative changes in the degree of their acceptance of other people. The reason for it we see in a lack of students' experience of understanding the inner world of others, their uniqueness and individuality, presence of inflated self-esteem.

Formative experiment results indicate positive changes in the indicators of *emotional comfort* in a new intellectual and educational environment. Based on the obtained data, it can be stated that a number of the experimental group students, for whom higher education is associated with emotional comfort, has increased by 13.33% (from 96.67% to 83.34%). It proves the fact that students have become more confident in themselves and others, feel more secure and calm in the new intellectual and educational environment, they have lost the feeling of anxiety in a new learning situation. Accordingly, a number of respondents of the experimental group, for whom the new educational space is associated with discomfort and emotional experience of learning situation as an unpleasant and difficult one, has decreased by 13.33% (16.66% to 3.33%). It disrupts their normal learning and mental activity. Formative experiment results indicate some slight changes in the above mentioned indicators among students of the control group. In particular, the difference between the indicators before and after the experimental work in this sample is only 3.57%. The lack of adaptive mechanisms does not allow first-year students to get rid of anxiety, worry and fear associated with a new learning and mental activity. It negatively affects their functioning, confidence and mental capacity.

Indicators of *dominance and subordination* in the first-year students relations according to the results of the formative experiment show that qualitative changes in this indicator are found out only among the experimental group students, but they are insignificant. In particular, a number of respondents for whom dominance is a characteristic feature in the relationship, has increased by 3.34% (from 80.00% to 83.34%). Thus, it can be stated that the implemented system to some extent contributed to the development of the first-year students' faith in their ideas and capabilities, encouraged them to be a leader, and be able to manage their destiny without lowering their expectations after many failures. It also helps them to maintain a sense of control over the environment. Accordingly, there is a decrease by 3.34% (from 20.00% to 16.66%) in the number of respondents, who prefer subordination, and want to obey the decisions of leaders. They don't feel able to manage the events of their lives, even after success. In our opinion, such insignificant changes are connected not with the ineffectiveness of the implemented program, but rather with the internal attitude, type of temperament and worldview of students. Instead, the indicators of the control group according to the results of the experiment remained constant.

Qualitative changes in the indicators of students' *escapism* have taken place. According to the experiment results, it was found out that the most significant changes were recorded in the experimental group, where this indicator has increased by 9.97% (from 83.34% to 73.37%). The indicators of these students' escapism are within normal limits, these students are able to either escape problems or solve them by looking for constructive methods, choosing alternative ways and applying their personal and intellectual potential. But the chosen strategy depends on a situation. Due to it, a number of respondents, who are characterized by a high level of escapism, has decreased by 13.34% (from 20.00% to 6.66%). These students experience difficulties during the fulfillment of educational and mental activities in the university, as there appear some problems during their adaptation to the educational institution. It has to be mentioned that a number of the first-year students with a low level of escapism has increased by 3.34% (from 6.66% to 10.00%). During formative experiment, students learned to solve difficult situations, keeping faith in themselves and their abilities, as well as to manage the appropriate level of their mental capacity. Some changes in this regard were recorded in the control group, where the indicators of a high level have decreased by 3.58% (from 14.29% to 10.71%) and a level of escapism within the norm has increased by 3.58%, respectively (from 82.14% to 85.72%). In addition, a lack of skills of constructive problem solving left unchanged, the indicators of a low level of escapism in the control group were 3.57%.

The implemented program also contributed to the correction of indicators of psychophysiological maladaptation of students (table 4).

Table 4
Quantitative indicators (%) of levels of psychophysiological maladaptation of students of experimental ($n = 30$) and control ($n = 28$) groups after a formative experiment. Indicators in % (absolute number)

Level of maladaptation	Experimental group before	Experimental group after	Control group before	Control group after
high	6.66 (2)	0	7.14 (2)	7.14 (2)
sufficient	10.00 (3)	3.33 (1)	10.71 (3)	7.14 (2)
medium	70.00 (21)	60.00 (18)	67.86 (19)	71.43 (20)
low	13.37 (4)	36.67 (11)	14.29 (4)	14.29 (4)

Table 4 shows that in the experimental group there were significant changes in the indicators of maladaptation. In particular, a number of students with a low level has increased by 23.3% (from 13.37% to 36.67%) and a sufficient level of maladaptation has decreased by 6.67% (10.00% to 3.33%). It shows that some students have overcome strong feelings, associated with insufficient socialization in the new conditions. They struggle with unacceptable attitudes, sharp change in living conditions, and a break in important social relations, etc. In addition, the work allowed to completely “get rid” of students with a high level of psychophysiological maladaptation (0% instead of 6.66%). They became more adaptable to the life and conditions of university, acquired skills of independence in the organization of their mental activity. The indicators of a medium level have also changed (from 70.00% to 60.00%) due to the change of the indicated results. Students have learned to overcome difficulties, associated with changing forms of learning, teaching and assessment methods, and the discomfort of a new learning environment. Instead, the results of the control group according to this indicator have remained almost constant. The number of students with a sufficient level has decreased by only 10.00% and increased accordingly in terms of the medium level of maladaptation. The experimental work contributed to the effective formation of experimental group students’ *value motivation to study* in the university (table 5).

As we can see from table 5, there was an increase of 16.66% in the number of experimental group students seeking for mastering the profession (from 10.00% to 26.66%). Thus, they rethought themselves as future professionals, they began to strive to develop professionally

Table 5
Motives of learning of students of experimental ($n = 30$) and control ($n = 28$) groups according to the formative experiment results. Indicators in % (absolute number)

Motives of learning	Experimental group before	Experimental group after	Control group before	Control group after
Knowledge acquisition	33.36 (10)	36.67(11)	28.57 (8)	28.57 (8)
Professional development	10.00 (3)	26.66 (8)	7.14 (2)	10.71 (3)
Getting a diploma	56.66 (17)	36.67 (11)	64.29 (18)	60.71 (17)

important qualities, to become an educated person and a highly professional specialist. In addition, a number of the first-year students, who are focused on acquiring certain professional knowledge, showing curiosity, determination and independence in the process of learning, has slightly increased (from 33.36% to 36.67%). Due to it, a number of respondents, who consider getting a diploma and higher education to be a priority when studying in the university, has decreased by 20.01%. So, it can be stated that learning motivation of the first-year students of the experimental group after the implementation of the program has become more evident. Analyzing the indicators of the control group, we can see only episodic changes. There was a shift of only 3.57% in terms of mastering the profession and getting a diploma.

Along with it, the created conditions contributed to the development of different types of relationships, characteristic for a team, which improves the microclimate in the group (table 6).

Table 6
Quantitative indicators (%) of levels of social relations development among the students of experimental (n = 30) and control (n = 28) groups after the formative experiment Indicators in % (absolute number)

Types of relations	Experimental group before	Experimental group after	Control group before	Control group after
informativeness	33.34 (10)	10.00 (3)	39.29 (11)	32.13 (9)
contacts	23.34 (7)	3.33 (1)	21.44 (6)	21.44 (6)
openness	13.33 (4)	13.33 (4)	10.71 (3)	14.29 (4)
responsibility	13.33 (4)	16.67 (5)	10.71 (3)	7.14 (2)
collectivism	6.66 (2)	30.00 (9)	7.14 (2)	7.14 (2)
unity of opinion	10.00 (3)	23.34 (7)	7.14 (2)	14.29 (4)
good organization	-	3.33 (1)	3.57 (1)	3.57 (1)

As it is seen from table 5 after the experimental work collectivism has become a priority for the experimental group students (from 6.66% to 30.00%), as well as a unity of opinion (from 10.00 to 23.34%) and responsibility (from 13.33 up to 16.67%). They became more eager to work together to solve all issues, at the same time preserving and strengthening the group as a whole, preventing its destruction. Students note that the group has common ideas and goals understood and perceived by everyone as their own. In addition, the first-year students have changed their attitude to joint mental and educational activities, to the tasks which the group has to do. It is the development of such relationships that most students in the experimental group have noticed. In addition, students became more organized (the indicator has increased by 3.33%), but they remain open to others (the result hasn't changed – 13.33%). It indicates the ability of the group to independently organize its work and leisure, quickly create an organizational structure of business relationships which are necessary for effective group work. In the control group, the results are stable according to almost all parameters.

Analyzing the obtained empirical data, we have come to the conclusion that there was an improvement of psychological and psychophysiological indicators of the first-year students' adaptive abilities as a result of their participation in the program "Adaptive", based on the use of cloud computing.

5. Conclusions and recommendations for future research

The rapid spread of cloud computing makes modern educational environment integrate cloud services into the educational institution, review its IT-infrastructure and introduce innovative technologies into the educational process. The use of Google Workspace for Education in the educational process not only contributes to the fulfillment of main task of modern education – formation of a competitive and successful personality in the electronic information society, but also significantly improves and diversifies the activity of a teacher, activates creativity of students, creates appropriate conditions for the formation and development of their relevant skills and abilities, improves the assimilation and reproduction of information obtained by them, promotes the development of students' adaptive potential. The implemented program "Adaptive", based on the cloud computing use, proved to be effective, as the experimental group students demonstrated significant positive changes (qualitative and quantitative) in the indicators of mental performance and psychological and pedagogical conditions of their development. The obtained results show a tendency to increase the adaptive abilities of the experimental group respondents, their neuropsychological stability and level of their adaptability. Students developed the skills necessary for their adaptation to the new intellectual and educational environment, they became more optimistic about it, they are able to use basic adaptive mechanisms, at the same time maintaining their integrity. The experimental work helped to reduce a level of the first-year students' psychophysiological maladaptation and sociopsychological stress; they became more adaptable to the life and conditions of university, acquired skills of independence and personal stress resistance in the mental activity. The experimental program also influenced the development of students' learning motivation, their focus on the acquisition of knowledge, curiosity and independence in performing intellectual tasks. There was a certain increase of a percentage of experimental group students who choose a strategy of coping, focus on solving the problem with the orientation for its rational analysis and constructive solution. After the experimental work, collectivism, unity of opinion and responsibility became a priority for the experimental group students. We have also noted a desire to fulfill joint activity, preserve and strengthen group as a whole, admit the value of each group member. As a result of the analysis of program participants' feedback, we can say that there is an increase in students' interest in some information services. It means that it is important to carry out a work on the introduction of cloud computing into the educational process. We consider information and communication technology to be a powerful means of increasing not only the effectiveness of learning, but also the development of professionally important personal traits as well as formation of future specialist's competitiveness.

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